How To Calcular The Number Of Hydrogen Atoms In A 100g In A Sample Of Tetraborane B4h10?

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Understanding the composition of chemical compounds is fundamental in chemistry, especially when it comes to calculating the number of specific atoms within a given mass of a substance. Tetraborane (B_4H_{10}) is a notable boron-hydrogen compound with interesting structural and chemical properties. Whether you're a student preparing for exams, a researcher analyzing sample compositions, or an enthusiast exploring molecular calculations, knowing how to determine the number of hydrogen atoms in a specified mass of tetraborane is a valuable skill.

In this comprehensive guide, we will walk through the step-by-step process of calculating the number of hydrogen atoms in 100 grams of tetraborane (B_4H_{10}). We will cover fundamental concepts such as molar mass calculations, mole-to-atom conversions, and practical calculation techniques. By the end of this article, you'll be equipped with the knowledge to perform similar calculations for other compounds with confidence.

Understanding the Chemical Structure of Tetraborane (B_4H_{10})

What Is Tetraborane?

Tetraborane, with the chemical formula B_4H_{10}, is a boron hydride compound composed of four boron (B) atoms and ten hydrogen (H) atoms. It belongs to a class of compounds known as boranes, which are characterized by complex structures and unique bonding.

Structural Features

Tetraborane has a cage-like structure, often described as a distorted tetragonal pyramid. Its molecular structure influences its chemical reactivity and physical properties. The key point for calculations is understanding the molecular formula, which indicates the ratio of boron to hydrogen atoms: 4 boron atoms to 10 hydrogen atoms per molecule.

Step-by-Step Guide to Calculating the Number of

Hydrogen Atoms in 100g of Tetraborane

The calculation involves several steps:
1. Calculating the molar mass of tetraborane (B_4H_{10})
2. Determining the number of moles in 100 grams of B_4H_{10}
3. Calculating the total number of molecules in that mass
4. Using the molecular formula to find the total number of hydrogen atoms

Let's explore each step in detail.

1. Calculating the Molar Mass of B_4H_{10}

The molar mass is the sum of the atomic masses of all atoms in one molecule.

- Atomic mass of boron (B): approximately 10.81 g/mol
- Atomic mass of hydrogen (H): approximately 1.008 g/mol

Calculations:
- Boron contribution: 4 atoms × 10.81 g/mol = 43.24 g/mol
- Hydrogen contribution: 10 atoms × 1.008 g/mol = 10.08 g/mol

Total molar mass:
- 43.24 g/mol + 10.08 g/mol = 53.32 g/mol

2. Determining Moles in 100g of Tetraborane

Number of moles (n) is calculated by dividing the mass of the sample by the molar mass:

n = mass / molar mass

Given:
- Mass = 100 grams
- Molar mass = 53.32 g/mol

Calculation:
n = 100 g / 53.32 g/mol ≈ 1.876 mol

3. Calculating the Number of Molecules

Avogadro's number (NA) is approximately 6.022×10^{23} molecules per mole.

Number of molecules:
Number of molecules = n × NA

Calculation:
Number of molecules = 1.876 mol × 6.022×10^{23} molecules/mol ≈

$1.876 \times 6.022 \times 10^{23} \approx 1.13 \times 10^{24}$ molecules

4. Calculating the Total Number of Hydrogen Atoms

Since each molecule of B_4H_{10} contains 10 hydrogen atoms:

Total hydrogen atoms = number of molecules × 10

Calculation:
Total hydrogen atoms ≈ $1.13 \times 10^{24} \times 10 = 1.13 \times 10^{25}$ hydrogen atoms

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Summary of the Calculation Process

To summarize:
- Molar mass of B_4H_{10} = 53.32 g/mol
- Moles in 100g = approximately 1.876 mol
- Molecules in 100g = approximately 1.13×10^{24}
- Hydrogen atoms in 100g = approximately 1.13×10^{25}

This comprehensive approach provides an accurate estimation of how many hydrogen atoms are present in a 100-gram sample of tetraborane.

Additional Considerations and Tips

Using Precise Atomic Masses

For more precise calculations, consider using atomic masses from the latest IUPAC standards or scientific data sources, which might differ slightly from the rounded values used here.

Handling Other Masses

The same method can be applied to other masses. Simply adjust the initial mass value and repeat the steps to determine the corresponding number of hydrogen atoms.

Understanding the Importance of Units

Always keep track of units throughout the calculation process. Molar masses are in grams per mole, Avogadro's number is molecules per mole, and mass is in grams. Maintaining consistency ensures accurate results.

