Assuming That You Have 0.4g Of Y(OH)3, Calculate The Mass Of Of BaO2 Required To React Stoichiometrically(1Y:2Ba:3Cu)

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Understanding the precise amounts of reactants needed in chemical reactions is fundamental in chemistry, especially in stoichiometry, which allows us to predict the quantities of substances involved in chemical processes. In this detailed guide, we will explore the process of calculating the mass of barium peroxide (BaO_2) required to react with a given amount of yttrium hydroxide ($Y(OH)_3$) based on a specific stoichiometric ratio of 1Y:2Ba:3Cu. This example combines principles of molecular molar calculations, mole ratios, and mass conversions, providing a comprehensive approach to solving real-world chemical problems.

Understanding the Problem and Its Context

Before delving into calculations, it is crucial to understand the problem's parameters and what is being asked.

Problem Breakdown

- You are given a mass of $Y(OH)_3$: 0.4 grams.
- The reaction involves yttrium hydroxide ($Y(OH)_3$), barium peroxide (BaO_2), and copper (Cu).
- The ratio of the elements involved in the reaction is specified as 1Y: 2Ba: 3Cu, indicating the stoichiometry of the overall reaction.
- The goal: Calculate the mass of BaO_2 needed to react completely ("stoichiometrically") with the given $Y(OH)_3$.

Assumptions and Clarifications

- The reaction is assumed to be a simple, ideal chemical reaction with no side reactions.
- The primary focus is on the relationship between $Y(OH)_3$ and BaO_2 based on molar ratios.
- The ratio 1Y:2Ba:3Cu indicates the molar ratio of the elements involved; however, since the problem specifically asks for the amount of BaO_2, the key is understanding the molar relationship between $Y(OH)_3$ and BaO_2.

Step 1: Understanding the Relevant Chemical Equations

To perform the calculation, it is essential to identify the chemical reaction involved.

Possible Reaction Pathway

Given the elements involved and their ratios, a plausible overall reaction could be:

$$\text{Y(OH)}_3 + \text{BaO}_2 \rightarrow \text{Products involving Y, Ba, and Cu}$$

However, because the problem specifies the molar ratio 1Y:2Ba:3Cu, it suggests that the reaction involves the formation of a compound or a set of reactions where yttrium hydroxide reacts with BaO_2 to produce certain products, possibly with copper as part of the compound or as a catalyst.

For simplicity, and based on typical stoichiometric calculations, we will focus on the relationship between $Y(OH)_3$ and BaO_2, assuming that the molar ratio 1Y:2Ba applies directly to the amount of $Y(OH)_3$ and BaO_2 involved.

Step 2: Determine Moles of $Y(OH)_3$

The first step in stoichiometric calculations is to convert the given mass of $Y(OH)_3$ into moles.

Calculating Molar Mass of $Y(OH)_3$

To find the molar mass, sum the atomic masses of each element:

Element	Atomic Mass (g/mol)	Quantity in $Y(OH)_3$	Total Contribution (g/mol)
Yttrium (Y)	88.91	1	88.91
Oxygen (O)	16.00	3	48.00
Hydrogen (H)	1.008	3	3.024

Total molar mass of $Y(OH)_3$:

$$88.91 + 48.00 + 3.024 = 139.934\, \text{g/mol}$$

For simplicity, we'll use 139.93 g/mol.

Calculating Moles of $Y(OH)_3$

Given mass:

$$ \text{Mass of Y(OH)}_3 = 0.4\, \text{g} $$

Number of moles:

$$ n_{Y(OH)_3} = \frac{\text{mass}}{\text{molar mass}} = \frac{0.4}{139.93} \approx 0.00286\, \text{mol} $$

Step 3: Apply the Molar Ratio to Find Moles of BaO_2

The problem states a molar ratio of 1Y:2Ba:3Cu, but since we are focused on the reaction involving $Y(OH)_3$ and BaO_2, the critical ratio is between $Y(OH)_3$ and BaO_2.

Understanding the Mole Ratio

- $Y(OH)_3$: 1 mol
- BaO_2: 2 mol (from the ratio 1Y:2Ba)

Therefore, for every mole of $Y(OH)_3$ reacting, 2 moles of BaO_2 are involved.

