If 3.90 G Of CuNO3 Is Dissolved In Water To Make A 0.840 M Solution, What Is The Volume Of The Solution

If 3.90 G Of CuNO3 Is Dissolved In Water To Make A 0.840 M Solution, What Is The Volume Of The Solution is a common chemistry problem that involves understanding molarity, molar mass, and solution preparation. Whether you're a student preparing for exams or a chemistry enthusiast interested in solution chemistry, grasping how to calculate the volume of a solution based on the mass of solute and molarity is fundamental. This article provides a comprehensive explanation of the concepts involved, step-by-step calculations, and tips for solving similar problems efficiently.

Understanding the Problem: Key Concepts and Definitions

Before diving into the calculations, it’s essential to understand the fundamental concepts related to solutions and molarity.

What is Molarity?

Molarity (M) is a measure of concentration that expresses the number of moles of solute dissolved in one liter of solution. It is defined as:

$$\text{Molarity (M)} = \frac{\text{moles of solute}}{\text{liters of solution}}$$

In our problem, the molarity is given as 0.840 M, meaning there are 0.840 moles of CuNO3 in one liter of solution.

What is the Molar Mass of CuNO3?

Calculating the molar mass of CuNO3 is essential to convert the given mass of the solute into moles. The atomic masses (approximate) are:

- Copper (Cu): 63.55 g/mol
- Nitrogen (N): 14.01 g/mol
- Oxygen (O): 16.00 g/mol

The chemical formula CuNO3 suggests:

$$\text{CuNO}_3 = \text{Cu} + \text{N} + 3 \times \text{O}$$

Calculating the molar mass:

$$
\begin{aligned}
\text{Molar mass of CuNO}_3 &= 63.55 + 14.01 + (3 \times 16.00) \\
&= 63.55 + 14.01 + 48.00 \\
&= 125.56 \text{ g/mol}
\end{aligned}
$$

Step-by-Step Solution to Find the Volume of the Solution

The main goal is to determine the volume (in liters or milliliters) of the solution prepared when 3.90 g of CuNO3 is dissolved to produce a 0.840 M solution.

Step 1: Convert the Mass of CuNO3 to Moles

Using the molar mass:

$$
\text{Number of moles} = \frac{\text{mass}}{\text{molar mass}} = \frac{3.90 \text{ g}}{125.56 \text{ g/mol}}
$$

Calculating:

$$
\text{Moles of CuNO}_3 = 0.03106 \text{ mol}
$$

Step 2: Use Molarity to Find the Volume

Since molarity is defined as moles per liter, rearranged as:

$$
\text{Volume} = \frac{\text{moles of solute}}{\text{molarity}}
$$

Substituting the known values:

$$
\

$$
\text{Volume} = \frac{0.03106 \text{ mol}}{0.840 \text{ mol/L}} \approx 0.03700 \text{ L}
$$

Converting liters to milliliters:

$$
0.03700 \text{ L} \times 1000 = 37.00 \text{ mL}
$$

Final answer: The volume of the solution is approximately 37.00 mL.

Additional Insights and Practical Tips

Understanding this calculation process enhances your ability to solve related problems efficiently. Here are some key points and tips:

Key Points to Remember

- Always start by converting the given mass of solute to moles using the molar mass.
- Use the molarity formula to find the volume of the solution.
- Ensure units are consistent; convert volume to liters when using molarity, then convert to milliliters if needed.
- Use precise atomic weights for more accurate calculations, especially in laboratory settings.

Common Mistakes to Avoid

- Forgetting to convert grams to moles.
- Mixing units (e.g., using grams and molarity directly without conversion).
- Incorrectly calculating the molar mass, especially with complex compounds.
- Misinterpreting the problem by confusing the amount of solute with the total solution volume.

Example Variations

To deepen your understanding, consider practicing similar problems:
- What volume of solution is prepared if 5.00 g of $CuNO3$ is dissolved to make a 1.00 M solution?
- How much mass of $CuNO3$ is needed to prepare 250 mL of a 0.500 M solution?
- How does changing molarity affect the required volume for a fixed mass of solute?