Applications of This Calculation in Real-World Scenarios

Calculating the number of atoms in a sample has several practical applications:
- Chemical Reactions: Determining reactant quantities for synthesis or analysis.
- Laboratory Experiments: Calculating molar ratios to optimize reactions.
- Material Science: Understanding the composition of boron hydrides for applications in energy storage, medicine, or materials engineering.
- Educational Purposes: Enhancing understanding of mole concept and atomic-scale calculations.

Conclusion

Understanding how to calculate the number of hydrogen atoms in a given mass of tetraborane (B_4H_{10}) is a fundamental skill that combines knowledge of molecular formulas, molar masses, and Avogadro's number. By following a systematic approach—calculating molar mass, determining moles, finding the total molecules, and then multiplying by the number of hydrogen atoms per molecule—you can accurately quantify atomic-scale details from macroscopic samples.

This process not only reinforces core chemical concepts but also empowers you to perform similar calculations for other compounds, facilitating deeper insights into chemical composition and reactions. Whether for academic, research, or practical purposes, mastering these calculations is essential for anyone involved in chemistry or related fields.

Keywords: tetraborane, B_4H_{10}, hydrogen atoms, molar mass, molecular calculation, atomic count, chemistry, mole concept, Avogadro's number, chemical analysis

Frequently Asked Questions

How do I determine the number of moles in 100g of tetraborane (B4H10)?

First, calculate the molar mass of B4H10: (4 × 10.81 g/mol for B) + (10 × 1.008 g/mol for H) = 4×10.81 + 10×1.008 = 43.24 + 10.08 = 53.32 g/mol. Then, divide 100 g by 53.32 g/mol: 100 / 53.32 ≈ 1.88 moles.

How many hydrogen atoms are present in 1 mole of B4H10?

Each molecule of B4H10 contains 10 hydrogen atoms. Therefore, 1 mole of B4H10 contains 10 moles of hydrogen atoms.

What is the total number of hydrogen atoms in 100g of B4H10?

First, find the moles of B4H10 in 100g (approximately 1.88 mol). Since each mole has 10 moles of H atoms, multiply 1.88 mol by 10: 1.88 × 10 = 18.8 mol of H atoms. Convert moles to atoms by multiplying by Avogadro's number (6.022×10^23): 18.8 × 6.022×10^23 ≈ 1.13×10^25 hydrogen atoms.

How do I convert moles of hydrogen atoms to the total number of atoms?

Multiply the number of moles by Avogadro's number (6.022×10^23 atoms/mol). For example, 18.8 mol of H atoms × 6.022×10^23 atoms/mol = approximately 1.13×10^25 atoms.

What steps are involved in calculating the number of hydrogen atoms in a given mass of tetraborane?

First, determine the molar mass of B4H10. Second, calculate the number of moles in the given mass by dividing the mass by the molar mass. Third, find the total moles of hydrogen atoms by multiplying the moles of B4H10 by 10. Fourth, convert moles of hydrogen atoms to atoms using Avogadro's number. The result is the total number of hydrogen atoms.

Additional Resources

Hydrogen Atoms Calculation in Tetraborane B4H10: An Expert Guide

When exploring the fascinating world of chemical compounds, understanding their molecular composition is fundamental. Tetraborane B_4H_{10}, a notable boron hydride, presents an intriguing case due to its unique structure and properties. For students, chemists, and enthusiasts alike, accurately calculating the number of hydrogen atoms in a given mass of tetraborane is an essential skill—whether for academic purposes, research, or practical applications. This comprehensive guide aims to walk you through the meticulous process of determining the number of hydrogen atoms in a 100-gram sample of tetraborane, combining foundational chemistry principles with detailed calculations.

Understanding Tetraborane B_4H_{10}: The Basics

Before delving into calculations, it’s crucial to understand the molecular makeup of tetraborane B_4H_{10}.

What Is Tetraborane?

Tetraborane B_4H_{10} is an inorganic boron hydride compound characterized by its distinctive structure comprising four boron atoms and ten hydrogen atoms. It belongs to a class of compounds known as boranes, which are known for their electron-deficient, cluster-like molecules. Tetraborane is notable for its

use in boron chemistry, rocket propellants, and as a precursor in the synthesis of more complex boron compounds.

Structural Overview

- The molecule typically adopts a distorted tetrahedral structure with boron atoms connected via bridging hydrogens.
- The hydrogens are distributed between terminal hydrogens (attached to individual boron atoms) and bridging hydrogens (shared between two boron atoms).

