Calculate The Mass Of Solid Agcl That Is Produced When 525ml Of .35 M Alcl3 Is Used With Excess Ag2so4

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Understanding the chemical reactions and stoichiometry involved in the formation of silver chloride (AgCl) is essential for students and professionals working in chemistry laboratories and industries. In this comprehensive guide, we will explore how to accurately calculate the mass of solid AgCl produced when a specific volume and concentration of aluminum chloride ($AlCl_3$) react with excess silver sulfate (Ag_2SO_4). We will cover the fundamental concepts, step-by-step calculations, and practical considerations to ensure precise results. Whether you're a student preparing for exams or a chemist involved in experimental protocols, this article will serve as an invaluable resource.

Introduction to the Chemical Reaction

Before diving into the calculations, it's important to understand the underlying chemical principles and the balanced reactions involved.

Key Chemicals Involved

- Aluminum chloride ($AlCl_3$)
- Silver sulfate (Ag_2SO_4)
- Silver chloride (AgCl), the precipitate
- The solvent, typically water

Reaction Overview

When aluminum chloride reacts with silver sulfate in aqueous solution, a double displacement (metathesis) reaction occurs, resulting in the formation of silver chloride (a solid precipitate) and aluminum sulfate in solution.

The overall reaction can be written as:

\[3Ag_2SO_4 (aq) + 2AlCl_3 (aq) \rightarrow 6AgCl (s) + Al_2(SO_4)_3 (aq) \]

This balanced chemical equation indicates that 2 moles of $AlCl_3$ react with 3 moles of Ag_2SO_4 to produce 6 moles of AgCl.

Understanding the Reactants and Their Quantities

To determine the mass of AgCl produced, we need to analyze the initial quantities of reactants, specifically aluminum chloride.

Given Data

- Volume of $AlCl_3$ solution: 525 mL
- Concentration of $AlCl_3$: 0.35 M (moles per liter)
- Excess Ag_2SO_4: present in sufficient quantity to react completely with $AlCl_3$

Step 1: Convert Volume to Liters

Since molarity is expressed in mol/L, convert the volume from milliliters to liters:

$$ 525 \text{ mL} = 0.525 \text{ L} $$

Step 2: Calculate Moles of $AlCl_3$

Using the molarity formula:

$$ \text{Moles of AlCl}_3 = \text{Molarity} \times \text{Volume in liters} $$

$$ = 0.35 \, \text{mol/L} \times 0.525 \, \text{L} $$

$$ = 0.18375 \text{ mol} $$

Thus, the reaction involves approximately 0.18375 moles of $AlCl_3$.

Stoichiometry of the Reaction

The balanced chemical equation provides the molar ratio between reactants and products.

Key Stoichiometric Ratios

- 2 mol $AlCl_3$ reacts with 3 mol Ag_2SO_4
- 2 mol $AlCl_3$ produces 6 mol AgCl

From the molar ratio, we can determine the moles of AgCl produced per mole of $AlCl_3$:

$$ \frac{6 \text{ mol AgCl}}{2 \text{ mol AlCl}_3} = 3 \text{ mol AgCl per mol AlCl}_3 $$

Therefore, for 0.18375 mol of $AlCl_3$:

$$ \text{Moles of AgCl} = 0.18375 \times 3 = 0.55125 \text{ mol} $$

Calculating the Mass of Silver Chloride (AgCl)

To find the mass of AgCl formed, we need the molar mass of AgCl.

Molar Mass of AgCl

- Atomic mass of Ag (Silver): approximately 107.87 g/mol
- Atomic mass of Cl (Chlorine): approximately 35.45 g/mol

$$
\text{Molar mass of AgCl} = 107.87 + 35.45 = 143.32 \text{ g/mol}
$$

Mass Calculation

Multiply the moles of AgCl by its molar mass:

$$
\text{Mass of AgCl} = 0.55125 \text{ mol} \times 143.32 \text{ g/mol} \approx 78.92 \text{ g}
$$

Result: Approximately 78.92 grams of solid AgCl will be produced.

