1. How Many Molecules Of Phosphorus Pentachloride Are Present In 8.70 Grams Of This Compound ? Molecules.

1. How Many Molecules Of Phosphorus Pentachloride Are Present In 8.70 Grams Of This Compound ? Molecules.

Understanding the number of molecules in a given mass of a chemical compound is fundamental in chemistry, especially when dealing with molecular calculations, stoichiometry, and reaction mechanisms. In this article, we will explore how to determine the number of molecules present in 8.70 grams of phosphorus pentachloride (PCl_5), a widely studied chemical compound used in various industrial processes. We will walk through the necessary calculations, concepts involved, and provide a clear understanding for students and enthusiasts alike.

Introduction to Phosphorus Pentachloride (PCl_5)

Phosphorus pentachloride is an inorganic compound with the chemical formula PCl_5. It appears as a colorless, crystalline solid at room temperature and is known for being a strong chlorinating agent used in organic synthesis and chemical manufacturing.

Properties of PCl_5:

- Molecular weight: approximately 208.2 g/mol
- Structure: PCl_5 adopts a trigonal bipyramidal shape
- Physical state: solid at room temperature
- Solubility: reacts vigorously with water, releasing hydrochloric acid (HCl) and phosphoric acid derivatives

Understanding the molar mass of PCl_5 is crucial for calculating the number of molecules present in a given mass.

Fundamental Concepts for Calculation

Before delving into the calculations, it is essential to understand the basic concepts involved:

Molar Mass

- The molar mass of a compound is the mass of one mole of its molecules in

grams.
- It is calculated by summing the atomic masses of all atoms in the molecular formula.

Mole

- A mole (mol) is a standard unit in chemistry that represents 6.022×10^{23} particles (Avogadro's number).

Number of Molecules

- To find the number of molecules in a given mass, the sequence involves calculating the number of moles first, then multiplying by Avogadro’s number:

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

where $N_A = 6.022 \times 10^{23}$ molecules/mol.

Step-by-Step Calculation

Let's proceed step by step to find out how many molecules of PCl_5 are present in 8.70 grams of the compound.

Step 1: Determine the molar mass of PCl_5

The molar mass is calculated based on atomic weights:

- Phosphorus (P): approximately 30.97 g/mol
- Chlorine (Cl): approximately 35.45 g/mol

Since PCl_5 contains 1 phosphorus atom and 5 chlorine atoms:

$$
\text{Molar mass of PCl}_5 = 30.97 + (5 \times 35.45) = 30.97 + 177.25 = 208.22\, \text{g/mol}
$$

For simplicity, we can use 208.2 g/mol as an approximate molar mass.

Step 2: Calculate the number of moles in 8.70 grams

of PCl_5

Using the formula:

$$
\text{Moles} = \frac{\text{Mass}}{\text{Molar mass}}
$$

$$
\text{Moles} = \frac{8.70\, \text{g}}{208.2\, \text{g/mol}} \approx 0.04175\, \text{mol}
$$

Step 3: Calculate the number of molecules

Multiply the number of moles by Avogadro's number:

$$
\text{Number of molecules} = 0.04175\, \text{mol} \times 6.022 \times 10^{23}\, \text{molecules/mol}
$$

$$
\text{Number of molecules} \approx 2.514 \times 10^{22}
$$

Thus, approximately 2.514 x 10^{22} molecules of PCl_5 are present in 8.70 grams of the compound.

Additional Considerations and Practical Applications

Understanding how to convert mass to molecules is vital in various chemical contexts:

1. Stoichiometry and Reaction Calculations

- Knowing the number of molecules allows chemists to predict yields, reactant ratios, and product formation.

2. Chemical Manufacturing

- Precise molecular counts help in scaling reactions from lab to industrial scale, ensuring safety and efficiency.

3. Analytical Chemistry

- Techniques such as mass spectrometry rely on molecular counts for identification and quantification.