Molecular Formula and Molar Mass

- Molecular Formula: B_4H_{10}
- Molar Mass Calculation:
- Boron (B): approximately 10.81 g/mol
- Hydrogen (H): approximately 1.008 g/mol

Calculating the molar mass:

$$
\text{Molar mass of B}_4\text{H}_{10} = (4 \times 10.81) + (10 \times 1.008)
\\
= 43.24 + 10.08 = 53.32\, \text{g/mol}
$$

This figure is fundamental for converting mass to moles, which is the backbone of our calculation process.

Step-by-Step Guide to Calculating the Number of Hydrogen Atoms in 100g of Tetraborane

The process involves several core steps: determining moles of tetraborane in the sample, calculating the number of hydrogen atoms per mole, and then scaling to the total sample mass.

Step 1: Convert the Mass of the Sample to Moles of Tetraborane

Knowing the total mass of your sample (100 grams), the first step is to convert this to moles using the molar mass:

$$
\text{Moles of B}_4\text{H}_{10} = \frac{\text{Mass of sample}}{\text{Molar mass of B}_4\text{H}_{10}}
$$

Plugging in the known values:

$$
\[

$$
\text{Moles} = \frac{100\, \text{g}}{53.32\, \text{g/mol}} \approx 1.874\, \text{mol}
$$

This figure indicates that your sample contains approximately 1.874 moles of tetraborane molecules.

Step 2: Determine the Number of Hydrogen Atoms per Mole of Tetraborane

Each molecule of tetraborane contains 10 hydrogen atoms, as indicated by its molecular formula B_4H_{10}. Therefore, in one mole of tetraborane molecules, there are:

$$
10\, \text{hydrogen atoms} \times 1\, \text{mol} = 10\, \text{moles of hydrogen atoms}
$$

This is a crucial point—since the mole ratio of hydrogen atoms to tetraborane molecules is 10:1, one mole of tetraborane contains 10 moles of hydrogen atoms.

Step 3: Calculate Total Moles of Hydrogen Atoms in the Sample

Multiply the moles of tetraborane in your sample by the number of hydrogen atoms per molecule:

$$
\text{Moles of H} = 1.874\, \text{mol of B}_4\text{H}_{10} \times 10\, \text{mol of H per mol of B}_4\text{H}_{10} = 18.74\, \text{mol of H}
$$

This means your 100-gram sample contains approximately 18.74 moles of hydrogen atoms.

Step 4: Convert Moles of Hydrogen Atoms to Number of Atoms

Using Avogadro's number (6.022×10^{23} atoms/mol), convert moles of hydrogen into individual atoms:

$$
\text{Number of H atoms} = 18.74\, \text{mol} \times 6.022 \times 10^{23}\, \text{atoms/mol}
$$

Calculating this:

$$
\text{Number of H atoms} \approx 1.128 \times 10^{25}
$$

\]

Thus, in a 100-gram sample of tetraborane, there are approximately 1.128×10^{25} hydrogen atoms.

Additional Considerations and Practical Applications

Understanding this calculation provides a foundation for various practical scenarios, including:

- Material Synthesis: Knowing the hydrogen content is vital when using tetraborane in chemical syntheses or reactions where hydrogen transfer is involved.
- Safety and Handling: Precise knowledge of hydrogen content helps in assessing explosive or flammable risks, given hydrogen's flammable nature.
- Analytical Chemistry: This calculation aids in designing experiments, calibrating instruments, and verifying purity.

Summary of Calculation Process

To encapsulate, the process involves:

1. Determining molar mass of tetraborane (B_4H_{10}).
2. Converting the sample mass (100 g) into moles.
3. Using the molecular formula to find the molar ratio of hydrogen atoms.
4. Calculating total moles of hydrogen in the sample.
5. Converting moles of hydrogen to individual atoms via Avogadro's number.

Each step is grounded in fundamental chemistry principles and provides a clear pathway from raw data to meaningful results.

Final Thoughts: Why Precision Matters

Accurate calculations of molecular composition are essential in both academic and industrial settings. Whether you're preparing a laboratory experiment, assessing material safety, or conducting research, understanding how to compute the number of hydrogen atoms in a given mass of tetraborane is a vital skill. By following this detailed, step-by-step method, you ensure your work is precise, reliable, and scientifically sound.

In conclusion, calculating the number of hydrogen atoms in a 100-gram sample of tetraborane involves understanding the molecular structure, performing

molar conversions, and applying fundamental constants. This methodology not only demystifies the process but also enhances your overall grasp of chemical composition analysis, empowering you to tackle similar problems across a wide range of chemical compounds.

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