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Understanding the percent composition of a chemical compound is fundamental in chemistry, as it provides insight into the relative amounts of each element within a sample. In this article, we will explore how to determine the percent composition of a 16.75 g sample of a compound that contains 14.02 g of oxygen and 2.73 g of another element—likely a metal or non-metal depending on the compound's nature. By the end of this guide, you'll have a comprehensive understanding of how to calculate percent composition, its significance, and its applications in various chemical analyses.

What Is Percent Composition in Chemistry?

Percent composition refers to the percentage by mass of each element in a compound. It allows chemists to understand the elemental makeup and deduce the empirical formula of a compound. This information is crucial in various fields, including pharmaceuticals, materials science, and chemical manufacturing, where precise knowledge of molecular composition influences the synthesis, quality control, and reaction mechanisms.

Key Points About Percent Composition:

- It is expressed as a percentage.
- Calculated using the mass of each element divided by the total mass of the compound.
- Essential for determining empirical and molecular formulas.

Given Data and Objective

Let's first clarify the data provided:

- Total mass of the sample: 16.75 g
- Mass of oxygen in the sample: 14.02 g
- Mass of the other element (let's denote it as element X): 2.73 g

Our goal is to find the percent composition of each element in the sample, primarily focusing on:

- Percent of oxygen
- Percent of element X

Additionally, we can verify the total percentage sum and discuss implications.

Step-by-Step Calculation of Percent Composition

To determine the percent composition, we'll follow these steps:

1. Identify the masses of each element.
2. Calculate the percentage of each element by dividing its mass by the total sample mass.
3. Express the result as a percentage.

Let's perform these calculations.

1. Masses of Elements

- Oxygen: 14.02 g

- Element X: 2.73 g
- Total: 16.75 g (given, but also verify sum)

Check if the sum of the masses of oxygen and element X equals the total:

$$14.02 \text{ g} + 2.73 \text{ g} = 16.75 \text{ g}$$

Yes, it matches the total sample mass, confirming the data's consistency.

2. Calculating Percentages

Percent of Oxygen:

$$\% \text{ Oxygen} = \left(\frac{\text{Mass of Oxygen}}{\text{Total Mass}} \right) \times 100$$

$$= \left(\frac{14.02 \text{ g}}{16.75 \text{ g}} \right) \times 100 \approx 83.69\%$$

Percent of Element X:

$$\% \text{ Element X} = \left(\frac{\text{Mass of Element X}}{\text{Total Mass}} \right) \times 100$$

$$= \left(\frac{2.73 \text{ g}}{16.75 \text{ g}} \right) \times 100 \approx 16.31\%$$

Summary:

Element	Mass (g)	Percent Composition (%)
-----	-----	-----
Oxygen	14.02	83.69
Element X	2.73	16.31

The total of these percentages sums to approximately 100%, confirming the calculations' correctness.

Interpreting the Percent Composition Data

Knowing that oxygen constitutes about 83.69% of the sample indicates that oxygen is the predominant element in this compound. Conversely, element X makes up roughly 16.31%. This information can be used to determine the empirical formula of the compound, which reflects the simplest whole-number ratio of the elements.

Determining the Empirical Formula

The empirical formula provides the ratio of moles of elements in a compound. To derive it:

1. Convert the masses into moles by dividing by atomic masses.
2. Find the simplest whole-number ratio of these moles.

Let's proceed with this process, assuming element X is a specific element, such as carbon, nitrogen, or a metal. For illustration, suppose element X is nitrogen (atomic mass approximately 14.01 g/mol). The atomic mass of oxygen is approximately 16.00 g/mol.

Calculating Moles of Each Element

Oxygen:

$$n_{\text{O}} = \frac{14.02 \text{ g}}{16.00 \text{ g/mol}} \approx 0.876 \text{ mol}$$

Element X (assuming nitrogen):

$$n_{\text{X}} = \frac{2.73 \text{ g}}{14.01 \text{ g/mol}} \approx 0.195 \text{ mol}$$

Finding the Mole Ratio

Divide each by the smallest number of moles:

Smallest mole value: 0.195 mol (element X)

Oxygen:

$$\frac{0.876}{0.195} \approx 4.49 \approx 4.5$$

Element X:

$$\frac{0.195}{0.195} = 1$$

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\]

The ratio is approximately 4.5:1 for oxygen to element X, which suggests multiplying both by 2 to obtain whole numbers:

- Oxygen: $4.5 \times 2 = 9$
- Element X: $1 \times 2 = 2$

Thus, the empirical formula ratio is roughly X_2O_9 . Since molecular formulas are typically represented with whole numbers, this might be simplified further or used to determine the molecular formula if molar mass data is available.

Note: If element X is different, the atomic mass used should correspond accordingly.

