What Mass Of Na2so4 Is Needed To Prepare 350. Ml Of A Solution Having A Sodium Ion Concentration Of 0.125

What Mass Of Na2SO4 Is Needed To Prepare 350. Ml Of A Solution Having A Sodium Ion Concentration Of 0.125

Preparing a solution with a specific concentration requires an understanding of the relationship between the solute's mass, the solution volume, and the desired molarity or ion concentration. In this case, the goal is to determine how much sodium sulfate (Na_2SO_4) is needed to prepare 350 mL of a solution that contains a sodium ion (Na^+) concentration of 0.125 mol/L. This process involves calculating the amount of sodium ions present in the solution and then determining the corresponding amount of Na_2SO_4 that supplies these ions.

Understanding the Basics of Solution Concentrations

Before diving into calculations, it’s essential to understand key concepts related to solution concentrations:

1. Molarity (M)

- Molarity is expressed as moles of solute per liter of solution (mol/L).
- It indicates the concentration of a particular ion or compound in a solution.

2. Ionic Concentration

- The concentration of specific ions (such as Na^+) depends on the amount of solute dissolved.
- For salts like Na_2SO_4, the total molarity relates to the concentration of its constituent ions based on the chemical formula.

3. Molar Mass

- Molar mass of Na_2SO_4 = 142.04 g/mol.
- Na: 22.99 g/mol
- S: 32.07 g/mol
- O: 16.00 g/mol (×4 for four oxygen atoms)

Step-by-Step Calculation Process

The process involves several key steps:

Step 1: Convert the solution volume to liters

- Since molarity is in mol/L, convert 350 mL to liters:

350 mL = 0.350 L

Step 2: Determine the amount of sodium ions needed

- Given sodium ion concentration = 0.125 mol/L
- Total moles of Na^+ required:

Moles of Na^+ = concentration × volume = 0.125 mol/L × 0.350 L = 0.04375 mol

Step 3: Find the relationship between Na_2SO_4 and Na^+ ions

- The chemical formula Na_2SO_4 indicates each formula unit contains 2 Na^+ ions.
- Therefore, the number of Na_2SO_4 formula units needed:

Moles of Na_2SO_4 = Moles of Na^+ / 2 = 0.04375 mol / 2 = 0.021875 mol

Step 4: Calculate the mass of Na_2SO_4 required

- Using molar mass:

Mass of Na_2SO_4 = moles × molar mass = 0.021875 mol × 142.04 g/mol ≈ 3.107 g

Result: Approximately 3.11 grams of Na_2SO_4 are needed to prepare 350 mL of solution with a sodium ion concentration of 0.125 mol/L.

Additional Considerations

While the calculation above provides a straightforward answer, there are important factors to consider:

1. Purity of the Na_2SO_4

- The calculation assumes pure Na_2SO_4.
- If the salt has impurities, adjust the mass accordingly.

2. Dissolution and Volume Change

- Dissolving Na_2SO_4 in water may slightly change the volume.
- For precise work, measure the final volume after dissolution.

3. Experimental Accuracy

- Use accurate weighing scales.
- Ensure complete dissolution of the salt.

4. Safety Precautions

- Handle chemicals with appropriate safety gear.
- Follow standard lab safety protocols.

Practical Tips for Preparing the Solution

To ensure accurate preparation, follow these practical steps:

1. Calculate the exact mass of Na_2SO_4 needed as per your desired concentration.

2. Use a clean, dry container to weigh the salt accurately.

3. Gradually add the salt to a volumetric flask containing some distilled water.

4. Swirl or stir until the salt fully dissolves.

5. Adjust the volume to 350 mL with distilled water, ensuring the solution is well mixed.

6. Label the container with the concentration and date for reference.

Understanding the Importance of Accurate Calculations in Chemistry

Accurate chemical calculations are fundamental in laboratory practices, ensuring the reproducibility and reliability of experiments. Whether preparing solutions for titrations, reactions, or analytical procedures, precise measurements determine the success and safety of chemical processes.

Common Errors to Avoid

- Incorrect unit conversions: Always convert volumes to liters before calculations.
- Ignoring ion ratios: Remember that salts dissociate into ions; consider stoichiometry.
- Using impure chemicals: Purity affects the actual concentration.
- Not accounting for solution volume change: Dissolution might slightly alter the total volume.

