How Many Liters Of Water Are Needed To Make A 4.0 M Solution With 125 Grams Of Sodium Chloride (NaCl)?

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Creating a solution with a specific molarity requires understanding the relationship between the amount of solute, the volume of solvent, and the molar concentration. In this article, we will explore how to determine the volume of water needed to prepare a 4.0 molar (4.0 M) solution of sodium chloride (NaCl) when starting with 125 grams of the compound. This step-by-step guide will help students, chemists, and anyone interested in solution preparation grasp the essential calculations involved.

Understanding Molarity and Its Significance

Molarity (M) is a common unit of concentration in chemistry, defined as the number of moles of solute dissolved in one liter of solution.
Mathematically, it is expressed as:

- **Molarity (M) = Moles of solute / Volume of solution (L)**

To prepare a solution of known molarity, one must determine:
- The number of moles of solute (NaCl in this case)
- The volume of solvent (water) needed to achieve that molarity

Step 1: Calculating Moles of Sodium Chloride (NaCl)

The first step involves converting the given mass of NaCl into moles.

Calculating Molar Mass of NaCl

The molar mass of sodium chloride (NaCl) is calculated based on atomic weights:
- Sodium (Na): approximately 22.99 g/mol
- Chlorine (Cl): approximately 35.45 g/mol

Therefore:

- **Molar mass of NaCl = 22.99 + 35.45 = 58.44 g/mol**

Converting 125 grams of NaCl to moles

Using the molar mass:
$$
\text{Moles of NaCl} = \frac{\text{Mass of NaCl}}{\text{Molar mass of NaCl}} = \frac{125\, \text{g}}{58.44\, \text{g/mol}} \approx 2.14\, \text{mol}
$$

Result: 125 grams of NaCl corresponds to approximately 2.14 moles.

Step 2: Determining the Required Volume of Water for a 4.0 M Solution

Since molarity is defined as moles per liter, to find out how many liters of water are needed:
- Use the desired molarity (4.0 M)
- Use the moles of solute (2.14 mol)

Apply the formula:
$$
\text{Volume of solution (L)} = \frac{\text{Moles of solute}}{\text{Desired molarity}}
$$
$$
\text{Volume} = \frac{2.14\, \text{mol}}{4.0\, \text{mol/L}} = 0.535\, \text{L}
$$

Result: Approximately 0.535 liters of water are needed to prepare the solution.

Step 3: Final Considerations and Practical Tips

Preparing a solution with precise concentration involves more than just calculations. Here are some practical points to consider:

1. Adjusting for purity of NaCl

- Ensure the NaCl used is pure; impurities can affect the actual molarity.
- If impurities are present, adjust the mass accordingly.

2. Volume measurement accuracy

- Use a volumetric flask or graduated cylinder for precise measurement.
- Add water gradually while stirring until the total volume reaches approximately 0.535 liters.

3. Dissolving the solute

- Dissolve the 125 grams of NaCl in less water initially, then transfer to a volumetric container.
- Add water until the total volume reaches the target volume, mixing thoroughly.

4. Final volume adjustments

- Since dissolving NaCl can cause slight volume changes, after initial mixing, make final volume adjustments to exactly 0.535 liters for accuracy.

Summary of Key Calculations

- Mass of NaCl: 125 grams
- Molar mass of NaCl: 58.44 g/mol
- Moles of NaCl: approximately 2.14 mol
- Desired molarity: 4.0 M
- Volume of water needed: approximately 0.535 liters

Conclusion

To prepare a 4.0 molar solution of sodium chloride using 125 grams of NaCl, you need about 0.535 liters of water. This calculation is based on fundamental principles of molarity and molar mass, illustrating the importance of precise measurements in solution chemistry. Whether for laboratory experiments or educational demonstrations, understanding these calculations ensures accurate solution preparation and reliable results.

Remember: Always use accurate laboratory equipment and double-check calculations to ensure safety and precision in chemical preparation.

Keywords: water volume for NaCl solution, molarity calculation, how much water for 4.0 M NaCl, preparing NaCl solution, molar concentration, solution preparation, chemistry calculations

Frequently Asked Questions

How do you calculate the volume of water needed to prepare a 4.0 M NaCl solution with 125 grams of NaCl?

To calculate the volume, first determine the moles of NaCl (125 g ÷ 58.44 g/mol ≈ 2.14 mol), then use the molarity formula: Volume (L) = moles / molarity = 2.14 mol / 4.0 M ≈ 0.535 L of water.

What is the role of molarity in determining how much water is needed for a NaCl solution?

Molarity defines the concentration of the solution in moles of solute per liter of solution. By knowing the desired molarity and the amount of NaCl, you can calculate the required volume of water to achieve that concentration.

If I want to make a 4.0 M NaCl solution with 125 grams of NaCl, how many liters of water should I add?

You should add approximately 0.535 liters of water to dissolve 125 grams of NaCl to make a 4.0 M solution.

Can I prepare a 4.0 M NaCl solution using less or more water than the calculated volume?

Yes, adding less water will result in a more concentrated solution, while adding more will dilute it. To achieve exactly 4.0 M, follow the calculated volume of approximately 0.535 liters.

What are the steps to prepare a 4.0 M NaCl solution from solid NaCl and water?

First, calculate the moles of NaCl needed (125 g ÷ 58.44 g/mol). Then, determine the required volume of water (about 0.535 L). Dissolve the NaCl in a smaller volume of water and add more water until the total volume reaches 0.535 liters, ensuring the solution reaches the desired molarity.