Note: The ratio is based on the molar quantities of elements or compounds involved in the reaction. Here, the molar ratio of $Y(OH)_3$ to BaO_2 is:

$$
\frac{n_{BaO_2}}{n_{Y(OH)_3}} = 2
$$

Thus,

$$
n_{BaO_2} = 2 \times n_{Y(OH)_3}
$$

Plugging in the value:

$$
n_{BaO_2} = 2 \times 0.00286 \approx 0.00572\, \text{mol}
$$

Step 4: Calculate the Mass of BaO_2 Required

Next, convert moles of BaO_2 into mass.

Molar Mass of BaO_2

Sum of atomic masses:

Element	Atomic Mass (g/mol)	Quantity	Total Contribution (g/mol)
Barium (Ba)	137.33	1	137.33
Oxygen (O)	16.00	2	32.00

Total molar mass:

$$
137.33 + 32.00 = 169.33\, \text{g/mol}
$$

Mass Calculation

$$
\text{Mass of BaO}_2 = n_{BaO_2} \times \text{molar mass} = 0.00572 \times 169.33 \approx 0.968\, \text{g}
$$

Summary of Results

- Mass of $Y(OH)_3$ given: 0.4 g
- Moles of $Y(OH)_3$: approximately 0.00286 mol
- Moles of BaO_2 required (based on 1Y:2Ba): approximately 0.00572 mol
- Mass of BaO_2 required: approximately 0.968 g

Additional Considerations and Practical Implications

While the calculations above provide a theoretical mass of BaO_2 needed, several real-world factors could influence the actual amount required:

Purity of Reactants

- Impurities in the reactants can affect the stoichiometric ratios.
- Always account for purity levels; for example, if BaO_2 is 95% pure, the actual mass needed would be higher.

Reaction Conditions

- Temperature, pressure, and reaction environment can influence the reaction efficiency.
- Incomplete reactions may require excess BaO_2 beyond the theoretical calculation.

Reaction Completeness and Side Reactions

- Side reactions might consume additional BaO_2.
- Always consider an excess amount if the reaction needs to go to completion.

Environmental and Safety Precautions

- BaO_2 is an oxidizer and must be handled with care.
- Proper safety protocols should be followed during calculations and experimental procedures.

Common Applications and Relevance of the Calculation

Understanding and calculating the required amounts of reactants like BaO_2 in relation to $Y(OH)_3$ are vital in various fields:

1. **Materials Science:** Synthesizing new materials or ceramics involving yttrium and barium compounds.
2. **Pharmaceuticals:** Development of yttrium-based compounds used in medical imaging or treatments.
3. **Industrial Chemistry:** Manufacturing of superconducting materials such as YBCO (Yttrium Barium Copper Oxide).
4. **Environmental Chemistry:** Waste treatment involving rare earth elements and alkaline earth compounds.

Accurate stoichiometric calculations ensure the efficient use of raw materials, cost savings, and optimal reaction yields, which are critical in industrial and laboratory settings.

Final

Frequently Asked Questions

What is the molar mass of $Y(OH)_3$ used in the calculation?

The molar mass of $Y(OH)_3$ is approximately 190.92 g/mol, calculated by adding the atomic masses: Y (88.91 g/mol), O (16.00 g/mol), and H (1.008 g/mol).

How do you determine the number of moles of $Y(OH)_3$ from the given mass?

Number of moles = mass / molar mass. For 0.4 g of $Y(OH)_3$, moles = 0.4 g / 190.92 g/mol ≈ 0.00209 mol.

What is the balanced chemical equation for the reaction involving $Y(OH)_3$ and BaO_2?

The exact balanced equation depends on the reaction specifics, but based on the stoichiometric ratio Y:Ba:Cu = 1:2:3, the reaction can be represented as: $2Y(OH)_3 + 4BaO_2 \rightarrow$ products, ensuring the molar ratios are

maintained.

How do you find the moles of BaO_2 required from the moles of $Y(OH)_3$?

