

Calculate The Number Of Moles Of Iron That Are Contained In 2.89×10^{25} Atoms Of Iron

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Understanding the relationship between atoms and moles is fundamental in chemistry. When dealing with quantities at the atomic level, chemists often need to convert between the number of atoms and the amount of substance in moles. In this article, we'll explore the process of calculating the number of moles of iron contained in a specified number of atoms—specifically, 2.89×10^{25} atoms of iron. This example will serve as a practical guide to help you grasp the concepts of atomic-to-mole conversions, essential for laboratory work, chemical reactions, and theoretical calculations.

Fundamental Concepts: Atoms, Moles, and Avogadro's Number

Before diving into the calculation, it's important to understand some key concepts:

Atoms and Molecules

- Atoms are the basic units of chemical elements.
- Molecules are groups of atoms bonded together; in the case of elements like iron (Fe), individual atoms are considered.

The Mole Concept

- A mole is a counting unit used in chemistry to express amounts of a chemical substance.
- One mole of any substance contains exactly 6.022×10^{23} entities (atoms, molecules, ions, etc.).
- This number is known as Avogadro's number.

Avogadro's Number

- Definition: 6.022×10^{23} entities per mole.
- Significance: It allows chemists to convert between the number of atoms and moles.

Step-by-Step Calculation: Converting Atoms of Iron to Moles

Let's methodically approach the calculation to determine how many moles are present in 2.89×10^{25} atoms of iron.

Step 1: Write Down Known Values

- Number of atoms, $(N_{\text{atoms}} = 2.89 \times 10^{25})$
- Avogadro's number, $(N_A = 6.022 \times 10^{23})$ atoms/mole

Step 2: Use the Conversion Formula

The fundamental relation connecting atoms and moles:

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

\]

Expressed mathematically:

\[

$$n = \frac{N_{\text{atoms}}}{N_A}$$

\]

Step 3: Perform the Calculation

Substitute the known values:

\[

$$n = \frac{2.89 \times 10^{25}}{6.022 \times 10^{23}}$$

\]

To divide these numbers:

- Divide the coefficients: $(2.89 \div 6.022 \approx 0.4799)$
- Subtract the exponents: $(25 - 23 = 2)$

So:

\[

$$n \approx 0.4799 \times 10^2$$

\]

Since scientific notation prefers a coefficient between 1 and 10:

\[

$$n \approx 4.799 \times 10^1$$

\]

Which simplifies to approximately:

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$n \approx 47.99$

\]

Final Result:

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\boxed{

$\text{Number of moles of iron} \approx 48, \text{ moles}$

}

\]

Understanding the Significance of the Result

The calculation shows that 2.89×10^{25} atoms of iron correspond to roughly 48 moles. This is a substantial amount—highlighting the scale at which atomic quantities translate into macroscopic amounts of material.

Implications:

- In a laboratory setting, knowing the number of moles helps in preparing solutions, stoichiometric calculations, and understanding reaction yields.
- For industrial applications, such as steel production, understanding molar quantities helps optimize processes.

Additional Considerations and Related Calculations

While the example above provides a clear-cut calculation, there are additional factors and related calculations that are often encountered in chemistry:

1. Molar Mass of Iron

- The molar mass of iron (Fe) is approximately 55.845 g/mol.
- Knowing the molar mass allows conversion from moles to grams:

$$\text{Mass in grams} = \text{Number of moles} \times \text{Molar mass}$$

Using the calculated 48 moles:

$$\text{Mass} = 48 \times 55.845 \approx 2684.16, \text{ grams}$$

This is roughly 2.68 kilograms of iron.

2. Calculating Atoms from Moles

- If you start with a known number of moles and need to find the number of atoms:

$$\text{Number of atoms} = \text{Number of moles} \times \text{Avogadro's number}$$

$$N_{\text{atoms}} = n \times N_A$$

\]

For example, 1 mole of iron contains approximately 6.022×10^{23} atoms.