Applications of Solution Chemistry in Real Life

Understanding the relationship between mass, molarity, and volume is essential beyond academic exercises. Here are some practical applications:

1. Pharmaceutical Preparations

Accurate calculation of solution concentrations ensures proper dosing and formulation of medicines.

2. Industrial Chemical Production

Manufacturers rely on precise calculations to produce chemicals at desired concentrations, optimizing efficiency and safety.

3. Environmental Science

Monitoring pollutant concentrations in water involves calculating solution volumes based on measured masses and molarities.

4. Laboratory Research

Researchers frequently prepare solutions of specific molarities to conduct experiments, requiring mastery of these calculations.

Conclusion

In summary, determining the volume of a solution when given the mass of solute and molarity involves straightforward calculations grounded in fundamental chemistry principles. For the problem at hand—dissolving 3.90 g of $CuNO3$ in water to produce a 0.840 M solution—the calculated volume is approximately 37.00 milliliters. Mastery of these concepts enables accurate solution preparation, essential for laboratory experiments, industrial applications, and scientific research. Whether you're studying for exams or applying chemistry principles practically, understanding how to manipulate molarity, molar mass, and volume is indispensable.

Remember: Always verify your units, double-check calculations, and practice similar problems to build confidence and proficiency in solution chemistry calculations.

Frequently Asked Questions

How do you calculate the volume of a solution when given the mass of CuNO3 and its molarity?

First, convert the mass of CuNO3 to moles using its molar mass, then use the molarity formula (M = moles of solute / volume in liters) to find the volume by rearranging to volume = moles / molarity.

What is the molar mass of copper(II) nitrate (CuNO3)?

The molar mass of CuNO3 is approximately 187.56 g/mol, calculated as Cu (63.55) + N (14.01) + 3×O (16.00×3).

How many moles of CuNO3 are present in 3.90 grams?

Number of moles = mass / molar mass = 3.90 g / 187.56 g/mol ≈ 0.02078 mol.

What is the formula to find the volume of the solution in liters?

Volume = moles of solute / molarity = 0.02078 mol / 0.840 M ≈ 0.02472 liters.

Convert the volume from liters to milliliters for practical use. What is it?

0.02472 liters × 1000 = approximately 24.72 milliliters.

Why is understanding the relationship between mass, molarity, and volume important in solution preparation?

It allows precise calculation of solution concentrations and volumes, ensuring accurate preparation of solutions for experiments and industrial processes.

Additional Resources

Understanding the Dissolution of $CuNO_3$ and Calculating Solution Volume

When it comes to preparing solutions in chemistry, understanding the relationships between mass, molarity, and volume is fundamental. In particular, dissolving a specific mass of a compound like copper(I) nitrate ($CuNO_3$) to achieve a desired molarity involves a precise calculation process. This review delves deeply into the problem: If 3.90 g of $CuNO_3$ is dissolved in water to make a 0.840 M solution, what is the volume of the solution? We will explore the chemistry involved, the calculations step by step, and the broader implications of such problems in laboratory settings.

Fundamentals of Molarity and Solution Preparation

What Is Molarity?

Molarity (M) is a way of expressing concentration, defined as the number of moles of solute dissolved per liter of solution:
$$ \text{Molarity} (M) = \frac{\text{moles of solute}}{\text{liters of solution}} $$

This unit is critical in chemistry because it allows chemists to relate quantities of substances in consistent and manageable terms, especially when reactions depend on molar ratios.

