Calculate The Number Of Moles Of Silicon, Si, If You Begin With 5.84 X 1024 Atoms Of Silicon.

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This problem involves converting a given number of silicon atoms into moles, a fundamental concept in chemistry that links microscopic particles to macroscopic quantities. Understanding how to perform this calculation is essential for students and professionals working with chemical reactions, material science, and nanotechnology. In this article, we will explore the methodology for calculating moles from atoms, the significance of Avogadro's number, and provide step-by-step instructions to perform such conversions accurately.

Understanding the Concept of Moles and Avogadro's Number

What Is a Mole?

A mole is a standard scientific unit used to quantify the amount of a substance. One mole contains exactly 6.022 x 10^23 particles, whether they are atoms, molecules, ions, or other entities. This number is known as Avogadro's number, named after the Italian scientist Amedeo Avogadro, who proposed that equal volumes of gases, at the same temperature and pressure, contain equal numbers of molecules.

Why Use Moles?

Using moles simplifies chemical calculations by providing a bridge between the microscopic world of atoms and molecules and the macroscopic world of grams and liters. Instead of counting individual particles, chemists work with moles to relate mass, volume, and particle counts easily.

Given Data and Objective

The problem states:
- Number of silicon atoms = 5.84 x 10^24
- Goal: Find the number of moles of silicon corresponding to this number of atoms.

This is a straightforward conversion problem that involves dividing the number of atoms by Avogadro's number.

Step-by-Step Calculation Method

Step 1: Recall the Conversion Factor (Avogadro's Number)

Avogadro's number, N_A, is:
- 6.022×10^{23} atoms/mole

Step 2: Set Up the Conversion Formula

Number of moles (n) is calculated as:
$$ n = \frac{\text{Number of atoms}}{\text{Avogadro's number}} $$

Step 3: Plug in the Known Values

$$ n = \frac{5.84 \times 10^{24}}{6.022 \times 10^{23}} $$

Step 4: Perform the Division

Dividing the coefficients and subtracting exponents:
$$ \frac{5.84}{6.022} \approx 0.969 $$
$$ 10^{24} / 10^{23} = 10^{1} $$

Therefore,
$$ n \approx 0.969 \times 10^{1} = 9.69 $$

Result:
The number of moles of silicon is approximately 9.69 moles.

Interpreting the Result

This means that starting with 5.84×10^{24} silicon atoms corresponds to about 9.69 moles of silicon. Since one mole contains 6.022×10^{23} atoms, the calculation confirms that nearly 10 moles of silicon atoms are involved.

Additional Considerations

Significance of Significant Figures

The initial data had three significant figures (5.84), so the final answer should be expressed with three significant figures:
9.69 moles

Practical Applications

- Chemical Reactions: Knowing the moles involved helps in stoichiometry calculations, preparing solutions, and predicting reaction yields.

- Material Science: Quantifying atoms in nanomaterials or thin films.
- Educational Purposes: Understanding the scale of atoms and molecules in real-world quantities.

Summary of the Calculation Process

Step	Description	Mathematical Expression	Result
1	Recall Avogadro's number	$N_A = 6.022 \times 10^{23}$	—
2	Set up conversion	n = number of atoms / N_A	—
3	Substitute known values	$n = 5.84 \times 10^{24} / 6.022 \times 10^{23}$	—
4	Calculate	$n \approx 9.69$	Moles of silicon

Conclusion

Converting atoms to moles is an essential skill in chemistry, providing a bridge between the microscopic and macroscopic worlds. In this specific case, starting with 5.84 x 10^{24} silicon atoms yields approximately 9.69 moles of silicon. Mastering such calculations enhances understanding of chemical quantities, reactions, and material properties, enabling more precise and effective scientific work.

Remember: Always pay attention to the significant figures in your data and results to ensure accuracy and clarity in your scientific communication.

Frequently Asked Questions

How do I calculate the number of moles of silicon from a given number of atoms?

To calculate the moles of silicon, divide the number of atoms by Avogadro's number (6.022 x 10^{23} atoms/mol).

What is the formula to convert atoms of silicon to moles?

Number of moles = (Number of atoms) / (Avogadro's number).

Given 5.84 x 10^{24} atoms of silicon, how many moles are present?

Number of moles = (5.84 x 10^{24}) / (6.022 x 10^{23}) ≈ 9.7 moles.

Why do we divide the number of atoms by Avogadro's number to find moles?

Because one mole contains exactly 6.022 x 10^{23} atoms, so dividing gives the equivalent amount in moles.

What is the significance of calculating moles in chemistry?

Calculating moles allows chemists to understand and quantify the amount of substance involved in chemical reactions.

Can I use the same method to convert other atomic quantities to moles?

Yes, the same approach applies to convert any number of atoms or molecules to moles by dividing by Avogadro's number.

Additional Resources

Calculate The Number Of Moles Of Silicon, Si, If You Begin With 5.84 x 10^{24} Atoms Of Silicon

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Introduction

In the realm of chemistry, understanding the concept of moles and how to convert between atoms and moles is foundational. Silicon (Si), a pivotal element in technology and industry, often appears in various chemical calculations. Today, we explore a fundamental problem: Calculate the number of moles of silicon, Si, if you begin with 5.84 x 10^{24} atoms of silicon. This question, while straightforward at first glance, offers a gateway into the core principles of atomic theory, Avogadro's number, and stoichiometry that underpin much of chemical science.