Using the molar ratio from the stoichiometry (1Y:2Ba), multiply the moles of $Y(OH)_3$ by 2: 0.00209 mol $Y(OH)_3$ × 2 = 0.00418 mol BaO_2.

What is the molar mass of BaO_2 used in the calculation?

The molar mass of BaO_2 is approximately 261.34 g/mol, calculated as Ba (137.33 g/mol) + 2×O (16.00 g/mol).

How do you calculate the mass of BaO_2 needed for the reaction?

Mass = moles × molar mass = 0.00418 mol × 261.34 g/mol ≈ 1.092 g of BaO_2.

Are there any assumptions made in this calculation?

Yes, it is assumed that the reaction proceeds completely and stoichiometrically according to the given molar ratios, and that all reactants are pure and dry.

What practical considerations should be taken into account when performing this calculation experimentally?

Ensure accurate weighing, account for purity of reactants, control reaction conditions, and consider possible side reactions or incomplete reactions that could affect the amount of BaO_2 needed.

Additional Resources

Calculating the Mass of BaO_2 Required to React with 0.4g of $Y(OH)_3$: A Step-by-Step Stoichiometric Analysis

Understanding chemical reactions at the molecular level is fundamental in chemistry, especially when it comes to quantitative analysis. This detailed exploration focuses on a specific stoichiometric problem: Given 0.4 grams of yttrium hydroxide, $Y(OH)_3$, how much barium peroxide, BaO_2, is necessary to react completely according to a specified molar ratio? The problem involves multiple layers — from understanding the chemical formulas involved, interpreting the molar ratios, to executing precise calculations. Let's dissect each step thoroughly.

Understanding the Chemical Context and Reactants

Yttrium Hydroxide ($Y(OH)_3$)

- Chemical Formula: $Y(OH)_3$
- Molecular Composition:
- Yttrium (Y): Atomic number 39
- Hydroxide groups (OH): each consists of 1 oxygen and 1 hydrogen
- Molecular Weight Calculation:
- Atomic weight of Y: approximately 88.91 g/mol
- Atomic weight of O: approximately 16.00 g/mol
- Atomic weight of H: approximately 1.008 g/mol

Therefore,

$$
\text{Molar mass of } Y(OH)_3 = 88.91 + 3 \times (16.00 + 1.008) = 88.91 + 3 \times 17.008 = 88.91 + 51.024 = \mathbf{139.934\,g/mol}
$$

Barium Peroxide (BaO_2)

- Chemical Formula: BaO_2
- Molecular Composition:
- Barium (Ba): atomic weight approximately 137.33 g/mol
- Peroxide ion (O_2^{2-}): contains 2 oxygen atoms per peroxide group

- Molecular Weight Calculation:

$$
\text{Molar mass of } BaO_2 = 137.33 + 2 \times 16.00 = 137.33 + 32.00 = \mathbf{169.33\,g/mol}
$$

Deciphering the Stoichiometric Ratio: 1Y : 2Ba : 3Cu

The ratio provided indicates the molar relationship among yttrium (Y), barium (Ba), and copper (Cu) in the reaction or compound of interest. Although the problem specifically involves $Y(OH)_3$ and BaO_2, the ratio suggests a broader context, likely related to the formation of a complex compound or a synthesis involving these elements.

- Interpretation of the ratio 1Y : 2Ba : 3Cu:

- For every 1 mole of yttrium involved, 2 moles of barium and 3 moles of copper are also involved.
- In the context of the reaction, it probably signifies the molar proportion among the elements in the resulting compound or the reaction pathway.

However, since the problem states "Assuming that you have 0.4 g of $Y(OH)_3$, calculate the mass of BaO_2 required to react stoichiometrically," we need to establish the specific reaction equation involving these reactants and elements. Given the ratio, the key is to identify the molar relationship between $Y(OH)_3$ and BaO_2.

Establishing the Reaction Equation

Given the ratio and common chemical behaviors:

- $Y(OH)_3$ is often involved in reactions forming yttrates or yttrium-based compounds.
- BaO_2 can act as an oxidizing agent or as a source of barium in synthesis.
- The ratio indicates that for each mole of $Y(OH)_3$, 2 moles of BaO_2 are needed.

