How Many H Atoms Are In 17.5 G (NH4)2C2O4?

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Understanding the number of hydrogen (H) atoms in a given mass of a compound like ammonium oxalate, $(NH_4)_2C_2O_4$, involves a combination of chemical formulas, molar mass calculations, and basic stoichiometry principles. This type of problem is common in chemistry, especially when dealing with molar conversions, and is fundamental for students and professionals who work with chemical reactions, formulations, or laboratory measurements. In this article, we will explore step-by-step how to determine the number of hydrogen atoms in 17.5 grams of $(NH_4)_2C_2O_4$, providing detailed explanations, calculations, and relevant background information.

Understanding the Compound: $(NH_4)_2C_2O_4$

Before diving into calculations, it is essential to understand the chemical structure and composition of ammonium oxalate.

What is $(NH_4)_2C_2O_4$?

- Chemical Formula: $(NH_4)_2C_2O_4$
- Common Name: Ammonium oxalate
- Type of Compound: Organic salt, often used in laboratory settings, analytical chemistry, and as a standard in titrations.

Components of $(NH_4)_2C_2O_4$

The formula indicates that:

- There are 2 ammonium ions (NH_4^+)
- There is 1 oxalate ion ($C_2O_4^{2-}$)

The structure can be viewed as:

$(NH_4)_2 + C_2O_4$

Breaking down the components:

- Ammonium ion (NH_4^+):
- Contains 1 nitrogen atom and 4 hydrogen atoms
- Oxalate ion ($C_2O_4^{2-}$):
- Contains 2 carbon atoms and 4 oxygen atoms

The key point for our calculation is the hydrogen content, which comes exclusively from the ammonium ions.

Molar Mass of $(NH_4)_2C_2O_4$

Calculating the molar mass (molecular weight) of $(NH_4)_2C_2O_4$ is crucial for converting grams to moles.

Atomic masses (approximate):

- Hydrogen (H): 1.008 g/mol
- Nitrogen (N): 14.01 g/mol
- Carbon (C): 12.01 g/mol
- Oxygen (O): 16.00 g/mol

Calculations:

1. Ammonium ion (NH_4^+):

- N: 14.01 g/mol
- H: 4 × 1.008 = 4.032 g/mol

- Total for NH_4^+: 14.01 + 4.032 = 18.042 g/mol

2. Two ammonium ions: $(NH_4)_2$

- 2 × 18.042 = 36.084 g/mol

3. Oxalate ion ($C_2O_4^{2-}$):

- 2 × C: 2 × 12.01 = 24.02 g/mol
- 4 × O: 4 × 16.00 = 64.00 g/mol

- Total for $C_2O_4^{2-}$: 24.02 + 64.00 = 88.02 g/mol

4. Total molar mass of $(NH_4)_2C_2O_4$:

- 36.084 + 88.02 = 124.104 g/mol

For simplicity, we can round this to 124.10 g/mol.

Calculating the Number of Moles in 17.5 g of $(NH_4)_2C_2O_4$

Knowing the molar mass allows us to convert grams into moles:

$$
\text{Number of moles} = \frac{\text{mass in grams}}{\text{molar mass in g/mol}}
$$

\]

Applying this:

\[
\text{Moles of } (NH_4)_2C_2O_4 = \frac{17.5\, \text{g}}{124.10\, \text{g/mol}} \approx 0.141\, \text{mol}
\]

This value indicates that 17.5 grams of ammonium oxalate contains approximately 0.141 moles of the compound.

Determining the Number of Hydrogen Atoms

Since each $(NH_4)_2C_2O_4$ molecule contains hydrogen atoms only within the ammonium ions, we focus on the hydrogen content in the compound.

Number of hydrogen atoms per molecule

- Each ammonium ion (NH_4^+) contains 4 hydrogen atoms.
- There are 2 ammonium ions per molecule of $(NH_4)_2C_2O_4$.

\[
\text{Hydrogen atoms per molecule} = 2 \times 4 = 8
\]

Thus, each molecule of ammonium oxalate contains 8 hydrogen atoms.

Calculating total hydrogen atoms in 17.5 g

- Total molecules in 0.141 mol:

\[
\text{Number of molecules} = 0.141\, \text{mol} \times (6.022 \times 10^{23}\, \text{molecules/mol}) \approx 8.498 \times 10^{22}
\]

- Total hydrogen atoms:

\[
\text{Hydrogen atoms} = \text{Number of molecules} \times 8
\]

\[
8.498 \times 10^{22} \times 8 \approx 6.799 \times 10^{23}
\]

Therefore, there are approximately 6.80×10^{23} hydrogen atoms in 17.5 grams of $(NH_4)_2C_2O_4$.

Summary of the Calculation Steps

To summarize, the process involves:

1. Understanding the chemical formula and identifying the components contributing to hydrogen content.
2. Calculating the molar mass of the compound.
3. Converting the given mass (17.5 g) into moles using molar mass.
4. Determining the number of molecules from moles using Avogadro's number.
5. Calculating the total number of hydrogen atoms by multiplying the number of molecules by the number of hydrogen atoms per molecule.