The Significance of the Question

Why is this calculation important? In practical applications, chemists, materials scientists, and engineers frequently need to convert between microscopic quantities (atoms, molecules) and macroscopic amounts (moles, grams). Whether designing semiconductors, analyzing mineral compositions, or conducting laboratory experiments, mastering these conversions is essential. The question at hand exemplifies such a fundamental conversion: translating a count of atoms into moles, which relate directly to measurable quantities like mass and volume.

Understanding the Core Concepts

The Mole and Avogadro's Number

The mole is a SI base unit representing a specific number of particles (atoms, molecules, ions). Defined precisely, one mole contains exactly 6.022 x 10^{23} particles, known as Avogadro's number.

- Avogadro's Number (N_a): 6.022 x 10^{23} particles/mole

This constant provides the bridge between the microscopic world of atoms and molecules and the macroscopic world that scientists can measure and manipulate.

Atomic Count to Moles Conversion

The process of converting from a number of atoms to moles involves dividing the total number of atoms by Avogadro's number:

$$
\text{Number of moles} = \frac{\text{Number of atoms}}{N_a}
$$

where:
- Number of atoms = 5.84×10^{24}
- N_a = 6.022×10^{23}

This formula is the backbone of stoichiometric calculations involving atomic counts.

Step-by-Step Calculation

Step 1: Write down the known quantities

- Atoms of silicon: 5.84×10^{24}
- Avogadro's number: 6.022×10^{23}

Step 2: Set up the conversion

$$
\text{Moles of silicon} = \frac{5.84 \times 10^{24}}{6.022 \times 10^{23}}
$$

Step 3: Perform the division

Dividing the coefficients:

$$
\frac{5.84}{6.022} \approx 0.97
$$

Subtracting the exponents:

$$
10^{24} / 10^{23} = 10^{1}
$$

Thus:

$$
\text{Moles of silicon} \approx 0.97 \times 10^{1} = 9.7
$$

Final Result:

\[
\boxed{

\text{Number of moles of silicon} \approx 9.7 \text{ mol}
}
\]

Therefore, starting with 5.84 x 10^{24} atoms of silicon yields approximately 9.7 moles of silicon.

Deep Dive: Factors Affecting the Calculation

While the calculation appears straightforward, several factors can influence the accuracy and application of this kind of conversion:

1. Precision of Constants

Using more precise values for Avogadro's number (6.02214076 x 10^{23}) can slightly alter the result, especially in high-precision contexts.

2. Significant Figures

Properly maintaining significant figures is crucial to ensure the precision of the result aligns with the input data. In this case, the initial atom count has three significant figures, so the final answer should also be expressed with three significant figures: 9.70 mol.

3. Assumptions

- The calculation assumes all atoms are silicon and are counted correctly.
- It presumes no loss or gain of atoms during any process, a reasonable assumption in pure calculations.

Broader Implications and Context

Silicon in Industry and Science

Silicon's role extends beyond mere atomic counts. It's the backbone of modern electronics, forming the basis of semiconductor devices, solar panels, and integrated circuits. Understanding the molar quantities of silicon involved in manufacturing processes is vital for:

- Material budgeting
- Reaction stoichiometry in synthesis
- Purity assessments

From Atoms to Mass

Once the number of moles is known, scientists can determine the mass of silicon using molar mass:

\[
\text{Mass} = \text{Number of moles} \times \text{Molar mass of Si}
\]

Given the molar mass of silicon (~28.0855 g/mol), the mass corresponding to 9.7 mol would be approximately:

$$
9.7 \times 28.0855\, \text{g} \approx 272.4\, \text{g}
$$

This conversion underscores how microscopic atomic counts relate directly to tangible quantities used in laboratory and industrial settings.

Advanced Considerations

1. Isotopic Variations

Silicon has three stable isotopes (^{28}Si, ^{29}Si, ^{30}Si), but for most calculations, the average atomic weight (~28.0855 u) suffices. In isotope-specific studies, the calculation might need to account for isotopic abundances.

2. Molecular vs. Atomic Calculations

While this problem involves atomic silicon, similar principles apply to molecules and compounds, with the key difference being the use of molecular weights and Avogadro's number in compound calculations.

Practical Applications and Significance

Understanding how to calculate moles from atomic counts is essential across multiple disciplines:

- Materials Science: Estimating quantities needed for synthesis or doping processes.
- Chemistry Education: Teaching students fundamental concepts of atomic theory and stoichiometry.
- Industrial Manufacturing: Managing raw material inputs and waste outputs based on atomic or molar quantities.
- Research: Designing experiments that require precise atomic counts, such as in isotope labeling.

Conclusion

The calculation of the number of moles of silicon from a given number of atoms exemplifies a core principle in chemistry: the bridge between the microscopic and macroscopic worlds. Starting with 5.84×10^{24} atoms of silicon, we find approximately 9.7 moles of the element, illustrating the vast scale differences and the importance of constants like Avogadro's number.

This understanding not only deepens our grasp of atomic theory but also empowers practical applications across scientific research, manufacturing, and education. Mastery of such conversions remains a fundamental skill for anyone seeking to navigate the complexities of chemical science effectively.

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