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Understanding chemical reactions and stoichiometry is fundamental to mastering chemistry. One common question involves determining the amount of product formed in a reaction given certain reactants. In this article, we will explore the specific scenario of calculating how many grams of magnesium oxide (MgO) are produced when 40.0 grams of oxygen gas (O_2) completely reacts with magnesium (Mg). This problem is an excellent example of applying stoichiometric principles to real-world chemical reactions.

By the end of this article, you will understand how to approach such problems step-by-step, including balancing chemical equations, converting grams to moles, performing mole-to-mole conversions, and finally converting moles of product back to grams. Whether you're a student preparing for exams or a chemistry enthusiast, this comprehensive guide will clarify the process and enhance your problem-solving skills.

Understanding the Chemical Reaction: Magnesium and Oxygen

The Reaction Between Magnesium and Oxygen

The reaction between magnesium (Mg) and oxygen (O_2) is a classic example of a synthesis reaction, where two reactants combine to form a compound. The balanced chemical equation for this reaction is:

$Mg\ (s) + \frac{1}{2}\ O_2\ (g) \rightarrow MgO\ (s)$

This equation indicates that one mole of magnesium reacts with half a mole of oxygen gas to produce one mole of magnesium oxide.

Key points:
- Magnesium (Mg) is a metal that readily reacts with oxygen.
- Oxygen gas (O_2) is diatomic in nature.
- Magnesium oxide (MgO) is an ionic compound formed from magnesium and oxygen.

Reaction details:
- The reaction is 100% complete and occurs under ideal conditions, meaning all reactants are fully converted to products.
- The ratio of reactants is critical for calculating the amount of product formed.

Step-by-Step Calculation Process

To determine how many grams of MgO are produced from 40.0 grams of O_2, we will follow these steps:

1. Write and interpret the balanced chemical equation.
2. Convert the given mass of O_2 to moles.
3. Use the mole ratio from the balanced equation to find moles of MgO produced.
4. Convert moles of MgO to grams.

Let's delve into each step.

Step 1: Balanced Chemical Equation

As established:

$Mg\ (s) + \frac{1}{2}\ O_2\ (g) \rightarrow MgO\ (s)$

This equation is already balanced, with coefficients: 1 Mg, $\frac{1}{2}$ O_2, and 1 MgO.

To avoid dealing with fractions, multiply the entire equation by 2:

$2\ Mg\ (s) + O_2\ (g) \rightarrow 2\ MgO\ (s)$

Now, the mole ratio is clearer:
- 2 moles of Mg react with 1 mole of O_2 to produce 2 moles of MgO.

This simplifies calculations and maintains clarity.

Step 2: Convert grams of O_2 to moles

Given:
- Mass of O_2 = 40.0 grams

Molecular weight of O_2:
- Atomic weight of oxygen (O) ≈ 16.00 g/mol
- O_2 molecule = 2 × 16.00 g/mol = 32.00 g/mol

Calculating moles of O_2:

Number of moles of O_2 = (Mass of O_2) / (Molecular weight of O_2)

Number of moles of O_2 = 40.0 g / 32.00 g/mol = 1.25 mol

Step 3: Use mole ratio to find moles of MgO produced

From the balanced equation:

2 Mg : 1 O_2 : 2 MgO

The mole ratio of O_2 to MgO is 1:2.

Therefore:

Moles of MgO = (Moles of O_2) × (2 moles MgO / 1 mole O_2)

Moles of MgO = 1.25 mol × 2 = 2.50 mol

This means that 1.25 moles of O_2 will produce 2.50 moles of MgO.

Step 4: Convert moles of MgO to grams

Molecular weight of MgO:
- Magnesium (Mg) ≈ 24.305 g/mol
- Oxygen (O) ≈ 16.00 g/mol

Molecular weight of MgO = 24.305 + 16.00 = 40.305 g/mol

Calculating grams of MgO:

Mass of MgO = (Moles of MgO) × (Molecular weight of MgO)

Mass of MgO = 2.50 mol × 40.305 g/mol ≈ 100.76 g

Final answer:

Approximately 100.76 grams of magnesium oxide are produced when 40.0 grams of

oxygen gas completely reacts with magnesium.