Additional Insights and Related Calculations

How many hydrogen atoms are in 1 mole of $(NH_4)_2C_2O_4$?

Since each molecule contains 8 hydrogen atoms:

$$
\text{Hydrogen atoms per mole} = 8 \times \text{Avogadro's number} \approx 8 \times 6.022 \times 10^{23} = 4.818 \times 10^{24}
$$

How does changing the mass affect the number of hydrogen atoms?

- The relationship is directly proportional: doubling the mass doubles the number of hydrogen atoms, tripling it triples, and so on.

Practical applications

- Knowing the number of hydrogen atoms can be useful in stoichiometry calculations, determining the amount of reactants needed, or assessing the extent of chemical reactions involving ammonium salts.

Conclusion

Calculating the number of hydrogen atoms in a specific mass of $(NH_4)_2C_2O_4$ involves understanding the compound's chemical structure, performing molar mass calculations, and applying basic stoichiometry principles. In the case of 17.5 grams of ammonium oxalate, the total hydrogen atoms amount to approximately 6.80×10^{23}. This process illustrates the fundamental concepts of chemical quantification, which are vital for accurate laboratory work, chemical manufacturing, and scientific research.

References

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- Atkins, P., & de Paula, J. (2014). Atkins' Physical Chemistry. Oxford University Press.
- Lide, D. R. (Ed.). (2004). CRC Handbook of Chemistry and Physics. CRC Press.

Note: All calculations are approximate and rounded to ensure clarity. For precise work, use exact atomic weights and constants as needed.

Frequently Asked Questions

How many hydrogen atoms are present in 17.5 g of (NH4)2C2O4?

There are 56 hydrogen atoms in 17.5 g of (NH4)2C2O4.

What is the molar mass of (NH4)2C2O4?

The molar mass of (NH4)2C2O4 is approximately 124.12 g/mol.

How do you calculate the number of moles in 17.5 g of (NH4)2C2O4?

Number of moles = 17.5 g ÷ 124.12 g/mol ≈ 0.141 moles.

How many total atoms are in one molecule of (NH4)2C2O4?

One molecule of (NH4)2C2O4 contains 2 nitrogen, 8 hydrogen, 2 carbon, and 4 oxygen atoms, totaling 16 atoms.

How many (NH4)2C2O4 molecules are in 17.5 g?

There are approximately 0.141 moles, which equals about 8.56 × 10^22 molecules.

How many total hydrogen atoms are in 17.5 g of (NH4)2C2O4?

There are approximately 56 hydrogen atoms in 17.5 g of (NH4)2C2O4.

What is the significance of calculating the number of H atoms in this compound?

It helps determine the compound's composition, molar relationships, and is

useful in stoichiometry calculations for reactions involving (NH4)2C2O4.

Can you explain the step-by-step process to find the number of H atoms in 17.5 g of (NH4)2C2O4?

First, find the molar mass of the compound; then calculate the number of moles in 17.5 g; next, determine the number of molecules using Avogadro's number; finally, multiply the number of molecules by the number of H atoms per molecule to get the total H atoms.

Additional Resources

How Many H Atoms Are In 17.5 G $(NH_4)_2C_2O_4$? – An In-Depth Chemical Analysis

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Introduction

Understanding the number of atoms within a compound is fundamental in chemistry, especially when translating between mass, moles, and atomic counts. When dealing with compounds like ammonium oxalate, $(NH_4)_2C_2O_4$, it becomes crucial to understand how the constituent atoms, particularly hydrogen (H), are present in a given mass. This detailed exploration aims to elucidate the process by which one can determine the number of hydrogen atoms in 17.5 grams of $(NH_4)_2C_2O_4$, including the necessary concepts, calculations, and considerations involved.

Understanding the Chemical Formula: $(NH_4)_2C_2O_4$

Before diving into calculations, it’s important to interpret the chemical formula accurately:

- $(NH_4)_2C_2O_4$ comprises:
- 2 ammonium ions (NH_4^+)
- 1 oxalate ion ($C_2O_4^{2-}$)

This composition indicates the number of atoms in each molecule:

- Nitrogen (N): 2 atoms (from 2 NH_4^+ ions)
- Hydrogen (H): 8 atoms (from 2 × 4 H in NH_4^+)
- Carbon (C): 2 atoms (from C_2O_4)
- Oxygen (O): 4 atoms (from O_4)

Our focus here is hydrogen, which is present as part of the ammonium ions.

Calculating Molar Mass of $(NH_4)_2C_2O_4$

To determine the number of hydrogen atoms in a specific mass, the first step is to compute the molar mass of the compound, which allows us to convert grams to moles.

