Consider A Sample Of Gas That Contains 850 Moles Of Smokestack Gas. How Many Molecules Of So2 Are Contained

Consider A Sample Of Gas That Contains 850 Moles Of Smokestack Gas. How Many Molecules Of SO_2 Are Contained

Understanding the relationship between moles and molecules is fundamental in chemistry, especially when dealing with gases emitted from industrial processes such as smokestacks. Smokestack gases often contain a mixture of pollutants, including sulfur dioxide (SO_2), which is a major contributor to acid rain and environmental pollution. Determining how many molecules of SO_2 are present in a given amount of smokestack gas is crucial for environmental monitoring, compliance with emission standards, and designing pollution control systems.

In this article, we will explore how to calculate the number of SO_2 molecules in a sample of smokestack gas containing 850 moles of total gas. We will break down the concepts involved, including the use of Avogadro's number, molar ratios, and related calculations, to provide a comprehensive understanding suitable for students, environmental scientists, and anyone interested in gas chemistry.

Understanding the Basics: Moles, Molecules, and Avogadro's Number

Before diving into the specific calculation, it is essential to review some fundamental concepts.

What Is a Mole?

- A mole is a standard unit in chemistry used to quantify the amount of a substance.
- One mole of any substance contains exactly 6.022×10^{23} particles (atoms, molecules, ions, etc.).
- This number is known as Avogadro's number.

Avogadro's Number

- Avogadro's number: 6.022×10^{23} particles/mole.
- It provides a bridge between the macroscopic scale (grams, liters) and the microscopic scale (individual molecules).

From Moles to Molecules

- To find how many molecules are in a given number of moles, multiply the number of moles by Avogadro's number:

Number of molecules = Moles × Avogadro's number

Breaking Down the Problem: Calculating SO_2 Molecules in the Smokestack Gas

Given:
- Total moles of smokestack gas = 850 mol
- The gas contains SO_2 molecules, but the problem does not specify the percentage or mole fraction of SO_2 in the mixture.

Key assumptions:
- For this calculation, we need to assume either:
1. The smokestack gas is pure SO_2 (100% SO_2), or
2. The mole fraction (i.e., the proportion of SO_2 in the gas mixture) is known.

Since the problem statement only gives total moles of smokestack gas, and asks for the number of SO_2 molecules, the most straightforward interpretation is that the entire 850 moles are SO_2 molecules.

If the problem intended to specify a different mole fraction or concentration, it would have provided that information. Without such data, the most logical assumption is that the sample consists entirely of SO_2 molecules.

Calculating the Number of SO_2 Molecules

Following the assumption that the entire 850 moles are SO_2 molecules, the calculation proceeds as follows:

Step 1: Apply Avogadro's Number

- Number of SO_2 molecules = 850 mol × 6.022×10^{23} molecules/mol

Step 2: Perform the Calculation

- Multiply:

$850 \times 6.022 \times 10^{23}$

- Let's compute this step-by-step:

1. Multiply 850 by 6.022:

$850 \times 6.022 = (850 \times 6) + (850 \times 0.022) = 5100 + 18.7 = 5118.7$

2. Append the power of ten:

$5118.7 \times 10^{23} = 5.1187 \times 10^{26}$ molecules

Final result:

The sample contains approximately 5.12×10^{26} molecules of SO_2.

Understanding the Significance of the Calculation

This calculation provides a quantitative measure of SO_2 molecules emitted from a smokestack, which is essential for:

- Environmental Impact Assessment: Knowing the number of SO_2 molecules helps evaluate the potential environmental damage caused by emissions.
- Regulatory Compliance: Many countries set limits on SO_2 emissions; understanding molecule counts helps in monitoring and ensuring compliance.
- Pollution Control Strategies: Designing scrubbers and other pollution control devices requires knowledge of the quantity of pollutants emitted.

Additional Considerations and Real-World Applications

While the calculation above assumes the entire smokestack gas is SO_2, real-world emissions are often a mixture of gases, including nitrogen oxides, carbon dioxide, water vapor, and SO_2. In such cases:

- The mole fraction of SO_2 in the mixture determines the actual number of SO_2 molecules.
- Calculating Mole Fraction:

If the total moles of gas are known, and the moles of SO_2 are known or measured, then:

Mole fraction of SO_2 = Moles of SO_2 / Total moles of gas

- The total number of SO_2 molecules would then be:

Number of SO_2 molecules = Moles of SO_2 × Avogadro's number

Example:

Suppose the smokestack gas contains 10% SO_2 by mole:

- Moles of SO_2 = 850 mol × 0.10 = 85 mol
- Number of SO_2 molecules = 85 mol × $6.022 \times 10^{23} \approx 5.12 \times 10^{25}$ molecules

This highlights how the composition of the gas significantly affects the number of specific molecules.

