How Many Moles Of Ammonia Would Be Required To React Exactly With 0.764 Moles Of Copper(II) Oxide In

How Many Moles Of Ammonia Would Be Required To React Exactly With 0.764 Moles Of Copper(II) Oxide In

Understanding the precise amount of reactants needed in chemical reactions is fundamental to stoichiometry, which allows chemists to predict product yields and plan experiments efficiently. In this article, we will explore how to determine the number of moles of ammonia (NH_3) required to react exactly with 0.764 moles of copper(II) oxide (CuO). This involves examining the chemical reaction between ammonia and copper(II) oxide, balancing the chemical equation, and applying stoichiometric principles to perform accurate calculations. Whether you're a student studying chemistry or a professional chemist, mastering these calculations is essential for experimental accuracy and efficiency.

Understanding the Reaction Between Ammonia and Copper(II) Oxide

Overview of Copper(II) Oxide (CuO)

Copper(II) oxide, CuO, is an inorganic compound known for its black color and is commonly used in ceramics, pigments, and as a catalyst. It is a metal oxide with copper in the +2 oxidation state. CuO can react with various compounds, including acids, bases, and complexing agents.

Properties of Ammonia (NH_3)

Ammonia is a colorless gas with a pungent smell, widely used in fertilizers, cleaning products, and chemical syntheses. It is a weak base that can react with metal oxides to form complex compounds or facilitate reduction reactions.

Reaction Between Ammonia and Copper(II) Oxide

The interaction between ammonia and copper(II) oxide often involves complexation or reduction processes, rather than simple acid-base reactions. One common reaction involves ammonia acting as a ligand, forming a complex with copper ions. Alternatively, ammonia can reduce copper(II) oxide to copper metal under certain conditions, but in the context of stoichiometry, the typical simplified reaction considered is:

Reaction:

$CuO + 2\ NH_3 \rightarrow Cu + N_2 + 3\ H_2O$

Note: This reaction depicts the reduction of copper(II) oxide to copper metal by ammonia, releasing nitrogen gas and water. The balanced equation is crucial for accurate calculations.

Balancing the Chemical Equation

Before calculating mole ratios, it is essential to have a correctly balanced chemical equation.

Balanced Equation:

$CuO + 2\ NH_3 \rightarrow Cu + N_2 + 3\ H_2O$

This equation indicates that:

- 1 mole of copper(II) oxide reacts with 2 moles of ammonia.
- The products are copper metal, nitrogen gas, and water.

Calculating the Required Moles of Ammonia

Given:

- Moles of copper(II) oxide = 0.764 mol

Objective:

- Find the moles of ammonia (NH_3) needed for an exact reaction.

Step-by-Step Calculation

1. Identify the mole ratio from the balanced equation:

Reactant	Coefficient
CuO	1

| NH_3 | 2 |

2. Set up the proportion based on the mole ratio:

Number of moles of NH_3 = Moles of CuO × (Coefficient of NH_3 / Coefficient of CuO)

3. Plug in the known value:

Number of moles of NH_3 = 0.764 mol × (2 / 1) = 1.528 mol

Result: Approximately 1.528 moles of ammonia are required to react exactly with 0.764 moles of copper(II) oxide.

Additional Considerations in Stoichiometric Calculations

While the straightforward calculation above provides the theoretical amount of ammonia needed, real-world scenarios might involve additional factors:

1. Purity of Reactants

- Actual amounts may vary if reactants are not pure.
- Adjust calculations based on purity percentages.

2. Reaction Conditions

- Temperature and pressure can influence reaction completion.
- Some reactions may not proceed to completion or may produce side products.

3. Limiting Reactant Analysis

- Ensuring copper(II) oxide is the limiting reactant helps in optimizing reactant use.
- Excess ammonia might be used to drive the reaction to completion.

4. Yield and Efficiency

- Actual yields are often less than theoretical yields.
- Consider reaction efficiency when planning quantities.

Practical Applications of the Calculation

Understanding the molar requirements for reactions like the one between ammonia and copper(II) oxide has numerous practical applications in industry and research:

1. Industrial Synthesis

- Manufacturing copper complexes or metal deposition processes.
- Ensuring optimal reactant ratios to maximize output and minimize waste.

2. Laboratory Experiments

- Planning reagent quantities for controlled experiments.
- Preventing excess reactant use, thereby reducing costs and hazards.

3. Environmental and Safety Considerations

- Proper calculation prevents excess ammonia release, which can be hazardous.
- Accurate reactant planning contributes to safer laboratory and industrial environments.

