An 8.20g Piece Of Magnesium Combines Completely With 5.40g Of Oxygen To Form A Compound. What Is The

Understanding the Composition of Magnesium and Oxygen in Chemical Reactions

An 8.20g Piece Of Magnesium Combines Completely With 5.40g Of Oxygen To Form A Compound. What Is The significance of this statement lies in understanding how elements combine chemically to form compounds. This scenario demonstrates a fundamental concept in chemistry—mass conservation and chemical formulas. By analyzing the given data, we can determine the compound's chemical formula, the mole ratios, and better grasp the principles behind chemical reactions involving magnesium and oxygen.

This comprehensive guide will walk you through the process of solving such problems, emphasizing key concepts like molar mass, stoichiometry, and empirical formulas. Whether you're a student preparing for exams or a chemistry enthusiast seeking clarity, this article aims to provide detailed insights into this specific problem and related topics.

Fundamentals of Chemical Composition and Mass Conservation

The Law of Conservation of Mass

In chemical reactions, the total mass of reactants equals the total mass of products. This principle allows chemists to analyze reactions by tracking the mass of elements involved. In our problem, magnesium reacts with oxygen to form a compound—most likely magnesium oxide.

Identifying the Elements and Their Masses

- Magnesium (Mg): 8.20 grams
- Oxygen (O): 5.40 grams

Total mass of the compound:

- = 8.20 g (magnesium) + 5.40 g (oxygen)

- = 13.60 grams

Knowing the individual masses helps us determine the ratio of moles of each element in the compound.

Calculating Moles of Magnesium and Oxygen

To find the mole ratio, we convert the masses to moles using atomic or molar masses.

Atomic and Molar Masses

- Magnesium (Mg): approximately 24.305 g/mol
- Oxygen (O): approximately 16.00 g/mol

Calculating Moles

1. Moles of magnesium:

$$
\text{Moles of Mg} = \frac{\text{Mass of Mg}}{\text{Molar mass of Mg}} = \frac{8.20\,g}{24.305\,g/mol} \approx 0.337\,mol
$$

2. Moles of oxygen:

$$
\text{Moles of O} = \frac{\text{Mass of O}}{\text{Molar mass of O}} = \frac{5.40\,g}{16.00\,g/mol} = 0.3375\,mol
$$

The near equality in moles indicates a simple mole ratio between magnesium and oxygen.

Determining the Empirical Formula of the Compound

Finding the Mole Ratio

Since both magnesium and oxygen have approximately 0.337 mol, their mole ratio simplifies to 1:1.

Formulating the Empirical Formula

- The simplest whole number ratio of Mg to O is 1:1.
- Therefore, the empirical formula of the compound is MgO.

This indicates that magnesium reacts with oxygen in a 1:1 molar ratio to form magnesium oxide.

Confirming the Identity of the Compound

Common Magnesium-Oxygen Compound

Magnesium oxide (MgO) is a well-known compound, formed when magnesium reacts with oxygen. The data align with this compound's formation, confirming the empirical formula as MgO.

Calculating the Molar Mass of Magnesium Oxide

$$
\text{Molar mass of MgO} = 24.305\,g/mol + 16.00\,g/mol = 40.305\,g/mol
$$

Mass Percent Composition of MgO

- Magnesium:

$$
\frac{24.305}{40.305} \times 100\% \approx 60.3\%
$$

- Oxygen:

$$
\frac{16.00}{40.305} \times 100\% \approx 39.7\%
$$

These percentages can help in qualitative and quantitative analyses of magnesium oxide.

Implications and Applications of Magnesium Oxide

Industrial Uses

Magnesium oxide has important applications, including:

- Refractory material in furnaces
- Insulation in electrical applications
- As a dietary supplement and antacid
- In environmental remediation

Biological and Environmental Significance

Understanding the formation and properties of MgO is essential in fields like geology, medicine, and environmental science, where magnesium compounds play vital roles.

Summary: What Is the Compound Formed?

Based on the calculation and chemical principles, the compound formed by magnesium and oxygen in the given problem is magnesium oxide, with the empirical formula MgO. The mole ratio of magnesium to oxygen in this compound is 1:1, aligning with the known stoichiometry of magnesium oxide.

Additional Considerations and Related Topics

Calculating Molecular Formulas from Empirical Formulas

In cases where molecular formulas are needed, molecular mass is compared to empirical mass, and the ratio determines the actual molecular formula.