Additional Considerations and Tips

1. Ensuring Accurate Stoichiometry

Always verify the balanced chemical equation before calculations. Errors in balancing can lead to incorrect mole ratios and flawed results.

2. Converting Units Correctly

- Use precise atomic weights for calculations.
- Keep track of units throughout to avoid mistakes.

3. Dealing With Excess Reactants

In this problem, the amount of magnesium is not specified. If magnesium were limiting or in excess, the calculations would need adjustment based on the limiting reagent.

4. Real-World Applications

Understanding such calculations is crucial in industries where magnesium oxide is produced, such as in refractory materials, agriculture, and environmental applications.

Summary

- The chemical reaction between magnesium and oxygen produces magnesium oxide.
- Starting with 40.0 grams of O_2, the complete reaction yields approximately 100.76 grams of MgO.
- The key steps involve balancing the chemical equation, converting grams to moles, using mole ratios, and converting moles back to grams.
- Accurate stoichiometric calculations are vital for industrial processes,

laboratory experiments, and academic understanding.

Conclusion

Calculating the amount of magnesium oxide produced from a given quantity of oxygen gas involves understanding the reaction's stoichiometry, balancing the chemical equation, and performing precise conversions between grams and moles. In this specific case, reacting 40.0 grams of O_2 with magnesium results in roughly 100.76 grams of MgO, assuming complete reaction and ideal conditions.

Mastering these calculations enhances your ability to analyze chemical reactions quantitatively, a skill essential for students, researchers, and professionals working in chemistry-related fields. Always double-check your balanced equations and unit conversions to ensure accuracy in your results.

Meta Description: Discover how to calculate the grams of magnesium oxide produced when 40.0 grams of oxygen reacts completely with magnesium. Step-by-step stoichiometry guide included.

Frequently Asked Questions

How do you calculate the grams of MgO produced when 40.0 g of O_2 reacts with magnesium?

First, write the balanced chemical equation: $2Mg + O_2 \rightarrow 2MgO$. Calculate moles of O_2: 40.0 g ÷ 32.00 g/mol = 1.25 mol. Since the molar ratio of O_2 to MgO is 1:2, moles of MgO produced = 1.25 mol × 2 = 2.50 mol. Then, convert moles of MgO to grams: 2.50 mol × 40.30 g/mol = 100.75 g. So, approximately 100.75 grams of MgO are produced.

What is the molar mass of MgO and how does it relate to the reaction?

The molar mass of MgO is approximately 40.30 g/mol, calculated by adding magnesium (24.30 g/mol) and oxygen (16.00 g/mol). This value is used to convert moles of MgO produced into grams after determining the moles from the reaction.

If only 30.0 g of O_2 reacts, how much MgO is produced?

Calculate moles of O_2: 30.0 g ÷ 32.00 g/mol = 0.9375 mol. Using the molar ratio, moles of MgO = 0.9375 mol × 2 = 1.875 mol. Convert to grams: 1.875 mol × 40.30 g/mol ≈ 75.56 g. Therefore, about 75.56 grams of MgO are produced.

Why is it important to balance the chemical equation when calculating product mass?

Balancing ensures the correct molar ratios of reactants and products, which is essential for accurately predicting the amount of product formed based on reactant quantities.

What assumptions are made when calculating the mass of MgO produced from O_2 consumption?

The calculations assume the reaction goes to completion with 100% efficiency, no side reactions occur, and all reactants are pure and measured accurately.

Additional Resources

How Many Grams Of MgO Are Produced When 40.0 g Of O_2 React Completely With Mg

Understanding the precise amount of magnesium oxide (MgO) produced in a chemical reaction is fundamental in fields ranging from industrial manufacturing to academic research. When magnesium (Mg) reacts with oxygen (O_2), it forms magnesium oxide—a compound vital in numerous applications including refractory materials, agriculture, and healthcare. This article delves into the quantitative aspects of this reaction, exploring how 40.0 grams of oxygen reacts with magnesium to produce MgO, and guiding readers through the calculations involved in determining the mass of the resultant compound.

The Fundamental Reaction: Magnesium and Oxygen

The chemical reaction between magnesium and oxygen is straightforward but serves as an excellent example of stoichiometry—the quantitative study of reactants and products in chemical reactions.