Atomic masses (approximate, in atomic mass units - amu):

- Hydrogen (H): 1.008 g/mol
- Nitrogen (N): 14.01 g/mol
- Carbon (C): 12.01 g/mol
- Oxygen (O): 16.00 g/mol

Calculating molar mass:

1. Nitrogen contribution:
2 N atoms: 2 × 14.01 = 28.02 g/mol

2. Hydrogen contribution:
8 H atoms: 8 × 1.008 = 8.064 g/mol

3. Carbon contribution:
2 C atoms: 2 × 12.01 = 24.02 g/mol

4. Oxygen contribution:
4 O atoms: 4 × 16.00 = 64.00 g/mol

Total molar mass:
28.02 + 8.064 + 24.02 + 64.00 = 124.104 g/mol

Converting Mass to Moles

Given mass of the compound: 17.5 grams

Using the molar mass:

$$
\text{Number of moles} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{17.5\, \text{g}}{124.104\, \text{g/mol}} \approx 0.141 \text{ mol}
$$

This value tells us how many moles of $(NH_4)_2C_2O_4$ are present.

Determining the Number of Hydrogen Atoms

Now that we know the moles of the compound, we can determine the number of hydrogen atoms by following these steps:

Step 1: Find moles of hydrogen atoms

Each molecule of $(NH_4)_2C_2O_4$ contains 8 hydrogen atoms. Therefore:

$$
\text{Moles of H atoms} = \text{Moles of compound} \times 8
$$

$$
= 0.141 \text{ mol} \times 8 = 1.128 \text{ mol of H atoms}
$$

Step 2: Convert moles of H to number of atoms

Using Avogadro's number (6.022×10^{23} atoms/mol):

$$
\text{Number of H atoms} = 1.128 \text{ mol} \times 6.022 \times 10^{23} \text{ atoms/mol}
$$

$$
= 6.796 \times 10^{23} \text{ atoms}
$$

Thus, approximately 6.80×10^{23} hydrogen atoms are present in 17.5 grams of $(NH_4)_2C_2O_4$.

Additional Considerations and Clarifications

While the calculation above provides a clear pathway, there are several nuances and factors worth exploring to deepen understanding.

1. Purity of the Sample

- The calculation assumes 100% purity of $(NH_4)_2C_2O_4$.
- In real-world scenarios, impurities or hydration (water molecules attached) could alter the molar mass, thus affecting the count.
- If the compound is hydrated (e.g., $(NH_4)_2C_2O_4 \cdot H_2O$), the molar mass increases, changing the number of hydrogen atoms per given mass.

2. Hydration and Its Effect

- Hydrated salts are common; for example, if the compound is monohydrate, molar mass increases by approximately 18 g/mol.
- For accurate calculations, always verify the actual form of the compound.

3. Significance of Atomic Counts

- The number of hydrogen atoms is directly proportional to the number of moles of the compound.
- This concept applies universally to any element in a compound, making molar mass and atomic ratios fundamental tools in chemistry.

4. Application in Laboratory Settings

- Quantitative analysis often involves calculating atom counts to determine yields, purity, or reaction completeness.
- Knowing the number of hydrogen atoms helps in stoichiometry calculations, especially in reactions involving hydrogen transfer or consumption.

5. Implications in Molecular Biology and Pharmacology

- Precise knowledge of atomic composition influences synthesis, drug design, and understanding biochemical pathways.
- For example, hydrogen atoms are key in hydrogen bonding, affecting molecular interactions.

Alternative Approaches and Related Calculations

In addition to the straightforward method outlined above, there are other calculations and approaches that can be useful:

1. Using Mass Percentages

- Calculate the percentage of hydrogen in the compound:

$$
\% \text{H} = \frac{\text{Mass of H in 1 mol}}{\text{Molar mass of compound}} \times 100
$$

$$
= \frac{8.064\, \text{g}}{124.104\, \text{g}} \times 100 \approx 6.5\%
$$

- Then, multiply the total mass (17.5 g) by this percentage to get the mass

of hydrogen, and convert to atoms.

2. Using Empirical Formulas and Ratios

- For more complex compounds or mixtures, empirical formulas help simplify calculations.

3. Extending to Other Elements

- Similar methods can be used to find counts of carbon, oxygen, nitrogen, and other atoms, enabling comprehensive molecular analysis.

Summary of Key Steps and Findings

- Determine molar mass of $(NH_4)_2C_2O_4$: approximately 124.10 g/mol.
- Calculate moles of compound in 17.5 g: approximately 0.141 mol.
- Identify hydrogen atoms per molecule: 8.
- Calculate moles of hydrogen atoms: approximately 1.128 mol.
- Convert moles to atoms: approximately 6.80×10^{23} atoms.

This systematic approach ensures accurate quantification of hydrogen atoms in the given mass of ammonium oxalate.

Conclusion

Understanding the number of hydrogen atoms in a compound like $(NH_4)_2C_2O_4$ is a fundamental aspect of chemical stoichiometry. Through careful calculation—starting from the molar mass, converting grams to moles, and utilizing Avogadro's number—we can precisely determine that approximately 6.80×10^{23} hydrogen atoms are contained within 17.5 grams of this compound. This process exemplifies core principles in chemistry, including molar calculations, atomic ratios, and the importance of molecular formulas. Whether applied in research, education, or industrial contexts, mastery of these concepts empowers chemists to analyze and manipulate chemical substances with confidence and accuracy.

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