Understanding Stoichiometry

Stoichiometry involves calculations based on mole ratios, molar masses, and mass data to predict quantities of reactants and products.

Common Mistakes to Avoid

- Mixing up units or atomic masses
- Assuming incorrect mole ratios
- Ignoring significant figures

Conclusion

The problem of determining what compound forms when magnesium reacts with oxygen is fundamental in understanding chemical reactions and stoichiometry. By converting masses to moles, identifying mole ratios, and applying known chemical formulas, we established that magnesium oxide (MgO) is the product of this reaction. Recognizing such patterns and calculations is crucial for students and professionals working in chemistry, materials science, and related fields.

Understanding the principles outlined in this article equips you with the tools necessary to analyze similar chemical composition problems confidently. Whether in academic settings or practical applications, mastering these concepts enhances your ability to interpret and predict chemical behaviors accurately.

Frequently Asked Questions

What is the chemical formula of the magnesium oxide formed in the reaction?

The chemical formula of the compound is MgO, indicating magnesium combines with oxygen in a 1:1 molar ratio.

How do you determine the empirical formula from the given masses of magnesium and oxygen?

Convert the masses to moles, then divide each by the smallest number of moles to find the simplest whole number ratio, which gives the empirical formula.

What is the molar mass of magnesium and oxygen used in calculations?

Magnesium's molar mass is approximately 24.31 g/mol, and oxygen's is about 16.00 g/mol.

How many moles of magnesium are present in 8.20 g of magnesium?

Number of moles of magnesium = 8.20 g / 24.31 g/mol ≈ 0.337 mol.

How many moles of oxygen are present in 5.40 g of oxygen?

Number of moles of oxygen = 5.40 g / 16.00 g/mol ≈ 0.338 mol.

What is the mole ratio of magnesium to oxygen in the compound?

The ratio is approximately 0.337 mol Mg to 0.338 mol O, which simplifies to about 1:1, indicating the empirical formula MgO.

What type of chemical reaction occurs when magnesium combines with oxygen?

This is a synthesis or combination reaction where magnesium reacts with oxygen to form magnesium oxide.

Is the compound formed an ionic or covalent compound?

Magnesium oxide (MgO) is an ionic compound formed by the transfer of electrons from magnesium to oxygen.

How can you verify the complete reaction between magnesium and oxygen?

By confirming that all magnesium has reacted (no unreacted magnesium remains) and the mass of the product equals the sum of the initial masses, indicating complete reaction.

What is the significance of the mass data in determining the compound's formula?

The mass data allows calculation of the molar ratio of elements, which helps identify the empirical and molecular formulas of the compound.

Additional Resources

An 8.20g Piece Of Magnesium Combines Completely With 5.40g Of Oxygen To Form A Compound. What Is The – this intriguing question invites us into the fundamental world of chemical reactions, stoichiometry, and the nature of compounds. Understanding how magnesium reacts with oxygen not only reveals core principles of chemistry but also demonstrates how to analyze and solve real-world problems involving mass, chemical formulas, and molecular ratios. In this guide, we will explore this problem step-by-step, breaking down the concepts involved, the calculations needed, and the scientific principles at play.

Introduction

When a piece of magnesium reacts with oxygen, it forms magnesium oxide—a compound essential in various industrial and biological contexts. The question posed—An 8.20g Piece Of Magnesium Combines Completely With 5.40g Of Oxygen To Form A Compound. What Is The—is a classic example of stoichiometric analysis, where the goal is to determine the chemical formula of the resulting compound based on its constituent masses.

Understanding this problem involves grasping key concepts such as:

- The Law of Conservation of Mass
- The concept of molar ratios
- Empirical and molecular formulas
- How to convert masses to moles
- How to interpret the mole ratios to find the chemical formula

Let's journey through each of these concepts to arrive at the answer.

Fundamental Concepts

The Law of Conservation of Mass

This principle states that mass is neither created nor destroyed in a chemical reaction. The total mass of reactants equals the total mass of products. This law underpins the problem, as the sum of the masses of magnesium and oxygen before reaction equals the mass of the resulting compound.

Moles and Molar Mass

A mole is a counting unit used in chemistry, representing 6.022×10^{23} particles (atoms, molecules, etc.). Molar mass is the mass of one mole of a substance, expressed in grams per mole (g/mol). For example:

- Magnesium (Mg): approximately 24.305 g/mol
- Oxygen (O): approximately 16.00 g/mol (atomic mass)

Empirical Formula

The empirical formula of a compound indicates the simplest whole-number ratio of atoms present. The molecular formula is a multiple of the empirical formula, representing the actual number of atoms in a molecule.