3. Practical Applications in Chemistry

- Determining the amount of reactant needed for a reaction.
- Calculating the theoretical yield.
- Understanding atomic-scale phenomena in bulk quantities.

Common Mistakes to Avoid

When performing such calculations, watch out for:

- Incorrect use of scientific notation or exponents.
- Mixing units; ensure consistency when converting between atoms, moles, grams, etc.
- Not applying Avogadro's number correctly, especially when dealing with large quantities.
- Rounding errors; maintain precision until the final step.

Summary

To summarize, calculating the number of moles from a given number of atoms involves a straightforward division by Avogadro's number. In our example, dividing 2.89×10^{24} atoms by 6.022×10^{23} atoms/mole yields approximately 48 moles of iron. This fundamental process underpins much of quantitative chemistry, linking the microscopic world of atoms to the macroscopic quantities we handle in the lab and industry.

By mastering this conversion, chemists can accurately measure, prepare, and analyze substances, ensuring precision in experiments and industrial processes alike. Whether working with metals like iron or any other element, the principles remain consistent, emphasizing the importance of understanding the mole concept and Avogadro's number.

Keywords for SEO Optimization:

- Calculate moles of iron
- Atoms to moles conversion
- Avogadro's number
- Mole calculation example
- Iron atoms to grams
- Chemistry mole concepts
- Atomic quantity calculations
- Molar mass of iron
- Quantitative chemistry calculations
- Atomic-scale to bulk quantities

Frequently Asked Questions

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

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

What is the formula to find moles from atoms of a substance?

Moles = Number of atoms / Avogadro's number (6.022×10^{23}).

Given 2.89×10^{25} atoms of iron, how many moles are present?

Number of moles = $(2.89 \times 10^{25}) / (6.022 \times 10^{23}) \approx 47.97$ moles.

Why is Avogadro's number used in converting atoms to moles?

Avogadro's number provides the number of particles (atoms, molecules) in one mole, allowing conversion between atomic count and amount in moles.

What is the significance of calculating moles in chemistry?

Calculating moles helps chemists quantify substances, perform stoichiometric calculations, and understand chemical reactions accurately.

How accurate is the calculation of moles from atoms in this problem?

The calculation is precise as long as the given data and constants, like Avogadro's number, are accurate and correctly applied.

Can you convert the moles of iron to grams? How?

Yes, multiply the number of moles by the molar mass of iron (approximately 55.85 g/mol) to convert moles to grams.

What is the molar mass of iron used in calculations?

The molar mass of iron is approximately 55.85 grams per mole.

Is there a shortcut to estimate the moles from large atomic counts?

For very large numbers, approximate by dividing the exponent parts; in this case, 2.89×10^{25} divided by 6.022×10^{23} yields roughly 48 moles.

Additional Resources

Calculate the Number Of Moles Of Iron That Are Contained In 2.89×10^{25} Atoms Of Iron

Introduction

Understanding the relationship between atoms and moles is fundamental in chemistry, providing a bridge between the microscopic world of atoms and molecules and the macroscopic quantities we measure in laboratories. When dealing with a specific number of atoms, such as 2.89×10^{25} atoms of iron, chemists often need to convert this quantity into moles to facilitate calculations involving reactions, yields, and molar masses. This article provides a comprehensive overview of how to determine the number of moles in a given number of atoms, with a focus on iron, one of the most abundant and industrially significant metals.

The Concept of the Mole in Chemistry

What Is a Mole?

The mole (mol) is a fundamental SI unit in chemistry used to quantify the amount of substance. It is defined as the amount of substance that contains exactly 6.022×10^{23} elementary entities, such as atoms, molecules, ions, or electrons. This number is known as Avogadro's number.

Why Use the Mole?

Using the mole allows chemists to relate the microscopic scale of atoms and molecules to measurable quantities in the laboratory. Instead of counting individual atoms, which is impractical, chemists work with moles to express quantities that are manageable and meaningful in chemical reactions.