Conclusion

Calculating the number of molecules in a gas sample is a fundamental skill in chemistry and environmental science. In the scenario where a smokestack emits 850 moles of gas, and assuming the entire sample consists of SO_2 molecules, the total number of SO_2 molecules can be calculated by multiplying the moles by Avogadro's number.

Key takeaways:

- 1 mole of any substance contains 6.022×10^{23} particles.
- The total molecules of SO_2 in an 850-mole sample are approximately 5.12×10^{26} molecules.
- Real-world applications often require accounting for the gas composition, emphasizing the importance of molar ratios and mole fractions.

Understanding these calculations aids in environmental monitoring, regulatory compliance, and designing effective pollution mitigation strategies. Whether for academic purposes or practical applications, mastering the conversion from moles to molecules is a vital component of chemical literacy and environmental stewardship.

FAQs

Q1: What is the significance of knowing the number of SO_2 molecules emitted from a smokestack?
Knowing the number of SO_2 molecules helps assess environmental impacts, monitor pollution levels, and ensure compliance with emission standards.

Q2: How does the mole fraction of SO_2 affect the total number of molecules?
The mole fraction determines the proportion of SO_2 in the total gas mixture. A higher mole fraction results in more SO_2 molecules for the same total moles of gas.

Q3: Can this calculation be applied to other gases?
Yes, the same approach applies to any gas, provided you know the number of moles and the mole fraction of the specific gas.

Q4: Why is Avogadro's number important?

It provides a direct link between macroscopic quantities (like moles) and microscopic entities (molecules), enabling precise calculations in chemistry.

Q5: How accurate is this calculation in real-world scenarios?
In practice, the actual number depends on the precise composition of the gas mixture. The calculation assumes ideal conditions and known mole fractions.

References

- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Atkins, P., & de Paula, J. (2014). Physical Chemistry. Oxford University Press.
- U.S. Environmental Protection Agency (EPA). (2020). Emission Standards for Stationary Combustion Turbines.

Frequently Asked Questions

How do you calculate the number of SO_2 molecules in 850 moles of smokestack gas?

To find the number of SO_2 molecules, multiply the moles of gas by Avogadro's number (6.022×10^{23} molecules per mole).

What is the total number of SO_2 molecules in 850 moles of smokestack gas?

The total number is 850 moles × 6.022×10^{23} molecules/mole = 5.119×10^{26} molecules of SO_2.

If a sample contains 850 moles of smokestack gas, what assumptions are made about the composition for calculating SO_2 molecules?

It is assumed that all moles of the smokestack gas are SO_2 molecules or that the sample contains only SO_2 for the calculation to be accurate.

Why is Avogadro's number important in calculating molecules from moles?

Avogadro's number provides the number of molecules in one mole, allowing conversion from moles to individual molecules.

How can the calculation of molecules in a gas sample help in

environmental studies?

Determining the number of pollutant molecules like SO_2 helps assess emission levels and their potential environmental impact, aiding in regulation and mitigation efforts.

Additional Resources

Consider A Sample Of Gas That Contains 850 Moles Of Smokestack Gas. How Many Molecules Of SO_2 Are Contained

Understanding the relationship between moles of a substance and the number of molecules it contains is fundamental in chemistry, especially when dealing with gases. In this case, we are asked to analyze a sample of smokestack gas, which contains 850 moles, and determine the number of molecules of sulfur dioxide (SO_2) present within this sample. This problem provides an excellent opportunity to explore the core concepts of mole calculations, Avogadro's number, and the stoichiometry of gases, all of which are essential tools for chemists working in environmental science, industrial chemistry, and analytical chemistry.

Understanding the Concept of a Mole in Chemistry

Before diving into the calculations, it’s crucial to understand what a mole represents in chemistry. The mole is a fundamental unit used to quantify the amount of substance. One mole of any substance contains exactly 6.022×10^{23} particles—be they atoms, molecules, ions, or other entities. This number, known as Avogadro’s number, provides a bridge between the microscopic world of particles and the macroscopic quantities we can measure in the laboratory.

Key features of the mole:

- It standardizes measurements across different substances.
- It links mass, number of particles, and volume (for gases).
- It simplifies calculations involving large numbers of particles.

Calculating the Number of Molecules of SO_2 in the Sample

The problem states that the sample contains 850 moles of smokestack gas, and we need to determine how many molecules of SO_2 are present within this total. To proceed, we must clarify whether the entire sample is pure SO_2 or a mixture of various gases, including SO_2.

Assumption:

For simplicity, and because the problem specifically asks about SO_2 molecules, we assume that the entire 850 moles of smokestack gas are SO_2 molecules. If, in practice, the sample is a mixture, additional information such as the mole fraction of SO_2 would be necessary.