Importance of Precise Calculations

Accurate calculations ensure:
- Correct reagent proportions in reactions
- Consistent experimental results
- Safety in handling chemicals
- Proper scaling from lab to industrial processes

Understanding Copper(I) Nitrate ($CuNO_3$)

Chemical Composition

Copper(I) nitrate ($CuNO_3$) is an inorganic compound containing copper in the +1 oxidation state, combined with the nitrate ion (NO_3^-). Its molar mass is essential for calculations and is derived from atomic masses:
- Copper (Cu): approximately 63.55 g/mol
- Nitrogen (N): approximately 14.01 g/mol
- Oxygen (O): approximately 16.00 g/mol

Calculating the molar mass:
$$
\text{Molar mass of CuNO}_3 = 63.55 + 14.01 + (3 \times 16.00) = 63.55 + 14.01 + 48.00 = 125.56\, \text{g/mol}
$$

Physical and Chemical Properties

While primarily relevant in advanced studies, knowing these properties helps in understanding solubility and stability:
- Solubility: $CuNO_3$ dissolves in water to produce an aqueous solution.
- Stability: It remains stable under typical laboratory conditions.

- Uses: Typically in research, catalysis, or materials science.

Step-by-Step Calculation for Solution Volume

This is the core of the problem. To find the volume of the solution, given the mass of solute and the molarity, we proceed systematically.

Step 1: Convert Mass of $CuNO_3$ to Moles

Given:
- Mass of $CuNO_3$ = 3.90 g
- Molar mass of $CuNO_3$ ≈ 125.56 g/mol

Calculation:
$$
\text{Number of moles} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{3.90\, \text{g}}{125.56\, \text{g/mol}} \approx 0.03106\, \text{mol}
$$

Step 2: Use Molarity to Find Volume

Given:
- Molarity (M) = 0.840 mol/L
- Moles of $CuNO_3$ = 0.03106 mol

Rearranged formula:
$$
\text{Volume} = \frac{\text{Moles of solute}}{\text{Molarity}}
$$

Calculation:
$$
\text{Volume} = \frac{0.03106\, \text{mol}}{0.840\, \text{mol/L}} \approx 0.03700\, \text{L}
$$

Convert liters to milliliters for practical understanding:
$$
0.03700\, \text{L} \times 1000\, \text{mL/L} = 37.00\, \text{mL}
$$

Answer:
The volume of the solution required is approximately 37.00 mL.

Deeper Insights and Considerations

Accuracy and Precision

- The calculations assume perfect dissolution and no volume change upon dissolving.
- Real-world factors like temperature, purity of chemicals, and measurement precision can slightly affect results.

Implications of the Calculation

- This approach allows chemists to prepare solutions with specific concentrations starting from known quantities.
- It demonstrates the importance of molar mass calculations and unit conversions.

Potential Variations and Errors

- If the compound's purity is less than 100%, the actual amount of pure $CuNO_3$ might differ.
- The solubility limit: $CuNO_3$ must be fully soluble at the intended concentration; otherwise, the solution may be saturated or precipitate.

Broader Applications and Educational Significance

Laboratory Practice

- Such calculations underpin routine laboratory preparations.
- Understanding molarity calculation ensures proper experiment setup, reproducibility, and safety.

Educational Importance

- Reinforces fundamental concepts of chemical calculations.
- Develops problem-solving skills applicable in research, industry, and academia.

Real-World Contexts

- Pharmaceutical formulations: precise solution concentrations are crucial.
- Chemical manufacturing: scaling reactions and solutions accurately.
- Environmental science: calculating pollutant concentrations.

Summary and Key Takeaways

- To determine the volume of a solution when given mass and molarity, convert the mass to moles using the molar mass.
- Use the molarity equation to find the required volume.
- For the specific problem: dissolving 3.90 g of $CuNO_3$ to produce a 0.840 M solution results in approximately 37 mL of solution.
- Always consider real-world factors such as purity, temperature, and measurement accuracy to ensure practical reliability.

Final Thoughts

This detailed exploration underscores the importance of understanding fundamental chemical principles for solution preparation. By mastering these calculations, students and professionals can accurately design experiments, scale reactions, and interpret data confidently. The process exemplifies how basic arithmetic, combined with chemical knowledge, enables precise control over solution concentrations—a cornerstone of analytical and synthetic chemistry.

In conclusion, dissolving 3.90 g of $CuNO_3$ in water to make a 0.840 M solution requires approximately 37.00 mL of solution. This calculation is a fundamental example illustrating how mass, molar mass, and molarity interconnect, serving as a vital skill in both educational and practical chemical contexts.

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