What Is The Maximum Mass Of Lead That Can Be Obtained By The Reaction Of 57.33 G Pbo And 33.80 G Of Pbs

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Understanding the maximum mass of lead obtainable from specific chemical reactions is an essential aspect of stoichiometry, which plays a critical role in chemical engineering, laboratory procedures, and industrial applications. In this article, we will explore the reaction between lead(II) oxide (PbO) and lead sulfide (PbS), focusing on calculating the maximum amount of lead (Pb) that can be produced when starting with 57.33 grams of PbO and 33.80 grams of PbS. This process involves a detailed analysis of the chemical reactions, molar calculations, and the concept of limiting reactants.

Introduction to the Reaction Between PbO and PbS

Lead compounds are common in various industrial processes, including smelting and refining. The specific reaction between lead(II) oxide and lead sulfide is significant because it can lead to the production of metallic lead, which has numerous applications in batteries, radiation shielding, and other fields. Understanding the maximum yield of lead from this reaction helps optimize processes and minimize waste.

Chemical Reactions Involved

The primary chemical reaction between lead(II) oxide (PbO) and lead sulfide (PbS) can be represented as:

Reaction Equation

$$PbO + PbS \rightarrow 2Pb + SO_2$$

This reaction indicates that one mole of PbO reacts with one mole of PbS to produce two moles of metallic lead and sulfur dioxide gas.

Significance of the Reaction

- It demonstrates a reduction process where lead sulfide is oxidized, and lead oxide is reduced.
- The reaction's efficiency depends on the molar ratios and the limiting reactant.

Step-by-Step Calculation of Maximum Lead Yield

To determine the maximum mass of lead obtainable, we must analyze the reaction stoichiometry based on the given quantities of PbO and PbS.

1. Calculate the Molar Masses

- Lead(II) oxide (PbO):
- Pb: 207.2 g/mol
- O: 16.0 g/mol
- **Total: 223.2 g/mol**
- Lead sulfide (PbS):
- Pb: 207.2 g/mol
- S: 32.07 g/mol
- **Total: 239.27 g/mol**

2. Convert Given Masses to Moles

- For PbO:

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Moles of PbO = 57.33 g / 223.2 g/mol ≈ 0.257 mol
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- For PbS:

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Moles of PbS = 33.80 g / 239.27 g/mol ≈ 0.141 mol
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3. Determine the Limiting Reactant

- According to the balanced equation, 1 mol of PbO reacts with 1 mol of PbS.
- We have:
- PbO: 0.257 mol
- PbS: 0.141 mol

- Since 0.141 mol of PbS requires 0.141 mol of PbO to react completely, but we have 0.257 mol of PbO, PbS is the limiting reactant.

4. Calculate the Theoretical Yield of Lead

- From the balanced reaction, 1 mol of PbS produces 2 mol of Pb.
- Therefore, 0.141 mol of PbS will produce:

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Lead (Pb) = 0.141 mol × 2 = 0.282 mol
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- Convert moles of Pb to mass:

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Mass of Pb = 0.282 mol × 207.2 g/mol ≈ 58.4 g
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Thus, the maximum mass of lead that can be obtained is approximately 58.4 grams.

Understanding Limiting Reactants and Theoretical Yields

What Is a Limiting Reactant?

- The limiting reactant is the substance that is completely consumed first during a chemical reaction, limiting the amount of product formed.
- In our case, PbS is the limiting reactant because it is present in fewer molar quantities relative to the amount needed to react with all the PbO.

Calculating Theoretical Yield

- The theoretical yield is the maximum amount of product that can be obtained from a given amount of reactants.
- It is based on the limiting reactant and stoichiometric ratios from the balanced chemical equation.
- Our calculation shows that the maximum lead produced is approximately 58.4 grams.

Practical Considerations and Error Margins

While calculations provide an ideal maximum, real-world yields are often lower due to various factors:
- Incomplete reactions
- Side reactions
- Losses during handling
- Impurities in the reactants

Therefore, actual yields are typically less than the theoretical yield.

Conclusion

Based on the stoichiometric analysis of the reaction between lead(II) oxide and lead sulfide, the maximum mass of lead obtainable from 57.33 grams of PbO and 33.80 grams of PbS is approximately 58.4 grams. This calculation hinges on the identification of the limiting reactant, which in this case is PbS, and the use of molar conversions and balanced chemical equations.

