# A+molecular+compound+is+found+to+consist+of+30.4%+nitrogen+and+69.6%+oxygen.+if+the+molecule+contains+2+atoms+of+nitrogen,+what+is+the+molar+mass+of+the+molecule?

**A molecular compound is found to consist of 30.4% nitrogen and 69.6% oxygen. if the molecule contains 2 atoms of nitrogen, what is the molar mass of the molecule?**

## Understanding the Composition of the Molecular Compound

When analyzing a molecular compound with known elemental percentages, such as 30.4% nitrogen and 69.6% oxygen, chemists aim to determine its molecular formula and molar mass. Knowing the percentage composition provides vital clues about the ratio of atoms within the molecule, which is essential for identifying the compound and understanding its properties.

In this particular case, the compound's composition indicates a significant presence of nitrogen and oxygen atoms. The key question revolves around determining its molar mass, especially given that the molecule contains exactly two nitrogen atoms. This information allows us to deduce the molecular formula and calculate its molar mass accurately.

## Step-by-Step Approach to Find the Molar Mass

The process involves several steps:

1. Convert percentage composition to mass ratios
2. Determine the empirical formula
3. Calculate the molar mass based on the empirical formula and known number of nitrogen atoms
4. Verify the molecular formula

Let's explore each step in detail.

## Step 1: Convert Percentage Composition to Mass

# Ratios

Given:
- Nitrogen: 30.4%
- Oxygen: 69.6%

Assuming 100 grams of the compound:
- Mass of nitrogen = 30.4 g
- Mass of oxygen = 69.6 g

Next, convert these masses to moles:

$$
\text{Moles of nitrogen} = \frac{\text{mass of nitrogen}}{\text{atomic mass of nitrogen}} = \frac{30.4\, \text{g}}{14.01\, \text{g/mol}} \approx 2.17\, \text{mol}
$$

$$
\text{Moles of oxygen} = \frac{\text{mass of oxygen}}{\text{atomic mass of oxygen}} = \frac{69.6\, \text{g}}{16.00\, \text{g/mol}} = 4.35\, \text{mol}
$$

Note: Atomic masses:
- Nitrogen (N) = 14.01 g/mol
- Oxygen (O) = 16.00 g/mol

# Step 2: Determine the Empirical Formula

Calculate the ratio of moles:

$$
\text{N} : \text{O} = 2.17 : 4.35
$$

Divide both by the smallest number of moles (2.17):

$$
\frac{2.17}{2.17} = 1,\quad \frac{4.35}{2.17} \approx 2
$$

Thus, the mole ratio is approximately:

$$
\text{N} : \text{O} = 1 : 2
$$

This suggests the empirical formula is $NO_2$.

# Step 3: Determine the Molecular Formula Based on the Number of Nitrogen Atoms

The problem states that the molecule contains 2 atoms of nitrogen. The empirical formula we found has only 1 nitrogen atom per molecule, but since the actual molecule contains 2 nitrogen atoms, the molecular formula must be a multiple of the empirical formula.

- Empirical formula: $NO_2$ (1 N, 2 O)
- Molecular formula: $(NO_2)_n$, where n is an integer

Given:
- Number of N atoms in the molecular formula = 2

Since the empirical formula has 1 N atom, the molecular formula must have:

$$
n = 2
$$

Therefore, the molecular formula is:

$$
(\text{NO}_2)_2 = N_2O_4
$$

This confirms that the compound is $N_2O_4$ (dinitrogen tetroxide).

# Step 4: Calculate the Molar Mass of $N_2O_4$

Calculate molar mass:

$$
\text{Molar mass of N}_2\text{O}_4 = (2 \times 14.01\, \text{g/mol}) + (4 \times 16.00\, \text{g/mol}) = 28.02\, \text{g} + 64.00\, \text{g} = 92.02\, \text{g/mol}
$$

Therefore, the molar mass of the molecule $N_2O_4$ is approximately 92.02 g/mol.

# Summary and Final Remarks

- The compound with 30.4% nitrogen and 69.6% oxygen, containing 2 nitrogen atoms, is identified as $N_2O_4$.
- The empirical formula derived from percentage composition is $NO_2$.
- The molecular formula, based on the nitrogen atom count, is $N_2O_4$.
- The molar mass of $N_2O_4$ is approximately 92.02 g/mol.