The balanced chemical equation for the reaction is:

$$ 2\, \mathrm{Mg} (s) + \mathrm{O}_2 (g) \rightarrow 2\, \mathrm{MgO} (s) $$

This balanced equation indicates that:

- 2 moles of magnesium react with 1 mole of oxygen gas to produce 2 moles of magnesium oxide.

Understanding this ratio is crucial for calculating the amount of MgO produced from a given mass of oxygen.

Step 1: Determining Moles of Oxygen Reacted

To find out how much MgO is produced from 40.0 grams of oxygen, we first need to convert the mass of oxygen into moles.

Molecular weight of oxygen (O_2):

- Atomic weight of oxygen (O): approximately 16.00 g/mol
- Molecular weight of O_2: 16.00 g/mol × 2 = 32.00 g/mol

Calculating moles of oxygen:

$$
\text{Moles of } O_2 = \frac{\text{Mass of } O_2}{\text{Molar mass of } O_2} = \frac{40.0\, \text{g}}{32.00\, \text{g/mol}} = 1.25\, \text{mol}
$$

This means that 40.0 grams of oxygen corresponds to 1.25 moles of O_2.

Step 2: Using the Stoichiometric Ratio to Find Moles of MgO

From the balanced equation:

$$ \mathrm{O}_2 : \mathrm{MgO} = 1 : 2 $$

This ratio indicates that for every 1 mole of oxygen, 2 moles of MgO are produced.

Given 1.25 moles of oxygen:

$$
\text{Moles of MgO} = 2 \times 1.25\, \text{mol} = 2.50\, \text{mol}
$$

Thus, 1.25 moles of oxygen will produce 2.50 moles of magnesium oxide.

Step 3: Calculating the Mass of MgO Produced

Molecular weight of magnesium oxide (MgO):

- Atomic weight of magnesium (Mg): approximately 24.31 g/mol
- Atomic weight of oxygen (O): approximately 16.00 g/mol

$$
\text{Molar mass of MgO} = 24.31\, \text{g/mol} + 16.00\, \text{g/mol} = 40.31\, \text{g/mol}
$$

Mass of MgO produced:

$$
\text{Mass} = \text{Moles} \times \text{Molar mass} = 2.50\, \text{mol} \times 40.31\, \text{g/mol} \approx 100.78\, \text{g}
$$

Therefore, when 40.0 grams of oxygen completely reacts with magnesium, approximately 100.78 grams of magnesium oxide are produced.

Practical Implications and Considerations

While the calculations provide an idealized theoretical yield, real-world scenarios often involve factors such as incomplete reactions, impurities, or experimental losses. Nonetheless, these stoichiometric calculations are invaluable in planning and optimizing industrial processes where precise quantities of reactants and products are critical.

Key points to consider:

- Purity of reactants: Impurities can affect the actual yield.
- Reaction conditions: Temperature, pressure, and catalyst presence influence reaction completeness.
- Measurement accuracy: Precise weighing and measurement techniques improve the reliability of results.

Additional Context: Industrial Relevance of MgO Production

Magnesium oxide's production through the reaction of magnesium with oxygen is not merely an academic exercise but a vital industrial process. The method, known as direct oxidation, is favored for its efficiency and simplicity, especially in manufacturing magnesium oxide at scale.

Applications of MgO include:

- Refractory materials: Used to line furnaces and kilns due to its high melting point.
- Agriculture: As a soil amendment to correct acidity.
- Environmental: In flue gas desulfurization.

- Healthcare: As an antacid and laxative.

Understanding the stoichiometry involved in its production allows manufacturers to optimize reactant quantities, reduce waste, and improve cost efficiency.

Summary and Final Remarks

In conclusion, when 40.0 grams of oxygen reacts completely with magnesium, approximately 100.78 grams of magnesium oxide (MgO) are produced. This calculation underscores the importance of stoichiometry in chemistry, enabling precise predictions of product yields based on reactant quantities.

Key takeaways:

- Convert given masses to moles using molar mass.
- Use the balanced chemical equation to determine the molar ratio.
- Convert moles of product back to grams using molar mass.

Mastering these steps empowers chemists, engineers, and students alike to accurately estimate product yields, plan reactions efficiently, and understand the underlying principles governing chemical transformations. Whether in research laboratories or large-scale manufacturing, such quantitative insights are essential for advancing technological progress and ensuring safe, economical, and sustainable chemical processes.

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