Summary of Key Points

- To prepare 350 mL of a solution with a Na^+ concentration of 0.125 mol/L, approximately 3.11 grams of pure Na_2SO_4 are required.
- The calculation involves converting volume to liters, determining moles of Na^+ needed, relating Na_2SO_4 to Na^+ ions based on its formula, and finally calculating mass using molar mass.
- Practical preparation involves careful weighing, complete dissolution, and volume adjustment.

Related Topics for Further Study

- Dilution calculations and preparing solutions of desired concentration
- Understanding electrolyte dissociation and ionic strength
- Titration techniques involving sodium salts
- Stoichiometry and mole concepts in solution chemistry
- Safety procedures in handling chemical reagents

Conclusion

Preparing solutions with specific ionic concentrations is a fundamental skill in chemistry laboratories. By understanding the relationship between the amount of solute, solution volume, and ion concentration, chemists can accurately prepare solutions tailored for various experiments. In this scenario, approximately 3.11 grams of Na_2SO_4 are needed to produce 350 mL of a solution with a sodium ion concentration of 0.125 mol/L. Precise calculations and careful laboratory techniques ensure reliable results and uphold safety standards.

Meta Description: Learn how to calculate the exact mass of Na_2SO_4 needed to prepare 350 mL of solution with a sodium ion concentration of 0.125 mol/L. Step-by-step guide with detailed explanations.

Frequently Asked Questions

How do you calculate the mass of Na_2SO_4 needed to prepare 350 mL of solution with a sodium ion concentration of 0.125 M?

First, determine the number of moles of Na^+ required: 0.125 mol/L × 0.350 L = 0.04375 mol. Since each Na_2SO_4 molecule provides 2 Na^+ ions, the moles of Na_2SO_4 needed are 0.04375 mol / 2 = 0.021875 mol. Then, multiply by the molar mass of Na_2SO_4 (142.04 g/mol): 0.021875 mol × 142.04 g/mol ≈ 3.11 grams.

What is the molar mass of sodium sulfate (Na_2SO_4)?

The molar mass of Na_2SO_4 is approximately 142.04 grams per mole.

Why do we divide the moles of sodium ions by 2 when calculating the mass of Na_2SO_4?

Because each molecule of Na_2SO_4 contains 2 sodium ions, so the total moles of Na_2SO_4 needed are half the moles of sodium ions required.

If the desired sodium ion concentration is 0.125 M in 350 mL solution, what is the total number of sodium ions present?

Total sodium ions = concentration × volume = 0.125 mol/L × 0.350 L = 0.04375 mol of Na^+ ions.

How does the volume of solution affect the mass of Na_2SO_4 needed for a specific concentration?

The larger the volume, the greater the number of moles of Na^+ required, which increases the mass of Na_2SO_4 needed proportionally, since mass depends on moles calculated from the concentration and volume.

What are the key steps to prepare a solution with a specific sodium ion concentration from Na_2SO_4?

Determine the total moles of Na^+ needed based on the desired concentration and volume, convert that to moles of Na_2SO_4 considering its formula (dividing by 2), and then calculate the mass by multiplying the moles by the molar mass of Na_2SO_4.

Additional Resources

Determining the Mass of Na_2SO_4 Needed to Prepare a Specific Sodium Ion Concentration in Solution

In the realm of chemistry, preparing solutions with precise concentrations is fundamental to a myriad of scientific, industrial, and pharmaceutical processes. Among these, calculating the amount of a solute required to achieve a desired concentration involves a thorough understanding of chemical formulas, molar relationships, and solution preparation techniques. This article delves into the detailed methodology of determining the mass of sodium sulfate (Na_2SO_4) necessary to prepare 350 mL of solution with a specific sodium ion (Na^+) concentration of 0.125 mol/L. Through comprehensive explanations, step-by-step calculations, and analytical insights, readers will gain an in-depth understanding of the principles involved in solution preparation and molar calculations.

Understanding the Fundamentals: Key Concepts and Definitions

What is Na_2SO_4 and Why is It Used?

Sodium sulfate (Na_2SO_4) is an inorganic salt commonly used in various applications including detergents, paper manufacturing, and as a laboratory reagent. It is a soluble salt, meaning it dissolves readily in water, dissociating into its constituent ions. Its chemical formula indicates that each formula unit comprises two sodium ions (Na^+) and one sulfate ion (SO_4^{2-}).

Solution Concentration and Its Measurement

The concentration of a solution typically refers to the amount of solute dissolved in a specified volume of solution. The molarity (M) is the most common unit, defined as moles of solute per liter of solution (mol/L). In this context, a sodium ion concentration of 0.125 mol/L indicates that each liter of the prepared solution contains 0.125 moles of Na^+ ions.