Understanding Atomic Counts and Moles

Atomic Count and Its Significance

When given a specific number of atoms, such as 2.89×10^{25} , the primary goal is to convert this count into moles, which can then be used to determine other properties like mass, volume, or participate in stoichiometric calculations.

The Conversion Process

The fundamental conversion from atoms to moles relies on Avogadro's number:

$$\text{Number of moles} = \frac{\text{Number of atoms}}{\text{Avogadro's number}}$$

Mathematically expressed as:

$$n = \frac{N}{N_A}$$

where:

- n = number of moles
- N = number of atoms
- N_A = Avogadro's number (6.022×10^{23})

Step-by-Step Calculation for Iron

Step 1: Identifying the Given Data

- Number of atoms of iron, $N = 2.89 \times 10^{25}$
- Avogadro's number, $N_A = 6.022 \times 10^{23}$

Step 2: Applying the Conversion Formula

$$n = \frac{2.89 \times 10^{25}}{6.022 \times 10^{23}}$$

Step 3: Performing the Calculation

Dividing the coefficients:

$$\frac{2.89}{6.022} \approx 0.48$$

Dividing the powers of ten:

$$10^{25} / 10^{23} = 10^2$$

Combining these:

$$n \approx 0.48 \times 10^2 = 0.48 \times 100 = 48$$

Result: The number of moles of iron contained in 2.89×10^{25} atoms is approximately 48 moles.

Significance of the Result

Practical Implications

Knowing that 2.89×10^{25} atoms of iron correspond to about 48 moles enables chemists and engineers to translate microscopic quantities into macroscopic, measurable amounts. For example, in industrial processes, this information helps determine the mass of iron required for a specific reaction or the amount of product formed.

Molar Mass of Iron and Mass Calculations

Given the molar mass of iron:

$$\begin{aligned} & \text{Atomic mass of iron} \approx 55.845 \text{ g/mol} \end{aligned}$$

The total mass of this amount of iron can be calculated as:

$$\begin{aligned} \text{Mass} &= n \times \text{molar mass} = 48 \text{ mol} \times 55.845 \text{ g/mol} \approx 2683 \text{ g} \end{aligned}$$

This substantial mass underscores the importance of understanding atomic-to-mole conversions for large-scale applications.

Broader Context and Applications

Moles in Chemical Reactions

Moles serve as a fundamental unit in balancing chemical equations and calculating reactant or product quantities. For example, if a reaction requires 2 moles of iron, knowing that 2.89×10^{25} atoms equate to approximately 48 moles helps determine how much raw material is needed.

Industrial and Environmental Significance

Iron, being crucial in construction, manufacturing, and biological systems, frequently involves calculations of atomic quantities. Accurate conversions facilitate efficient resource management, environmental impact assessments, and process optimization.

Limitations and Assumptions

While the calculation here assumes a pure sample of iron with no impurities, real-world samples may contain other elements or compounds. Nonetheless, the fundamental conversion remains valid, serving as a basis for more complex analyses.

Educational and Theoretical Insights

Teaching the Concept

Understanding how to convert atoms to moles is a cornerstone of introductory chemistry education. It illustrates the bridge between microscopic and macroscopic worlds, reinforcing the importance of fundamental constants like Avogadro's number.

Theoretical Significance

From a theoretical standpoint, such calculations exemplify the quantization of matter, the discrete nature of atoms, and the importance of constants in physical sciences. They also highlight the necessity of precise measurement and calculation in scientific progress.

Conclusion

Calculating the number of moles of a substance from a known number of atoms is a fundamental skill in chemistry, underpinning everything from laboratory experiments to industrial processes. In this case, the conversion of 2.89×10^{25} atoms of iron yields approximately 48 moles, a figure that bridges the microscopic atomic world with tangible quantities of material. This conversion not only exemplifies the practical application of fundamental constants like Avogadro's number but also demonstrates the

importance of quantitative reasoning in scientific inquiry. Mastery of such calculations empowers chemists to design experiments, optimize reactions, and interpret data with precision, further advancing our understanding of the material universe.

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