# Additional Context and Applications

Understanding how to determine the molar mass of a compound from its percentage composition is a fundamental skill in chemistry. It allows chemists to identify unknown substances, analyze reaction products, and determine molecular formulas.

Applications include:
- Environmental chemistry, where identifying pollutants like nitrogen oxides is crucial.
- Industrial processes involving nitrogen and oxygen compounds, such as manufacturing fertilizers or explosives.
- Academic research, where analyzing molecular structures enables the development of new materials.

Why is this important?
Accurate knowledge of molecular formulas and molar masses enables precise calculations in stoichiometry, helps in designing chemical reactions, and ensures safety and efficiency in industrial applications.

# Conclusion

Through systematic analysis of percentage composition, mole ratios, and atomic masses, we deduced that the molecular compound with 30.4% nitrogen and 69.6% oxygen, containing two nitrogen atoms, is $N_2O_4$. Its molar mass, approximately 92.02 g/mol, provides essential information for further chemical analysis and practical applications. Mastery of these concepts is vital for students and professionals working in chemistry, environmental science, and related fields.

# Frequently Asked Questions

## What is the percentage composition of nitrogen and oxygen in the compound?

The compound consists of 30.4% nitrogen and 69.6% oxygen by mass.

## Given that the molecule contains 2 atoms of nitrogen, how can we determine the molar mass of the compound?

We use the mass of nitrogen in the compound and its atomic mass to find the total molar mass, considering the percentage composition and the number of nitrogen atoms.

## What is the atomic mass of nitrogen, and how does it relate to calculating the molar mass?

The atomic mass of nitrogen is approximately 14 g/mol; since there are 2 atoms, their combined mass is 28 g/mol, which helps in calculating the molar mass of the entire molecule.

## How do we find the molar mass of oxygen in the compound based on the percentage composition?

Since oxygen makes up 69.6% of the molecule by mass, and the total molar mass is unknown, we can set up equations to relate the mass of oxygen to its atomic mass (16 g/mol) and solve for the molar mass.

## What is the step-by-step method to calculate the molar mass of the molecule in this problem?

First, determine the mass contribution of nitrogen (2 atoms × 14 g/mol = 28 g). Then, find the total molar mass (M) using the percentage of nitrogen: 30.4% = 28 / M × 100. Solving for M gives the molar mass of the molecule.

## What is the final molar mass of the molecule based on the given data?

The molar mass of the molecule is approximately 92.1 g/mol.

# Additional Resources

A molecular compound is found to consist of 30.4% nitrogen and 69.6% oxygen. if the molecule contains 2 atoms of nitrogen, what is the molar mass of the molecule?

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Investigating the Composition and Molar Mass of a Nitrogen-Oxygen Compound

The identification and characterization of molecular compounds are fundamental tasks in chemistry, providing insights into their structure, reactivity, and potential applications. A recent analytical investigation has revealed a molecular entity composed predominantly of nitrogen and oxygen, with specific weight percentages. This article aims to meticulously analyze the compound's composition, determine its molecular formula, and calculate its molar mass based on the provided data.

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Background and Significance

Understanding the precise composition of molecules involving nitrogen and oxygen is

essential due to their prevalence in various chemical and biological systems. Nitrogen-oxygen compounds include vital classes such as nitrates, nitrites, nitrogen oxides, and peroxides, which have significant environmental, industrial, and biological roles.

The specific problem at hand involves a molecule with:

- 30.4% nitrogen by weight
- 69.6% oxygen by weight
- containing exactly two nitrogen atoms

Deciphering this data allows us to establish the molecular formula and molar mass, thereby contributing to a broader understanding of the compound's nature and potential functionalities.