Additional Resources

How Many Liters Of Water Are Needed To Make A 4.0 M Solution With 125 Grams Of Sodium Chloride (NaCl)?

In laboratories, classrooms, and industrial processes worldwide, solutions of precise molarity are essential for accuracy and reproducibility. Whether you're a student preparing a standard solution, a researcher conducting experiments, or an industrial

chemist formulating products, understanding how to determine the volume of water required to achieve a specific molarity with a given mass of solute is fundamental. Today, we'll explore the process of calculating the volume of water needed to prepare a 4.0 molar (4.0 M) sodium chloride (NaCl) solution using 125 grams of NaCl—breaking down the chemistry, calculations, and practical considerations involved.

Understanding the Basics: What Is Molarity and Why Is It Important?

Before diving into calculations, it’s crucial to grasp what molarity signifies and why it’s a key concept in chemistry.

Molarity (M) is a measure of concentration that indicates the number of moles of solute dissolved in one liter of solution. Mathematically,

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

This unit allows chemists to prepare solutions with precise concentrations, ensuring that reactions proceed under controlled conditions. For example, a 4.0 M NaCl solution contains 4 moles of NaCl per liter of solution.

Step 1: Calculating the Moles of Sodium Chloride (NaCl)

The first step in our calculation is to determine how many moles of NaCl are present in 125 grams.

Step 1.1: Find the molar mass of NaCl.

- Sodium (Na): approximately 22.99 g/mol
- Chlorine (Cl): approximately 35.45 g/mol

Adding these,

$$\text{Molar mass of NaCl} = 22.99 + 35.45 = 58.44 \, \text{g/mol}$$

Step 1.2: Calculate the number of moles in 125 grams.

$$
\text{Moles of NaCl} = \frac{\text{mass of NaCl}}{\text{molar mass of NaCl}} = \frac{125 \, \text{g}}{58.44 \, \text{g/mol}} \approx 2.14 \, \text{mol}
$$

So, 125 grams of NaCl contains approximately 2.14 moles.

Step 2: Determining the Volume of Water Required

Now, we want to prepare a solution with a molarity of 4.0 M, containing 2.14 moles of NaCl. Using the molarity formula,

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

we find:

$$
V = \frac{2.14 \, \text{mol}}{4.0\, \text{mol/L}} = 0.535 \, \text{L}
$$

Answer: Approximately 0.535 liters (or 535 milliliters) of water are needed to dissolve 125 grams of NaCl to make a 4.0 M solution.

Important Note: This calculation assumes complete dissolution and no volume change upon dissolving the salt, which is a reasonable approximation for dilute solutions but may vary slightly in practice.

Practical Considerations: Preparing the Solution

While the calculation provides a theoretical volume, real-world preparation involves additional considerations to ensure accuracy and safety.

1. Adjusting for Volume Displacement

Dissolving solutes can cause slight volume changes—especially with salts like NaCl, which typically cause minimal volume displacement. To be more precise:

- Start with less water than the calculated 0.535 liters.
- Dissolve the salt thoroughly in a portion of water.
- Add water gradually until reaching the final volume.

This approach ensures the final solution is close to the desired molarity.

2. Use of Proper Equipment

- Volumetric flask: Use a calibrated volumetric flask of at least 0.5 liters (preferably slightly larger for ease) for measurement.
- Analytical balance: For precise weighing of NaCl.
- Distilled or deionized water: To avoid impurities that could affect solution concentration.

3. Ensuring Complete Dissolution

NaCl dissolves readily in water at room temperature; however, gentle stirring or swirling helps achieve uniformity.

Step 3: Variations in Concentration and Volume

Suppose you need a different molarity or amount of salt:

- Higher molarity: For instance, preparing a 5.0 M solution with the same mass would require fewer liters.
- Different mass of NaCl: Adjust the calculation based on the actual amount of salt used.

This flexibility underscores the importance of understanding the underlying calculations, enabling adaptation to various experimental needs.

Additional Insights: Why Molarity Matters in Chemistry

Understanding how to calculate the water volume for a solution isn't merely academic. It impacts:

- Reproducibility: Ensures consistent results across experiments.
- Safety: Correct concentration minimizes risks associated with overly concentrated solutions.
- Efficiency: Accurate calculations save materials and time.

For instance, in pharmaceutical manufacturing, precise molarity ensures proper dosage and safety. In environmental testing, correct dilutions are vital for accurate pollutant measurement.

Concluding Remarks: The Art and Science of Solution Preparation

Preparing a solution with a specific molarity involves a blend of chemistry fundamentals and practical skills. The calculation for making a 4.0 M NaCl solution from 125 grams of salt illustrates the straightforward yet critical process of translating mass into molarity and volume. With a clear understanding of molar mass, stoichiometry, and solution preparation techniques, scientists and students alike can achieve the desired concentrations reliably.

Remember, while calculations provide a solid foundation, real-world factors such as temperature, purity of reagents, and equipment calibration influence the final outcome. By combining theoretical knowledge with meticulous practice, one can master the art of solution preparation—an essential skill in the diverse field of chemistry.

In summary:

- NaCl mass: 125 grams
- NaCl moles: approximately 2.14 mol
- Target molarity: 4.0 M
- Volume of water needed: approximately 0.535 liters (535 mL)

Understanding these calculations empowers you to tailor solutions precisely, ensuring accuracy in any chemical endeavor.

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