Step-by-step calculation:

1. Identify the known quantities:

- Total moles of gas = 850 mol
- Avogadro's number, N_A = 6.022×10^{23} molecules/mol

2. Calculate the total number of SO_2 molecules:

$$
\text{Number of molecules} = \text{moles} \times N_A
$$

$$
\text{Number of SO}_2\text{ molecules} = 850\, \text{mol} \times 6.022 \times 10^{23}\, \text{molecules/mol}
$$

3. Perform the multiplication:

$$
850 \times 6.022 \times 10^{23} = (850 \times 6.022) \times 10^{23}
$$

$$
850 \times 6.022 \approx 5,418.7
$$

Therefore,

$$
\text{Number of SO}_2\text{ molecules} \approx 5.4187 \times 10^{26}
$$

Final result:

The sample contains approximately 5.42 x 10^{26} molecules of SO_2.

Implications and Context of the Calculation

This calculation might seem straightforward, but it has several important implications in environmental and industrial contexts. Understanding the number of molecules of pollutants like SO_2 helps in quantifying emissions, designing scrubbers, and assessing environmental impact. Since SO_2

is a significant contributor to acid rain and respiratory problems, precise calculations are vital for regulatory compliance and pollution control.

Relevance in real-world applications:

- Environmental monitoring: Quantifying pollutant molecules helps regulate emissions and develop mitigation strategies.
- Industrial processes: Ensuring proper conversion and scrubbing of SO_2 during manufacturing.
- Health and safety: Assessing exposure risks based on molecule counts.

Factors That Influence the Accuracy of Such Calculations

While the calculation above provides a clear number, several factors can influence its accuracy and applicability:

Assumption of Purity

- The calculation assumes the entire sample is SO_2. In reality, smokestack gases are mixtures primarily of CO_2, SO_2, NOx, and other pollutants.
- If only a fraction of the total moles is SO_2, then the number of SO_2 molecules would be proportionally less.

Gas Composition Data

- To refine the calculation, knowing the mole fraction of SO_2 in the smokestack gas is essential. This data would allow for a more precise estimate.

Temperature and Pressure Conditions

- For gases, volume and pressure relationships are described by the ideal gas law. Although not directly needed for molecule count calculations, these factors influence gas sampling and measurement accuracy.

Understanding the Broader Context: Gas Laws and Mole Calculations

The calculation of molecules from moles is a fundamental application of the Avogadro’s Law, which states that equal volumes of gases at the same temperature and pressure contain an equal number of molecules. This principle underpins many stoichiometric calculations in chemistry.

Key concepts involved:

- Ideal Gas Law: \(PV = nRT \), relating pressure (P), volume (V), amount of gas in moles (n), the gas constant (R), and temperature (T).
- Mole Fraction: the ratio of moles of a specific component to total moles in a mixture.
- Conversion Factors: using known constants like Avogadro’s number to bridge between moles and molecules.

Pros and Cons of Mole-Based Calculations in Environmental Chemistry

Pros:

- Provides a standardized way to quantify large numbers of particles.
- Facilitates conversions between mass, volume, and number of molecules.
- Essential for understanding chemical reactions, pollutant dispersion, and emissions.

Cons:

- Assumes ideal behavior, which may not always be accurate under high pressure or low temperature.
- Requires precise knowledge of gas composition; assumptions can lead to inaccuracies.
- Sometimes oversimplifies complex mixtures or reactions in real-world scenarios.

Conclusion

In summary, the question of how many molecules of SO_2 are contained in a sample of 850 moles of smokestack gas is a classic example of applying basic stoichiometric principles and Avogadro’s number. Assuming the entire sample consists of SO_2, the number of molecules is approximately 5.42 x 10^{26}. This calculation underscores the importance of understanding mole concepts, gas laws, and the composition of mixtures, especially in environmental contexts where pollutant quantification is critical. While straightforward in theory, practical applications often require additional data and considerations to ensure accuracy and relevance. Mastery of these fundamental concepts enables chemists and environmental scientists to perform precise assessments, design effective mitigation strategies, and contribute to safeguarding environmental and public health.

Consider A Sample Of Gas That Contains 850 Moles Of Smokestack Gas How Many Molecules Of So2 Are Contained

Consider A Sample Of Gas That Contains 850 Moles Of Smokestack Gas How Many Molecules Of So2 Are Contained

Related Articles

- Data Gathered On The Shopping Patterns During The Months Of April And May Of High School Students Fropeanut
- For Financial Reporting Purposes, The Total Amount Of Product Costs Incurred To Make 4,000 Units Is Closest
- Suppose You Sell A Three-month Forward Contract At $35. One Month Later, New Forward Contracts With Similar

Back to Home