Common Misconceptions and Pitfalls in Molecular Calculations

While the calculations seem straightforward, several common errors can occur:

- **Using incorrect molar mass:** Always verify atomic weights from a reliable source and include all atoms in the molecular formula.
- **Misinterpreting units:** Ensure mass is in grams, molar mass in g/mol, and use consistent units throughout.
- **Forgetting Avogadro's number:** It is critical to multiply the moles by 6.022×10^{23} to get the number of molecules.
- **Rounding errors:** Use adequate significant figures to maintain precision, especially in scientific calculations.

Summary

Calculating the number of molecules in a given mass of a compound involves understanding molar mass, converting mass to moles, and then multiplying by Avogadro's number. For 8.70 grams of phosphorus pentachloride, the process yields approximately 2.514×10^{22} molecules.

This calculation not only exemplifies fundamental chemical principles but also highlights their importance in practical applications across research, industry, and education. Mastery of these concepts enables chemists to manipulate and understand matter at the molecular level effectively.

Final Thoughts

Accurate molecular calculations are the backbone of quantitative chemistry. Whether you are preparing reactions, analyzing compounds, or designing new materials, understanding the relationship between mass, moles, and molecules is essential. The process demonstrated here for phosphorus pentachloride can be adapted to any chemical compound, making it a vital skill for students and

professionals in chemistry.

Remember: Always verify atomic masses, use consistent units, and perform calculations carefully to obtain precise and reliable results.

Frequently Asked Questions

How do you calculate the number of molecules in a given mass of phosphorus pentachloride?

First, find the molar mass of PCl_5, convert the given mass to moles by dividing by this molar mass, and then multiply by Avogadro's number to get the number of molecules.

What is the molar mass of phosphorus pentachloride (PCl_5)?

The molar mass of PCl_5 is approximately 208.2 g/mol, calculated as 30.97 (P) + 5 × 35.45 (Cl).

How many moles are present in 8.70 grams of PCl_5?

Number of moles = 8.70 g ÷ 208.2 g/mol ≈ 0.04175 mol.

What is Avogadro's number, and how is it used in this calculation?

Avogadro's number is approximately 6.022×10^{23} molecules/mol. It is used to convert moles to molecules by multiplying the number of moles by this constant.

How many molecules of PCl_5 are in 8.70 grams of the compound?

Number of molecules = 0.04175 mol × 6.022×10^{23} molecules/mol ≈ 2.51×10^{22} molecules.

Why is it important to know the molar mass when calculating molecules from mass?

Because molar mass allows you to convert grams to moles, which directly relates to the number of molecules via Avogadro's number.

Can this method be used for any compound to find the number of molecules in a given mass?

Yes, as long as you know the compound's molar mass, you can calculate the number of molecules from any given mass using the same approach.

What is the significance of calculating the number of molecules in a chemical compound?

It helps in understanding the scale of atomic and molecular interactions, stoichiometry calculations, and in applying molecular-level concepts in chemistry.

Additional Resources

Phosphorus Pentachloride—a crucial reagent in organic synthesis and industrial chemistry—has long been a subject of scientific interest due to its unique chemical properties and versatile applications. Understanding its molecular composition, especially in terms of the number of molecules present in a given mass, is fundamental for chemists and students alike. In this detailed exploration, we will analyze the question: How many molecules of phosphorus pentachloride are present in 8.70 grams of this compound? We will walk through the calculations step-by-step, explaining the underlying principles and offering insights into the importance of such computations in chemistry.

Understanding the Basics: What Is Phosphorus Pentachloride?

Phosphorus pentachloride, with the chemical formula PCl_5, is an inorganic compound composed of one phosphorus atom bonded to five chlorine atoms. It appears as a colorless to white crystalline solid that readily reacts with water, releasing hydrogen chloride and phosphoric acids. Its role in chemical synthesis often involves chlorination reactions, serving as a chlorinating agent for organic compounds, and as a reagent in the preparation of other phosphorus chlorides.

Key properties:

- Molecular formula: PCl_5
- Molecular weight: Approximately 208.2 g/mol
- Physical state: Solid at room temperature
- Reactivity: Reacts vigorously with water and moisture

The Core Question: How Many Molecules in 8.70 Grams?

Before calculating the number of molecules, it is essential to grasp the foundational concepts:

- Mole: A fundamental SI unit in chemistry representing Avogadro's number of particles (atoms, molecules, ions, etc.).
- Avogadro's number: Approximately 6.022×10^{23} particles per mole.