Understanding these concepts is vital in fields such as metallurgy, chemical manufacturing, and laboratory research, where optimizing yields and understanding reaction efficiencies can significantly impact productivity and cost-effectiveness.

Key Takeaways

- The reaction between PbO and PbS produces metallic lead and sulfur dioxide gas.
- Stoichiometry allows us to predict maximum product yields based on reactant quantities.
- Identifying the limiting reactant is crucial for accurate yield calculations.
- The theoretical maximum yield of lead from the given reactants is approximately 58.4 grams.

- Actual yields may vary due to practical factors, but the theoretical yield provides a target for efficiency.

By mastering these calculations and concepts, chemists and engineers can optimize processes involving lead compounds, ensuring maximum productivity while minimizing waste and cost.

Frequently Asked Questions

What is the maximum mass of lead (Pb) obtainable from the reaction of 57.33 g of PbO and 33.80 g of PbS?

The maximum mass of lead obtainable is approximately 40.0 grams.

How do you determine the limiting reagent when reacting PbO with PbS?

By calculating the moles of each reactant and comparing their molar ratios to the balanced chemical equation, the reactant with fewer available moles relative to its stoichiometric requirement is the limiting reagent.

What is the balanced chemical equation for the reaction involving PbO and PbS to produce lead?

The specific reaction depends on the process, but a common reduction is: $PbO + PbS \rightarrow 2Pb + SO_2$.

How do you calculate the theoretical yield of lead in this reaction?

First, convert the given masses of PbO and PbS to moles, identify the limiting reagent, then use its molar amount to find the maximum mass of lead produced using the molar mass of Pb.

What is the molar mass of PbO and PbS used in calculations?

The molar mass of PbO is approximately 223.2 g/mol, and that of PbS is approximately 239.3 g/mol.

What assumptions are made when calculating maximum possible lead yield in this reaction?

It is assumed that the reaction goes to completion with 100% efficiency and that there are no side reactions

or losses.

How does the concept of limiting reagent affect the maximum amount of lead obtained?

The limiting reagent determines the maximum amount of product that can be formed; once it is consumed, no more product can be generated regardless of excess reactant.

Can excess reactants affect the maximum yield of lead in this reaction?

No, excess reactants do not affect the maximum theoretical yield; they simply remain unreacted after the limiting reagent is consumed.

What practical factors could cause the actual yield of lead to be less than the theoretical maximum?

Purity of reactants, incomplete reactions, side reactions, and losses during processing can all reduce the actual yield below the theoretical maximum.

Why is it important to identify the limiting reagent in reactions like this?

Identifying the limiting reagent helps in accurately calculating the maximum possible yield of product and optimizing the reaction process for efficiency.

Additional Resources

What Is The Maximum Mass Of Lead That Can Be Obtained By The Reaction Of 57.33 G PbO And 33.80 G PbS

Understanding the maximum mass of lead that can be obtained through a chemical reaction is essential in fields such as materials science, metallurgy, and chemical engineering. In this guide, we'll explore what is the maximum mass of lead that can be obtained by the reaction of 57.33 g PbO and 33.80 g PbS, providing a detailed step-by-step analysis to determine the theoretical yield based on stoichiometry. This inquiry not only highlights key concepts in chemical reactions and molar calculations but also demonstrates how to approach real-world problem-solving in chemistry.

Introduction

The question about the maximum mass of lead obtainable from specific reactants involves understanding

the reaction mechanisms, stoichiometry, and limiting reagents. When dealing with reactions involving lead compounds such as lead(II) oxide (PbO) and lead sulfide (PbS), we often aim to determine how much pure lead (Pb) can be produced given certain amounts of reactants.

In this context, the key is to identify the limiting reagent—the reactant that will be completely consumed first and thus limits the amount of product formed. Once the limiting reagent is known, calculations can be made to find the maximum possible yield of lead.

Chemical Reactions Involved

To analyze the problem, we must first understand the relevant chemical reactions. Typically, lead compounds like PbO and PbS can be involved in reduction or conversion reactions to produce elemental lead.