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Analytical Approach: From Percent Composition to Molecular Formula

1. Establishing the Basis for Calculation

The key to transforming percent composition into molecular insights lies in converting mass percentages into molar ratios. The approach involves:

- Assuming a sample size (commonly 100 grams for simplicity)
- Calculating the number of moles of each element present
- Using the mole ratio to deduce the empirical formula
- Incorporating the known number of nitrogen atoms to determine the molecular formula
- Calculating the molar mass accordingly

2. Assumptions and Data Summary

| Element | Percent by mass | Atomic mass (g/mol) | Moles per 100 g sample |
|---|---|---|---|
| Nitrogen (N) | 30.4% | 14.01 | ? |
| Oxygen (O) | 69.6% | 16.00 | ? |

3. Calculating Moles of Each Element

- Moles of nitrogen:

$$
\text{Moles of N} = \frac{30.4\, \text{g}}{14.01\, \text{g/mol}} \approx 2.17\, \text{mol}
$$

- Moles of oxygen:

$$
\text{Moles of O} = \frac{69.6\, \text{g}}{16.00\, \text{g/mol}} \approx 4.35\, \text{mol}
$$

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Determining the Empirical Formula

1. Mole Ratio Simplification

- Mole ratio of N to O:

$$
\frac{2.17}{2.17} : \frac{4.35}{2.17} \approx 1 : 2
$$

- Approximate empirical formula:

$$
\mathrm{N}_1 \mathrm{O}_2
$$

2. Adjusting for Given Nitrogen Atoms

The problem states the molecule contains 2 atoms of nitrogen. Since the empirical formula indicates 1 nitrogen atom per molecule, the molecular formula must be a multiple of the empirical formula.

- Therefore, the molecular formula:

$$
\mathrm{N}_2 \mathrm{O}_4
$$

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Calculating the Molar Mass of the Molecule

1. Molecular Formula Mass

- Molar mass of $N_2O_4$:

$$
(2 \times 14.01) + (4 \times 16.00) = 28.02 + 64.00 = 92.02\, \text{g/mol}
$$

2. Confirming Consistency with Percent Composition

- Percentage of nitrogen:

$$
\frac{28.02}{92.02} \times 100\% \approx 30.46\%
$$

- Percentage of oxygen:

$$
\

$$\frac{64.00}{92.02} \times 100\% \approx 69.54\%$$

These values closely match the provided percentages (30.4% N and 69.6% O), confirming the molecular formula as $N_2O_4$.

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Broader Implications and Contextual Analysis

1. Significance of $N_2O_4$

Nitrogen tetroxide ($N_2O_4$) is a well-documented compound, primarily used as an oxidizer in rocket propulsion and as an intermediate in nitrogen oxide chemistry. Its properties, including volatility, reactivity, and toxicity, make understanding its molecular mass and composition critical for safety and application purposes.

2. Structural Considerations

$N_2O_4$ exists in equilibrium with nitrogen dioxide ($NO_2$), and its structure involves a dimeric form stabilized by covalent bonds. Recognizing this equilibrium is essential when considering reactivity and environmental impact.

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Additional Analytical Considerations

1. Limitations and Assumptions

- The calculation assumes pure compound without impurities.
- Percentages are based on weight, presuming complete purity.
- The empirical-to-molecular formula deduction relies on the mole ratio approximation, which is validated by the close match to experimental percentages.

2. Potential Variations and Alternative Formulas

While $N_2O_4$ aligns with the data, other nitrogen-oxygen compounds such as $NO_2$, $N_2O_3$, or $N_2O_5$ could be considered in different contexts, but their percent compositions do not align as closely with the given data.

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Conclusion

Through rigorous analytical methods, the molecular compound with 30.4% nitrogen and 69.6% oxygen containing two nitrogen atoms is confidently identified as nitrogen tetroxide, $N_2O_4$. Its molar mass, calculated as approximately 92.02 g/mol, aligns with established data for this compound.

This investigation underscores the importance of combining percent composition analysis with elemental molar ratios to accurately determine molecular formulas and masses. Such

insights are vital across disciplines, from environmental monitoring to aerospace engineering, where understanding the precise nature of chemical substances informs safety, design, and environmental impact assessments.

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- Lide, D. R. (Ed.). (2004). CRC Handbook of Chemistry and Physics (85th ed.). CRC Press.

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Note: The detailed calculations and reasoning presented here are intended for educational and research purposes, illustrating the process of deducing molecular formulae and molar masses based on elemental analysis data.

## A Molecular Compound Is Found To Consist Of 30 4 Nitrogen And 69 6 Oxygen If The Molecule Contains 2 Atoms Of Nitrogen What Is The Molar Mass Of The Molecule

A Molecular Compound Is Found To Consist Of 30 4 Nitrogen And 69 6 Oxygen If The Molecule Contains 2 Atoms Of Nitrogen What Is The Molar Mass Of The Molecule

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