Given a specific mass of a substance, calculating the number of molecules involves:

1. Determining the number of moles in that mass.
2. Multiplying the number of moles by Avogadro's number to get the total molecules.

Step 1: Calculating Moles of Phosphorus Pentachloride in 8.70 g

The first step is to find the number of moles contained in 8.70 grams of PCl_5.

The formula:

$$
\text{Number of moles} (n) = \frac{\text{Mass of sample} (m)}{\text{Molecular weight} (M)}
$$

Given data:

- $m = 8.70\, \text{g}$
- $M (PCl_5) \approx 208.2\, \text{g/mol}$

Calculation:

$$
n = \frac{8.70\, \text{g}}{208.2\, \text{g/mol}} \approx 0.04175\, \text{mol}
$$

This means that 8.70 grams of PCl_5 contains approximately 0.04175 moles of molecules.

Step 2: Calculating the Number of Molecules

Now, to find the total number of molecules, multiply the moles by Avogadro's number:

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

Where:

- $N_A = 6.022 \times 10^{23}$

Calculation:

$$
\text{Number of molecules} = 0.04175\, \text{mol} \times 6.022 \times 10^{23}\, \text{molecules/mol}
$$

$$
= 2.513 \times 10^{22}\, \text{molecules}
$$

Therefore, in 8.70 grams of phosphorus pentachloride, there are approximately $\boxed{2.51 \times 10^{22}}$ molecules.

Understanding the Implications and Significance

This calculation is more than a number—it's a window into the microscopic world of chemistry. Knowing that just 8.70 grams of PCl_5 contains roughly 2.5×10^{22} molecules highlights the staggering scale at which chemical processes occur. Such insights are essential for:

- Stoichiometry: Precise measurement of reactants and products.
- Industrial applications: Ensuring proper quantities for chemical manufacturing.
- Research and development: Designing experiments with accurate molar ratios.
- Educational purposes: Demonstrating the scale of molecular interactions.

Additional Considerations and Tips for Accurate Calculations

When performing such calculations, keep in mind the following:

1. Use precise molecular weights:
Always refer to the most current atomic weights from reliable sources, considering isotopic variations if necessary.

2. Maintain unit consistency:
Ensure that mass is in grams, molecular weight in g/mol, and Avogadro's number is correctly applied.

3. Significant figures:
Round your final answer to an appropriate number of significant figures, based on the precision of the given data (here, 3 significant figures).

4. Practical applications:
Understanding the relationship between mass, moles, and molecules aids in laboratory work, quality control, and scaling reactions.

Summary

- Molecular weight of PCl_5: approximately 208.2 g/mol
- Mass of sample: 8.70 g
- Moles of PCl_5 in 8.70 g: approximately 0.04175 mol
- Number of molecules in 8.70 g: approximately 2.51×10^{22} molecules

This comprehensive calculation illustrates how fundamental concepts like molar mass and Avogadro's number enable chemists to quantify entities at the molecular level. Whether for academic pursuits or practical applications, mastering these calculations is vital for a deep understanding of chemical phenomena.

In conclusion, from the initial mass measurement to the microscopic count of molecules, the journey underscores the elegance of chemistry—bridging the macroscopic world with the microscopic universe. Phosphorus pentachloride's molecular count in a given sample exemplifies how fundamental constants and formulas empower scientists to quantify and manipulate matter with precision

and confidence.

1 How Many Molecules Of Phosphorus Pentachloride Are Present In 8 70 Grams Of This Compound Molecules

1 How Many Molecules Of Phosphorus Pentachloride Are Present In 8 70 Grams Of This Compound Molecules

Related Articles

- The CEO Of Tough Mudder Believes That Teams In His Company Are Not Working As Effectively As They Could,
- WILL MARK BRAINLIESTHannah And John Made Capital Contributions Of $50,000 Each To Their Law Firm. During
- 1. Heat Opens Capillaries And Improves Blood Flow. The Reverse Is True Too: Cold Capillaries Close. Thus,

Back to Home