Common reactions include:

1. Reduction of PbO to Pb:

$PbO + C \rightarrow Pb + CO$

2. Conversion of PbS to Pb:

$PbS + O_2 \rightarrow Pb + SO_2$ (though this requires oxidation conditions)

However, in many practical scenarios, the reaction of lead oxides and sulfides with suitable reducing agents or under specific conditions can produce metallic lead. For the purpose of this problem, we will assume the reaction involves a process where both reactants are converted into lead, and we are concerned with the theoretical maximum lead obtainable based on reactant amounts.

Step 1: Write the Relevant Chemical Equations

For this analysis, assuming the reactions are:

- PbO reacts with a reducing agent (say carbon) to produce lead:

$PbO + C \rightarrow Pb + CO$

- PbS reacts with oxygen or other oxidants to produce lead:

$PbS + O_2 \rightarrow Pb + SO_2$

Note: Since the problem states the reaction of PbO and PbS, and asks for the maximum lead obtained, we interpret that both reactants can produce lead through their respective reduction pathways, and that the amount of lead produced depends on their initial quantities.

Step 2: Convert Given Masses to Moles

To perform stoichiometric calculations, convert the provided masses to moles.

Molecular weights:

- PbO = 207.2 (Pb) + 16.0 (O) = 223.2 g/mol
- PbS = 207.2 (Pb) + 32.06 (S) = 239.26 g/mol
- Pb (elemental) = 207.2 g/mol

Calculations:

- Moles of PbO = 57.33 g / 223.2 g/mol ≈ 0.257 mol
- Moles of PbS = 33.80 g / 239.26 g/mol ≈ 0.141 mol

Step 3: Determine the Stoichiometry and Limiting Reagent

Assuming the reactions proceed with a 1:1 molar ratio for both PbO and PbS to lead (which is typical in their reduction to elemental lead):

- Each mole of PbO can produce 1 mole of lead.
- Each mole of PbS can produce 1 mole of lead.

Total possible lead production:

- From PbO: 0.257 mol
- From PbS: 0.141 mol

Total potential moles of lead = 0.257 + 0.141 = 0.398 mol

However, to determine the maximum lead obtainable, we need to understand if both reactants fully convert or if one limits the amount of lead produced.

Step 4: Identifying the Limiting Reagent

If both reactions are independent and both lead to lead, then the total potential yield depends on whether the reactions are carried out simultaneously or separately. Since the problem involves both reactants, the key is to see which reactant produces less lead—thus, the limiting reagent.

In this context:

- PbO can produce at most: 0.257 mol of Pb
- PbS can produce at most: 0.141 mol of Pb

The limiting reagent is PbS because it produces fewer moles of lead.

Step 5: Calculating the Maximum Mass of Lead

Given that PbS limits the amount of lead produced, the maximum mass of lead is:

- Moles of lead obtained = 0.141 mol

- Mass of lead = moles × molar mass = 0.141 mol × 207.2 g/mol ≈ 29.23 g

Therefore, the maximum mass of lead obtainable from the reaction, assuming complete conversion of the limiting reagent (PbS), is approximately 29.23 grams.

Summary of Key Findings

- The limiting reagent in the reaction between 57.33 g PbO and 33.80 g PbS is PbS, due to its lower molar quantity.
- The maximum theoretical mass of lead obtainable from the given reactants is approximately 29.23 grams.

Additional Considerations

While the calculation above provides a theoretical maximum, real-world yields are often lower due to factors such as incomplete reactions, side reactions, and purification losses. Nonetheless, understanding the stoichiometry helps chemists optimize processes and predict outcomes accurately.

Practical Implications and Applications

This analysis is vital in industries such as:

- Mining and metallurgy: optimizing lead extraction processes.
- Chemical manufacturing: designing efficient reduction pathways.
- Environmental science: understanding pollutant transformations involving lead compounds.

By mastering the stoichiometry involved in reactions like those between PbO, PbS, and elemental lead, professionals can better estimate yields, minimize waste, and improve process efficiencies.

Final Thoughts

Determining the maximum mass of lead obtained from specific reactants is a classic example of applying fundamental chemistry principles—mole conversions, stoichiometry, and limiting reagent analysis. This process underscores the importance of precise measurements and calculations in achieving desired chemical outputs, whether in laboratory research or industrial applications.

In conclusion, given 57.33 g of PbO and 33.80 g of PbS, the maximum theoretical mass of lead that can be obtained is approximately 29.23 grams, with PbS acting as the limiting reagent in this scenario.

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