Applications and Significance of Percent Composition

Understanding percent composition serves multiple purposes in chemistry:

- Formulating compounds: Helps in deducing empirical and molecular formulas.
- Quality Control: Ensures the correct elemental makeup in pharmaceuticals and materials.
- Reaction Analysis: Determines which elements are involved and in what proportions.
- Environmental Monitoring: Assesses pollutant composition.
- Educational Purposes: Fundamental in teaching stoichiometry and chemical calculations.

Additional Considerations and Practical Tips

- Purity of Sample: Ensure the sample is pure; impurities can skew results.

- Accurate Measurements: Use precise scales and proper measurement techniques.
- Atomic Masses: Use the most current atomic weights for calculations.
- Molecular vs. Empirical: Empirical formulas are based on simplest ratios; molecular formulas depend on molar mass.

Conclusion

Calculating the percent composition of a compound provides valuable insight into its elemental makeup, aiding in further chemical analysis and synthesis endeavors. For the given sample containing 14.02 g oxygen and 2.73 g of another element in a total mass of 16.75 g, the percent composition is approximately 83.69% oxygen and 16.31% of the other element. These calculations not only help in understanding the compound's structure but also form the foundation for determining empirical and molecular formulas, which are crucial in various scientific and industrial applications.

By mastering the steps involved in percent composition calculations, chemists can accurately analyze substances, verify purity, and design compounds with desired properties. Whether working in a laboratory, manufacturing plant, or academic setting, understanding these fundamental concepts enhances your ability to interpret chemical data effectively.

Remember: Always double-check your data, use precise atomic weights, and consider the context of your analysis when applying percent composition calculations to real-world chemical problems.

Frequently Asked Questions

How do you calculate the percent composition of oxygen in a 16.75 g sample containing 14.02 g oxygen?

To calculate the percent composition of oxygen, divide the mass of oxygen (14.02 g) by the total sample mass (16.75 g) and multiply by 100: $(14.02 / 16.75) \times 100 \approx 83.75\%$.

What is the percent composition of the remaining element(s) in the compound if the total sample is 16.75 g with 14.02 g oxygen?

Subtract the mass of oxygen from the total sample: $16.75 \text{ g} - 14.02 \text{ g} = 2.73 \text{ g}$. Then, divide this by the total sample mass and multiply by 100: $(2.73 / 16.75) \times 100 \approx 16.30\%$.

What is the significance of knowing the percent composition of elements in a compound?

Knowing the percent composition helps determine the elemental makeup, analyze purity, and derive empirical formulas of compounds, which are essential in chemical analysis and synthesis.

How can I verify the percent composition calculations for this compound?

Verify by ensuring the sum of the percent compositions of all elements adds up to 100%. In this case, oxygen is approximately 83.75%, and the other element is about 16.30%, totaling roughly 100%.

If the sample contains 2.73 g of another element, what is its percent composition in the compound?

Divide the mass of the element (2.73 g) by the total sample mass (16.75 g) and multiply by 100: $(2.73 / 16.75) \times 100 \approx 16.30\%$.

How does the percent composition help in determining the empirical formula of the compound?

Percent composition provides the ratio of elements in the compound, which can be converted to mole ratios to derive the empirical formula.

Additional Resources

What Is The Percent Composition Of A 16.75 G Sample Of A Compound Containing 14.02 G Oxygen And 2.73 G?

Understanding the percent composition of a chemical compound is fundamental in the fields of chemistry and materials science. It allows scientists to determine the relative amount of each element present within a sample, providing insights into its structure, purity, and potential reactivity. In this article, we will explore how to determine the percent composition of a specific compound based on given data: a total sample weight of 16.75 grams, with 14.02 grams of oxygen and 2.73 grams of another element (likely a typo or omission in the initial data, but we'll assume it's a different element, such as carbon or hydrogen). Through detailed explanation, step-by-step calculations, and contextual understanding, readers will gain clarity on how percent composition is derived and its significance.

Understanding Percent Composition: The Basics

Before delving into the specific calculations for this compound, it's important to grasp the fundamental concept of percent composition.

Percent composition refers to the percentage by mass of each element in a compound. It provides a breakdown of which elements make up the compound and in what proportion, expressed as a percentage of the total mass.

Mathematically, the percent composition of an element in a compound can be calculated as:

$$\text{Percent Composition} = \left(\frac{\text{Mass of Element}}{\text{Total Mass of Sample}} \right) \times 100\%$$

This calculation applies to each element present in the compound. For our case, with given data, we'll compute the percent composition of oxygen and the other element.

Analyzing the Given Data

The data provided is as follows:

- Total sample mass: 16.75 grams
- Mass of oxygen: 14.02 grams
- Mass of the other element: 2.73 grams

Note: The sum of the given element masses (14.02 g + 2.73 g) equals 16.75 g, which confirms these are the components of the entire sample.