Summary and Key Takeaways

- The balanced reaction between copper(II) oxide and ammonia is $CuO + 2\ NH_3 \rightarrow Cu + N_2 + 3\ H_2O$.
- To react exactly with 0.764 moles of CuO, approximately 1.528 moles of ammonia are required.
- Proper stoichiometric calculations are essential for efficient and safe chemical reactions.
- Always consider real-world factors such as purity, reaction conditions, and yield when planning reactions.

Conclusion

Determining the number of moles of ammonia required to react exactly with a given amount of copper(II) oxide involves understanding the balanced chemical equation, applying mole ratios, and performing straightforward calculations. In this case, 1.528 moles of ammonia are needed for 0.764

moles of CuO. Mastery of these principles enables chemists and students alike to plan reactions accurately, optimize resource use, and ensure safety in various chemical processes. Whether in laboratory settings or industrial applications, precise stoichiometric calculations are indispensable tools in the chemist's toolkit.

Frequently Asked Questions

What is the balanced chemical equation for the reaction between ammonia and copper(II) oxide?

The balanced chemical equation is 2 NH_3 + CuO → Cu + 2 NH_2O.

How do I determine the mole ratio between ammonia and copper(II) oxide in the reaction?

From the balanced equation, 2 moles of NH_3 react with 1 mole of CuO, so the mole ratio is 2:1.

How many moles of ammonia are required to react with 0.764 moles of copper(II) oxide?

Using the 2:1 ratio, multiply 0.764 mol CuO by 2 to get 1.528 mol NH_3 needed.

If I have 1.528 moles of ammonia, how much copper(II) oxide can I react with completely?

You can react completely with 0.764 moles of copper(II) oxide, based on the 2:1 ratio.

What is the significance of the mole ratio in stoichiometry calculations?

The mole ratio allows you to convert between quantities of reactants and products based on the balanced chemical equation.

Can I use molarity to determine the amount of ammonia needed in solution?

Yes, if you know the molarity and volume of the ammonia solution, you can calculate the moles required to react with 0.764 moles of CuO.

What practical considerations should I keep in mind when reacting ammonia with copper(II) oxide?

Ensure proper handling of ammonia gas or solution, maintain appropriate reaction conditions, and confirm the reaction is complete for accurate stoichiometry.

Additional Resources

How Many Moles Of Ammonia Would Be Required To React Exactly With 0.764 Moles Of Copper(II) Oxide In

---

Introduction

In the realm of inorganic chemistry, understanding stoichiometric relationships between reactants is fundamental to controlling and predicting chemical reactions. One common scenario involves the reaction of ammonia (NH_3) with metal oxides, such as copper(II) oxide (CuO). Quantifying the precise amount of ammonia needed to react with a given amount of copper(II) oxide is essential for applications ranging from industrial synthesis to laboratory experimentation.

This article explores the detailed stoichiometry involved in the reaction of ammonia with copper(II) oxide, focusing on calculating the exact number of moles of ammonia required to react completely with 0.764 moles of CuO. Through a thorough examination of the reaction mechanism, balanced chemical equations, and step-by-step calculations, the goal is to provide a comprehensive understanding suitable for chemists, students, and professionals interested in inorganic reaction stoichiometry.

Understanding Copper(II) Oxide and Ammonia Reactivity

The Nature of Copper(II) Oxide (CuO)

Copper(II) oxide is a black or brownish solid, characterized by copper in its +2 oxidation state. CuO is amphoteric but commonly acts as a basic oxide, capable of reacting with acids or forming complex compounds with ammonia under specific conditions. In many reactions, CuO can be reduced or can form complex coordination compounds with ammonia molecules, particularly in aqueous environments.

The Reactivity of Ammonia (NH_3)

Ammonia is a weak base and a Lewis base, with a lone pair of electrons that can coordinate with metal ions to form complex compounds. Its role in reactions with metal oxides often involves either basic reactions, complex formation, or reduction processes, depending on reaction conditions.

Identifying the Relevant Reaction(s)

Possible Reaction Pathways

The main reactions of ammonia with copper(II) oxide encompass:

1. Formation of Copper Ammonia Complexes
2. Reduction of CuO to Copper Metal
3. Formation of Copper Ammonia Hydroxide Complexes

Given the typical laboratory conditions and the common reactions, the most relevant pathway for stoichiometric calculations involves the formation of copper-ammonia complexes, particularly tetraamminecopper(II) complexes.

Focused Reaction: Formation of Tetraamminecopper(II) Complex

The primary reaction of interest is the formation of the tetraamminecopper(II) complex ion, $[Cu(NH_3)_4]^{2+}$, from copper(II) oxide in aqueous solution with excess ammonia. This complex forms when ammonia acts as a ligand, coordinating to Cu^{2+} ions.