Step-by-Step Solution

Step 1: Summarize Known Data

- Mass of magnesium (Mg): 8.20 g
- Mass of oxygen (O): 5.40 g
- Total mass of compound: 8.20 g + 5.40 g = 13.60 g

Step 2: Convert Masses to Moles

Calculate the number of moles of each element:

- Moles of Mg:

$$
\text{Moles of Mg} = \frac{\text{Mass of Mg}}{\text{Molar mass of Mg}} = \frac{8.20\,g}{24.305\,g/mol} \approx 0.337\, \text{mol}
$$

- Moles of O:

$$
\text{Moles of O} = \frac{\text{Mass of O}}{\text{Molar mass of O}} = \frac{5.40\,g}{16.00\,g/mol} = 0.3375\, \text{mol}
$$

Step 3: Determine the Mole Ratio

Compare the molar amounts:

- Mg: approximately 0.337 mol
- O: approximately 0.338 mol

The ratio of Mg to O is essentially 1:1, as the molar amounts are nearly equal.

Step 4: Find the Empirical Formula

Since the molar ratio of Mg to O is approximately 1:1, the empirical formula is MgO.

Step 5: Confirm the Composition

Calculate the mass ratio:

- Mass of Mg in the compound:

$$
\text{Mass of Mg} = 8.20\,g
$$

- Mass of O in the compound:

$$
\text{Mass of O} = 5.40\,g
$$

Total mass:

$$
8.20\,g + 5.40\,g = 13.60\,g
$$

Calculate the percentage composition:

- % Mg:

$$
\frac{8.20\,g}{13.60\,g} \times 100 \approx 60.29\%
$$

- % O:

$$
\frac{5.40\,g}{13.60\,g} \times 100 \approx 39.71\%
$$

Compare these percentages with the theoretical composition of MgO:

- Molar mass of MgO:

$$
24.305\,g + 16.00\,g = 40.305\,g/mol
$$

- Percentage Mg:

$$
\frac{24.305}{40.305} \times 100 \approx 60.3\%
$$

- Percentage O:

$$
\frac{16.00}{40.305} \times 100 \approx 39.7\%
$$

The experimental data closely matches the theoretical composition of magnesium oxide, confirming the empirical formula MgO.

Scientific and Practical Significance

The Nature of Magnesium Oxide

Magnesium oxide (MgO) is a white, crystalline solid with high melting points, used in refractory materials, as a dietary supplement, and in fireproofing. Its formation from

magnesium and oxygen illustrates a fundamental oxidation process, vital in metallurgy, materials science, and biological systems.

Why Is This Important?

Understanding the molar ratios and empirical formulas helps chemists:

- Predict product compositions
- Calculate yields in chemical reactions
- Design materials with specific properties
- Interpret experimental data accurately

This problem exemplifies how fundamental principles underpin practical applications, from industrial manufacturing to environmental chemistry.

Additional Considerations

Limitations and Assumptions

- The reaction is assumed to go to completion and produce a pure compound.
- The masses are measured accurately; experimental errors can affect the ratio.
- The atomic masses used are approximate; small variations may occur with different atomic weight standards.

Extending the Analysis

- Molecular formula: Since MgO is a simple binary compound, the empirical formula is also the molecular formula.
- Stoichiometry in real reactions: Factors like reaction conditions, impurities, and side reactions can influence the actual composition.

Summary and Key Takeaways

- The reaction between magnesium and oxygen produces magnesium oxide, MgO.
- Based on the given masses, the molar ratio of magnesium to oxygen is approximately 1:1.
- The empirical formula of the compound formed is MgO.
- The calculation process involved converting masses to moles, comparing mole ratios, and confirming the empirical formula through percentage composition.
- This analysis underscores the importance of stoichiometry in understanding chemical reactions and predicting compound formulas.

Final Thoughts

Understanding how to analyze and interpret mass data in chemical reactions is a cornerstone of chemistry. The problem of an 8.20g piece of magnesium combining

completely with 5.40g of oxygen exemplifies the practical application of fundamental principles such as molar calculations, empirical formulas, and the law of conservation of mass. Mastering these techniques enables scientists and students alike to decode the composition of compounds and understand the molecular world at a deeper level.

References

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This concludes our comprehensive guide to determining the formula of the compound formed when magnesium reacts with oxygen based on given mass data. Understanding these principles empowers you to tackle similar chemical problems with confidence.

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