Assumption:

- The reaction proceeds as:

$$
Y(OH)_3 + 2\ BaO_2 \rightarrow \text{Product(s)}
$$

- Note: The exact products depend on the specific reaction pathway, but since the question asks for the molar ratio, we focus on the molar relationship between reactants.

Therefore, the key is to determine how many moles of $Y(OH)_3$ are present, then apply the ratio to find the required moles of BaO_2.

Calculating the Moles of $Y(OH)_3$ in 0.4 g

- Step 1: Use the molar mass of $Y(OH)_3$:

$$
\text{Moles of } Y(OH)_3 = \frac{\text{Mass of } Y(OH)_3}{\text{Molar mass of } Y(OH)_3} = \frac{0.4\,g}{139.934\,g/mol}
$$

\]

- Step 2: Perform the calculation:

\[
\text{Moles of } Y(OH)_3 = 0.00286\, \text{mol}
\]

(rounded to five decimal places for precision).

Determining the Moles of BaO_2 Required

Based on the molar ratio:

\[
1\, \text{Y} : 2\, \text{Ba} \Rightarrow \text{for each mole of Y(OH)}_3, 2 \text{ moles of } BaO_2 \text{ are required}
\]

- Step 3: Calculate moles of BaO_2:

\[
\text{Moles of BaO}_2 = 2 \times \text{Moles of } Y(OH)_3 = 2 \times 0.00286 = 0.00572\, \text{mol}
\]

Calculating the Mass of BaO_2 Needed

- Step 4: Use molar mass of BaO_2 to find the required mass:

$$
\text{Mass of BaO}_2 = \text{Moles} \times \text{Molar mass} = 0.00572 \times 169.33\,g/mol
$$

- Step 5: Final calculation:

$$
\text{Mass of BaO}_2 = 0.968\,g
$$

Rounded to three decimal places, approximately 0.968 grams of BaO_2 are needed for complete stoichiometric reaction with 0.4 g of $Y(OH)_3$.

Implications and Practical Considerations

Significance of Stoichiometry in Laboratory and Industrial Contexts

- Accurate stoichiometric calculations are essential for:
- Synthesizing desired compounds with high purity.
- Minimizing waste of reagents.
- Ensuring safety in handling reactive chemicals.

- In this scenario, knowing the exact mass of BaO_2 helps avoid excess reagent, which could lead to unwanted side reactions or impurities.

Limitations and Assumptions

- The calculation assumes:
- Complete reaction without losses.
- The molar ratio of 1Y:2Ba:3Cu applies directly between $Y(OH)_3$ and BaO_2.
- The reaction proceeds straightforwardly without intermediate steps or competing reactions.

- Real-world reactions might involve:
- Side reactions.
- Different oxidation states.
- Variations in stoichiometry due to reaction conditions.

Potential Variations and Further Analysis

- If the reaction involves forming complex compounds, the molar ratios might shift, necessitating adjustments.
- Additional steps could involve balancing the entire reaction equation, especially if copper (Cu) is involved.
- Thermodynamic considerations, such as reaction enthalpy and feasibility, are also critical but beyond the scope of this calculation.

Summary of Key Findings

- The molar mass of $Y(OH)_3$: approximately 139.93 g/mol.
- Moles of $Y(OH)_3$ in 0.4 g: approximately 0.00286 mol.
- Molar ratio of BaO_2 to $Y(OH)_3$: 2:1.
- Moles of BaO_2 required: approximately 0.00572 mol.
- Mass of BaO_2 needed: approximately 0.968 g.

This detailed analysis underscores the importance of understanding chemical formulas, molar ratios, and precise calculations in stoichiometry. Whether in research, manufacturing, or academic exercises, such calculations are foundational to controlling chemical

processes effectively.

Final Remarks

Mastering stoichiometric calculations requires a deep understanding of chemical formulas, molar relationships, and mathematical precision. By carefully analyzing each step, chemists can reliably predict reagent quantities, optimize reactions, and ensure safety and efficiency in laboratory and industrial settings. This problem exemplifies the critical role of quantitative reasoning in chemistry, illustrating how a simple mass of a compound can be translated into the precise amount of another reagent needed for a complete reaction.

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