Additional Considerations and Practical Applications

While the theoretical calculation provides an ideal estimate, real-world factors can influence the actual yield.

Factors Affecting Actual Yield

- Purity of reactants: Impurities can reduce yield.
- Reaction completion: Excess Ag_2SO_4 ensures complete reaction, but incomplete mixing or reaction conditions may affect efficiency.
- Precipitate recovery: Losses during filtration or drying can impact the final mass.
- Measurement accuracy: Precise measurement of solutions and careful weighing are essential for accuracy.

Practical Applications

- Industrial manufacturing: Producing AgCl for photographic films, disinfectants, or optical applications.
- Laboratory experiments: Demonstrating precipitation reactions and stoichiometry.
- Environmental chemistry: Understanding waste treatment involving silver and sulfate compounds.

Summary of Key Steps for Calculating AgCl Mass

1. Convert volume to liters: 525 mL = 0.525 L
2. Calculate moles of $AlCl_3$: 0.35 mol/L × 0.525 L = 0.18375 mol
3. Use molar ratios to find moles of AgCl: 0.18375 mol $AlCl_3$ × 3 mol AgCl / 2 mol $AlCl_3$ = 0.55125 mol
4. Calculate mass of AgCl: 0.55125 mol × 143.32 g/mol ≈ 78.92 g

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Conclusion

By carefully analyzing the chemical reaction between aluminum chloride and silver sulfate, and applying stoichiometric principles, we can confidently determine that approximately 78.92 grams of solid AgCl are produced when 525 mL of 0.35 M $AlCl_3$ reacts with excess Ag_2SO_4. This calculation underscores the importance of understanding molarity, balanced equations, and molar mass in quantitative chemistry. Such precise calculations are fundamental in laboratory settings and industrial processes, ensuring optimal resource utilization and product quality.

Frequently Asked Questions (FAQs)

1. **Can the actual yield differ from the theoretical yield?** Yes, due to experimental errors, impurities, and incomplete reactions, the actual yield may be lower than the theoretical calculation.

2. **What is the significance of using excess Ag_2SO_4?** It ensures complete reaction of $AlCl_3$, allowing for maximum production of AgCl without limiting the reaction.

3. **How can I improve the accuracy of my measurements?** Use calibrated equipment, maintain consistent reaction conditions, and perform multiple trials for averaging results.

4. **Are there safety considerations when handling chemicals like AgCl and $AlCl_3$?** Yes, always wear appropriate personal protective equipment, work in well-ventilated areas, and dispose of chemicals according to safety regulations.

In summary, mastering the calculation of precipitate mass in chemical reactions is a vital skill in chemistry. By understanding the reaction mechanisms, stoichiometry, and molar relationships, you can accurately determine product yields, optimize processes, and advance your scientific knowledge.

Frequently Asked Questions

How do you calculate the mass of AgCl produced when reacting 525 mL of 0.35 M $AlCl_3$ with excess Ag_2SO_4?

First, determine the moles of $AlCl_3$: 0.525 L × 0.35 mol/L = 0.18375 mol. From the balanced equation, 1 mol $AlCl_3$ produces 3 mol AgCl. So, moles of AgCl = 0.18375 mol × 3 = 0.55125 mol. Then, multiply by the molar mass of AgCl (143.32 g/mol): 0.55125 mol × 143.32 g/mol ≈ 79.0 g. Therefore, approximately 79.0 grams of AgCl are produced.

What is the balanced chemical equation for the reaction between $AlCl_3$ and Ag_2SO_4?

The balanced equation is: $2\ AlCl_3 + 3\ Ag_2SO_4 \rightarrow 6\ AgCl + Al_2(SO_4)_3$.

Why is excess Ag_2SO_4 used in the reaction to produce AgCl from $AlCl_3$?