Clarification of Data

It's important to verify that the data is consistent:

$$14.02\text{ g} + 2.73\text{ g} = 16.75\text{ g}$$

Yes, the total matches the sample weight, indicating the compound consists of these two elements.

Element Identification

While the initial data mentions oxygen explicitly, the second element's identity isn't specified. Let's assume it is a generic element, perhaps carbon, hydrogen, or another relevant element.

For the purposes of this explanation, we will refer to this second element as “Element X,” which has a mass of 2.73 grams.

Calculating Percent Composition

Using the formula for percent composition, we proceed step-by-step:

Step 1: Calculate the Percent of Oxygen

$$\% \text{Oxygen} = \left(\frac{14.02 \text{ g}}{16.75 \text{ g}} \right) \times 100\%$$

$$\% \text{Oxygen} = (0.8376) \times 100\% \approx 83.76\%$$

Step 2: Calculate the Percent of Element X

$$\% \text{Element X} = \left(\frac{2.73 \text{ g}}{16.75 \text{ g}} \right) \times 100\%$$

$$\% \text{Element X} = (0.1630) \times 100\% \approx 16.30\%$$

\]

Summary of Results

- Oxygen: approximately 83.76%
- Element X: approximately 16.30%

These percentages indicate that oxygen is the predominant element in this compound, making up over four-fifths of the total mass.

Implications and Context of Percent Composition

Understanding the percent composition is more than a mere calculation; it opens avenues for deeper chemical analysis and application.

Determining Empirical and Molecular Formulas

Percent composition data can be used to deduce the empirical formula of the compound, which reflects the simplest whole-number ratio of elements.

Assuming Element X is carbon (a common assumption in organic chemistry), we can proceed to find the empirical formula:

- Convert percentages to moles using atomic weights:
- Atomic weight of oxygen: approximately 16.00 g/mol
- Atomic weight of carbon: approximately 12.01 g/mol

Step 1: Convert Masses to Moles

- Moles of oxygen:

\[

$$\text{Moles of O} = \frac{14.02 \text{ g}}{16.00 \text{ g/mol}} \approx 0.876 \text{ mol}$$

\]

- Moles of carbon:

\[

$$\text{Moles of C} = \frac{2.73 \text{ g}}{12.01 \text{ g/mol}} \approx 0.227 \text{ mol}$$

\]

Step 2: Find the Simplest Whole Number Ratio

Divide both by the smallest number of moles:

- For oxygen:

\[

$$\frac{0.876}{0.227} \approx 3.86$$

\]

- For carbon:

\[

$$\frac{0.227}{0.227} = 1$$

\]

To get whole numbers, multiply both ratios by approximately 2:

- C: $(1 \times 2 = 2)$

- O: $(3.86 \times 2 \approx 7.72 \rightarrow 8)$ (rounding to nearest whole number)

Empirical formula: $C_2H_4O_2$

Note: This is a simplified example; actual formulas depend on precise measurements and context.

Significance of the Percent Composition

Knowing the percent composition aids in:

- Identifying the compound: Certain compounds have characteristic element percentages.
- Calculating molecular formulas: When molar mass is known.
- Assessing purity: Deviations from expected percentages may indicate impurities.
- Understanding reactivity: Elements in certain ratios influence chemical behavior.

Limits and Considerations in Percent Composition Analysis

While calculations might seem straightforward, several factors can influence accuracy:

- Measurement precision: Using precise balances and calibrated instruments improves reliability.
- Sample purity: Contaminants can skew composition calculations.
- Elemental identification: Misidentification of elements affects the interpretation.
- Molecular complexity: Larger molecules may have multiple possible structures fitting the composition.

Real-World Applications

Percent composition calculations are foundational in:

- Pharmaceutical development: Ensuring correct proportions of active ingredients.
- Material science: Designing compounds with specific elemental ratios.
- Environmental chemistry: Analyzing pollutants by their elemental makeup.
- Forensic science: Identifying substances based on elemental composition.

Conclusion: The Importance of Percent Composition in Chemistry

Determining the percent composition of a compound provides vital insight into its structure, purity, and potential applications. In the case of the 16.75 g sample containing 14.02 g of oxygen and 2.73 g of another element, the calculations reveal that oxygen constitutes approximately 83.76% of the sample, with the remaining 16.30% attributed to the other element.

Such detailed analysis enables chemists to interpret the nature of the compound, formulate hypotheses about its structure, and plan further investigations or applications. As chemistry continues to evolve, the fundamental skill of calculating and understanding percent composition remains a cornerstone of scientific inquiry, bridging raw data to meaningful understanding in the world of molecules and materials.

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