The Balanced Chemical Equation

Step 1: Copper(II) oxide reacts with water to form copper(II) hydroxide

$CuO + H_2O \rightarrow Cu(OH)_2$

Step 2: Copper(II) hydroxide reacts with ammonia to form the complex

$Cu(OH)_2 + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+} + 2OH^-$

Overall Reaction:

$CuO + H_2O + 4NH_3 \rightarrow [Cu(NH_3)_4]^{2+} + 2OH^-$

This simplified overall reaction illustrates that one mole of CuO, with water, reacts with four moles of ammonia to form the complex ion.

Stoichiometric Calculations

Step 1: Establish the Mole Ratios

From the overall reaction:

- 1 mole of CuO reacts with 4 moles of NH_3

Step 2: Adjust for the Given Quantity of CuO

Given:

- Moles of CuO = 0.764 mol

Calculate the required moles of NH_3:

Number of moles of NH_3 = 4 × Moles of CuO
= 4 × 0.764 mol
= 3.056 mol

Answer:

3.056 moles of ammonia are required to react exactly with 0.764 moles of copper(II) oxide in the formation of the copper-ammonia complex.

Factors Influencing the Reaction and Practical Considerations

Reaction Conditions

- Aqueous Environment: The reactions assume that water is present to convert CuO to $Cu(OH)_2$, facilitating ligand coordination.
- Ammonia Excess: Typically, an excess of ammonia is used to drive complex formation; however, for stoichiometric purposes, the minimal amount is calculated as above.
- Temperature and pH: These can influence the formation of complexes and the extent of reaction.

Variations in Reaction Pathways

In different conditions, ammonia can also reduce CuO to metallic copper or form other complexes, potentially altering the molar ratios. Nonetheless, the pathway considered here is the most common in aqueous complex formation.

Broader Implications and Applications

Industrial and Laboratory Relevance

Understanding the precise molar requirements is critical in:

- Designing synthesis protocols for copper-ammonia complexes
- Calculating reagent quantities in analytical chemistry
- Developing processes for copper recovery or nanomaterial synthesis

Environmental and Safety Considerations

Ammonia is a hazardous chemical, and precise stoichiometry helps minimize waste and manage reaction safety effectively.

Summary and Key Takeaways

- The stoichiometric relationship between copper(II) oxide and ammonia depends on the specific reaction pathway.
- For complex formation, 1 mol of CuO reacts with 4 mol of NH_3.
- Given 0.764 mol of CuO, approximately 3.056 mol of ammonia are needed for complete reaction under ideal conditions.
- Real-world applications may require adjustments based on reaction conditions, excess reagents, and specific experimental goals.

Conclusion

Accurately determining the amount of ammonia required to react with a set quantity of copper(II) oxide hinges on understanding the underlying chemistry and the specific reaction pathway involved. In the commonly studied complex formation involving tetraamminecopper(II), the molar ratio of ammonia to copper oxide is 4:1. Therefore, for 0.764 moles of CuO, around 3.056 moles of ammonia are necessary to achieve complete reaction. This precise stoichiometric insight aids chemists in designing efficient, safe, and cost-effective experimental or industrial processes involving copper and ammonia chemistry.

References

- Housecroft, C. E., & Sharpe, A. G. (2012). Inorganic Chemistry (4th ed.). Pearson Education.
- Atkins, P., & de Paula, J. (2014). Atkins' Physical Chemistry (10th ed.). Oxford University Press.
- Miessler, G. L., & Tarr, D. A. (2010). Inorganic Chemistry (4th ed.). Pearson Education.
- Chang, R., & Goldsby, K. (2016). Chemistry. McGraw-Hill Education.

This detailed exploration provides a thorough understanding of the stoichiometry involved in reacting ammonia with copper(II) oxide, equipping readers with fundamental insights applicable to both academic and practical chemistry contexts.

How Many Moles Of Ammonia Would Be Required To React Exactly With 0 764 Moles Of Copper Ii Oxide In

How Many Moles Of Ammonia Would Be Required To React Exactly With 0 764 Moles Of Copper Ii Oxide In

Related Articles

- Joshua Is 1.45 Meters Tall. At 2 P.m., He Measures The Length Of A Tree's Shadow To Be 31.65 Meters.
- Imagine You Start Room Temperature Water And Hot Copper. If You Place The Copper Into The Water What
- Jermaine And Kesha Are Married, File A Joint Tax Return, Have AGI Of $82,500, And Have Two Children.

Back to Home