Excess Ag_2SO_4 ensures that all the $AlCl_3$ reacts completely, maximizing the formation of AgCl and driving the reaction to completion without limiting reagents.

How does the concentration of $AlCl_3$ affect the amount of AgCl produced in this reaction?

The amount of AgCl produced is directly proportional to the initial amount (moles) of $AlCl_3$. Higher concentration or volume of $AlCl_3$ increases the moles of $AlCl_3$, leading to more AgCl formed, assuming excess Ag_2SO_4.

What is the molar mass of silver chloride (AgCl), and why is it important in this calculation?

The molar mass of AgCl is approximately 143.32 g/mol. It is essential for converting moles of AgCl produced into mass, allowing us to determine the actual quantity of solid AgCl formed.

Additional Resources

Calculate The Mass Of Solid Agcl That Is Produced When 525ml Of .35 M Alcl3 Is Used With Excess Ag2so4

Understanding chemical reactions and stoichiometry is fundamental in chemistry, especially when it comes to calculating the amounts of products formed during a reaction. Today, we delve into a classic example involving silver chloride (AgCl), aluminum chloride ($AlCl_3$), and silver sulfate (Ag_2SO_4). Specifically, we aim to determine the mass of solid AgCl produced when 525 mL of a 0.35 M $AlCl_3$ solution reacts with excess Ag_2SO_4. This problem not only highlights the importance of mole concepts and balanced chemical equations but also demonstrates practical applications in laboratory and industrial settings.

Understanding the Reaction: The Chemical Equation

Before diving into calculations, it's essential to understand the chemical reaction taking place. The problem involves aluminum chloride reacting with silver sulfate to produce silver chloride and aluminum sulfate. Let's first write the balanced chemical equation.

Unbalanced Reaction:

$AlCl_3 + Ag_2SO_4 \rightarrow AgCl + Al_2(SO_4)_3$

However, to ensure accuracy, we need to balance this equation properly.

Balancing the Chemical Equation:

1. Write the unbalanced formula:

$AlCl_3 + Ag_2SO_4 \rightarrow AgCl + Al_2(SO_4)_3$

2. Balance aluminum (Al):

- Aluminum appears as $AlCl_3$ and $Al_2(SO_4)_3$.

- To balance Al, put a coefficient of 2 in

front of $AlCl_3$:

$2\ AlCl_3 + Ag_2SO_4 \rightarrow AgCl + Al_2(SO_4)_3$

3. Balance sulfate (SO_4):

- On the right, $Al_2(SO_4)_3$ contains 3 sulfate groups.

- On the left, Ag_2SO_4 contains 1 sulfate group. To match 3 sulfate groups, multiply Ag_2SO_4 by 3:

$2\ AlCl_3 + 3\ Ag_2SO_4 \rightarrow AgCl + Al_2(SO_4)_3$

4. Balance silver (Ag):

- On the left, $3\ Ag_2SO_4$ has $3 \times 2 = 6$ Ag atoms.

- On the right, each AgCl contains 1 Ag atom; to get 6 Ag atoms, we need 6 AgCl molecules:

$2\ AlCl_3 + 3\ Ag_2SO_4 \rightarrow 6\ AgCl + Al_2(SO_4)_3$

5. Final check:

- Aluminum: 2 on both sides.

- Chlorine: $2 \times 3 = 6$ Cl on the left; 6 Cl in 6 AgCl on the right.

- Silver: 6 on both sides.

- Sulfate: 3 on both sides.

Balanced Equation:

$2\ AlCl_3 + 3\ Ag_2SO_4 \rightarrow 6\ AgCl + Al_2(SO_4)_3$

This balanced equation indicates that 2 moles of aluminum chloride react with 3 moles of silver sulfate to produce 6 moles of silver chloride and 1 mole of aluminum sulfate.

Calculating Moles of Aluminum Chloride ($AlCl_3$) Used

The first step involves determining the number of moles of $AlCl_3$ present in the given solution.