Relationship Between Na_2SO_4 and Na^+ Ions

Since Na_2SO_4 dissociates completely in water, the relationship between the amount of Na_2SO_4 and Na^+ ions in solution is governed by its stoichiometry:

$Na_2SO_4 \rightarrow 2\ Na^+ + SO_4^{2-}$

This indicates that each mole of Na_2SO_4 yields two moles of Na^+ ions. Consequently, to achieve a certain sodium ion concentration, the amount of Na_2SO_4 needed must be calculated accordingly.

Step-by-Step Calculation Process

Step 1: Convert the Desired Solution Volume to Liters

Since molarity is expressed per liter, convert the given volume:

Volume = 350 mL = 0.350 L

Step 2: Determine the Moles of Na^+ Required

Given the sodium ion concentration (C_{Na^+}):

$C_{Na^+} = 0.125$ mol/L

Total moles of Na^+ needed:

$n_{Na^+} = C_{Na^+} \times \text{Volume} = 0.125\ \text{mol/L} \times 0.350\ \text{L} = 0.04375\ \text{mol}$

Step 3: Calculate the Moles of Na_2SO_4 Needed

Since each mole of Na_2SO_4 yields 2 moles of Na^+ ions, the moles of Na_2SO_4 required:

$n\_Na_2SO_4 = n\_Na^+ / 2 = 0.04375 \text{ mol} / 2 = 0.021875 \text{ mol}$

Step 4: Find the Molar Mass of Na_2SO_4

To convert moles to grams, determine the molar mass:

- Sodium (Na): 22.99 g/mol
- Sulfur (S): 32.07 g/mol
- Oxygen (O): 16.00 g/mol

Calculating:

Molar mass of $Na_2SO_4 = (2 \times 22.99) + 32.07 + (4 \times 16.00)$
$= 45.98 + 32.07 + 64.00$
$= 141.05$ g/mol

Step 5: Calculate the Mass of Na_2SO_4 Required

Mass (m) = moles × molar mass:

$m\_Na_2SO_4 = 0.021875 \text{ mol} \times 141.05 \text{ g/mol} \approx 3.084 \text{ g}$

Analytical Perspectives and Practical Considerations

Significance of Accurate Calculations in Laboratory Settings

Precision in solution preparation directly influences experimental outcomes, reproducibility, and safety. Slight deviations in the amount of solute can lead to significant variations in concentration, especially in reactions sensitive to molarity changes.

Purity of the Reagent and Its Effect on Calculations

In real-world scenarios, reagents are rarely 100% pure. Laboratory-grade Na_2SO_4 often contains impurities or moisture, which can affect the actual mass needed. If the reagent is not pure, the calculated mass must be adjusted based on the purity percentage.

Dissolution and Homogeneity

Once the calculated mass of Na_2SO_4 is weighed out, it should be dissolved thoroughly in a portion of distilled water before diluting to the final volume. Proper mixing ensures uniform ion distribution, critical for accurate concentration.

Alternative Approaches and Verification

Analytical techniques such as titration or spectrophotometry can be employed to verify the concentration of the prepared solution. These methods serve as quality control measures, confirming that the theoretical calculations align with actual results.

Broader Implications and Applications

Industrial and Pharmaceutical Relevance

Accurate preparation of solutions with specified ionic concentrations is vital in pharmaceutical formulations where ionic balance impacts drug efficacy and stability. In industrial processes, such precise calculations optimize resource use and process efficiency.

Environmental and Safety Considerations

Handling chemicals like Na_2SO_4 requires adherence to safety protocols. Proper calculation and labeling prevent overuse or accidental misuse, which could lead to environmental contamination or health hazards.

Educational Value and Skill Development

Mastering such calculations enhances understanding of stoichiometry, solution chemistry, and quantitative analysis—core competencies in chemistry education. It fosters analytical thinking, attention to detail, and problem-solving skills.

Conclusion

The process of determining the mass of sodium sulfate necessary to prepare a solution with a specific sodium ion concentration exemplifies the intersection of theoretical chemistry and practical laboratory application. By understanding the dissociation of Na_2SO_4, translating concentration requirements into moles, and converting these into measurable quantities, scientists and students alike can achieve precise and reliable results. This meticulous approach underscores the importance of foundational chemical principles in real-world contexts, ensuring accurate experimentation and safe, effective chemical handling. As science advances, such detailed calculations remain essential tools in the arsenal of chemists, underpinning innovations across diverse fields.

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