Given Data:

- Volume of $AlCl_3$ solution = 525 mL = 0.525 L

- Concentration of $AlCl_3$ = 0.35 M (moles per liter)

Calculation:

Number of moles of $AlCl_3$ = concentration × volume

= 0.35 mol/L × 0.525 L

= 0.18375 mol

Result:

Approximately 0.18375 moles of $AlCl_3$ are present in the solution.

Determining Moles of Silver Chloride (AgCl) Produced

Using the stoichiometric relationship from the balanced equation, we can find out how many moles of AgCl are formed from the reactant amount.

Understanding the Mole Ratio:

From the balanced equation:

$2\ AlCl_3 : 6\ AgCl$

This simplifies to:

$1\ AlCl_3 : 3\ AgCl$

Meaning, for every 1 mole of $AlCl_3$ reacted, 3 moles of AgCl are produced.

Calculation:

Number of moles of AgCl = moles of $AlCl_3$ × (3 moles AgCl / 1 mole $AlCl_3$)

= 0.18375 mol × 3

= 0.55125 mol

Result:

Approximately 0.55125 moles of AgCl are expected to be formed.

Calculating the Mass of Silver Chloride (AgCl) Formed

Now that we have the moles of AgCl produced, converting this to mass involves using the molar mass of AgCl.

Molar Mass of AgCl:

- Silver (Ag): approximately 107.87 g/mol

- Chlorine (Cl): approximately 35.45 g/mol

Total molar mass of AgCl = 107.87 + 35.45 = 143.32 g/mol

Calculation:

Mass of AgCl = moles × molar mass

= 0.55125 mol × 143.32 g/mol

≈ 78.94 grams

Final Result:

Approximately 78.94 grams of solid AgCl are produced under the given conditions.

Additional Considerations and Assumptions

While the above calculations provide a clear estimate, several factors could influence the actual amount of AgCl obtained in a practical setting:

- Excess Reactant: The problem states that Ag_2SO_4 is in excess, so the limiting reagent is $AlCl_3$. This ensures all $AlCl_3$ reacts completely.

- Purity of Reactants: Impurities in reactants could affect yields.

- Reaction Conditions: Temperature, agitation, and purity of solutions can influence the completeness of the reaction.

- Precipitation Efficiency: In laboratory conditions, the removal of AgCl might not be 100% efficient, leading to slightly less recovered solid.

Practical Applications and Significance

Understanding the stoichiometry of such reactions is vital in various fields:

- Industrial Synthesis: Precise calculation of product yields helps optimize manufacturing processes, especially in producing silver compounds for photographic, electronic, or photographic applications.

- Analytical Chemistry: Quantitative analysis often involves calculating product amounts based on reactants, critical for quality control.

- Environmental Chemistry: Knowing how much of a compound precipitates can assist in understanding pollutant removal processes.

Summary and Key Takeaways

- The balanced chemical equation for the reaction between aluminum chloride and silver sulfate is:

$$2\ AlCl_3 + 3\ Ag_2SO_4 \rightarrow 6\ AgCl + Al_2(SO_4)_3$$

- 525 mL of 0.35 M $AlCl_3$ contains approximately 0.18375 moles of $AlCl_3$.

- This amount of $AlCl_3$ yields about 0.55125 moles of AgCl, assuming complete reaction.

- The mass of AgCl produced is approximately 78.94 grams.

- Accurate stoichiometric calculations require understanding molar ratios, molar masses, and reaction conditions.

In conclusion, by carefully analyzing the chemical reaction, applying stoichiometry principles, and performing step-by-step calculations, we can determine that approximately 78.94 grams of solid AgCl are produced when 525 mL of 0.35 M $AlCl_3$ reacts with excess Ag_2SO_4. This process exemplifies the importance of precise quantitative analysis in chemistry, bridging theoretical knowledge with practical application.

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