An Analytical Chemist Wants To Make 750.0 ML Of A 6.00 M Solution Of Sodium Hydroxide. What Mass Of NaOH

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Creating precise solutions is a fundamental task in analytical chemistry, requiring both accuracy and understanding of chemical principles. When an analytical chemist aims to prepare a specific concentration and volume of a solution, such as 750.0 mL of a 6.00 M sodium hydroxide (NaOH) solution, they must carefully determine the amount of solid NaOH needed. This article provides a comprehensive guide on how to calculate the mass of NaOH required, along with explanations of relevant concepts and step-by-step procedures to ensure accuracy in solution preparation.

Understanding the Basics of Solution Preparation

Before delving into the calculations, it is important to grasp some fundamental concepts related to solution preparation:

Concentration Units

- Molarity (M): The number of moles of solute (NaOH) per liter of solution.
- Volume: The total volume of solution desired, expressed in milliliters (mL) or liters (L).
- Mass: The amount of solid solute needed, usually expressed in grams (g).

Key Relationships

- Number of moles (n): $n = C \times V$
- Where C is molarity in mol/L and V is volume in liters.
- Mass of solute (m): $m = n \times M_{NaOH}$
- Where M_{NaOH} is the molar mass of sodium hydroxide.

Step-by-Step Calculation of NaOH Mass

The process to determine the required mass of NaOH involves two main steps:

1. Calculating the number of moles of NaOH needed.
2. Converting moles to mass using molar mass.

Step 1: Convert Volume to Liters

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

$$
V = 750.0\, \text{mL} \times \frac{1\, \text{L}}{1000\, \text{mL}} = 0.750\, \text{L}
$$

Step 2: Calculate Moles of NaOH Needed

Using the molarity formula:

$$
n = C \times V
$$

$$
n = 6.00\, \text{mol/L} \times 0.750\, \text{L} = 4.50\, \text{mol}
$$

This means 4.50 moles of NaOH are required to make the solution.

Step 3: Find the Molar Mass of NaOH

The molar mass of sodium hydroxide (NaOH):

Element	Atomic Mass (g/mol)	Total for NaOH (g/mol)
Sodium (Na)	22.99	22.99
Oxygen (O)	16.00	16.00
Hydrogen (H)	1.008	1.008
Total		39.998 g/mol

Rounding to a reasonable degree of precision:

$$
M_{NaOH} \approx 40.00\, \text{g/mol}
$$

Step 4: Calculate the Mass of NaOH Required

Using the number of moles and molar mass:

$$
m = n \times M_{NaOH}
$$

$$
m = 4.50\, \text{mol} \times 40.00\, \text{g/mol} = 180.0\, \text{g}
$$

Therefore, approximately 180.0 grams of NaOH are needed to prepare 750.0 mL of a 6.00 M solution.

Practical Considerations in Preparing the Solution

While the calculation provides the theoretical amount of NaOH required, practical steps are essential to ensure accuracy and safety.

Materials Needed

- Analytical balance (for precise mass measurement)
- Stirring rod or magnetic stirrer
- Volumetric flask (750 mL capacity)
- Distilled water
- Protective gear (gloves, goggles)

Preparation Procedure

1. Weigh the NaOH
- Use an analytical balance to measure approximately 180.0 grams of solid NaOH.
- Handle NaOH with care, as it is caustic and can cause burns.

2. Dissolve NaOH in Water
- Add the NaOH to a beaker containing a small volume of distilled water.
- Stir continuously until the NaOH is completely dissolved.

3. Transfer to Volumetric Flask
- Pour the NaOH solution into a 750 mL volumetric flask.
- Rinse the beaker and stirring rod with distilled water, adding the rinsings to the flask to ensure complete transfer.

4. Dilute to the Mark

- Add distilled water gradually until the bottom of the meniscus reaches the calibration line on the flask.
- Mix thoroughly by inverting or stirring.

5. Label and Store
- Properly label the flask with solution concentration, date, and preparation details.
- Store the solution in a suitable container, following safety guidelines.

Understanding the Significance of Accurate Solution Preparation

Accurate preparation of solutions like the NaOH solution discussed is critical in various applications such as titrations, pH adjustments, and chemical analyses. Errors in measurement can lead to significant deviations in experimental results, affecting the validity and reproducibility of scientific work.

Importance of Precision
- Ensures reproducibility of experiments.
- Maintains safety, especially with caustic materials.
- Provides reliable data in analytical procedures.

Common Mistakes to Avoid
- Using impure or contaminated water.
- Not calibrating measurement instruments.
- Rushing the dissolution and mixing process.
- Incorrectly reading the meniscus on volumetric flasks.

Alternative Methods for Solution Preparation

While the direct calculation method outlined above is standard, alternative approaches can be employed depending on equipment and available resources.

Using Stock Solutions

- Prepare a concentrated stock solution and dilute it to the desired concentration.
- For example, prepare a 1.00 M NaOH stock solution and perform serial dilutions.

Using Titration for Precise Concentration Verification

- After preparing the solution, perform titration with a standard acid to verify concentration.
- Adjust if necessary to achieve the target molarity.

Safety Considerations When Handling NaOH

NaOH is a highly caustic chemical and requires careful handling:

- Always wear gloves, goggles, and protective clothing.
- Work in a well-ventilated area.
- Add NaOH slowly to water to prevent splattering.
- Be aware of emergency procedures in case of spills or contact.

Conclusion

Calculating the precise amount of NaOH needed to prepare a solution of specific volume and concentration is an essential skill in analytical chemistry. For the problem at hand—making 750.0 mL of a 6.00 M NaOH solution—the chemist must weigh approximately 180 grams of NaOH, dissolve it thoroughly in water, and dilute to the final volume. Ensuring accuracy in these steps guarantees the reliability of experimental results and the safety of laboratory procedures. Mastery of such calculations and methods forms the backbone of effective and safe laboratory practice, enabling chemists to produce solutions tailored precisely to their experimental needs.

Keywords: NaOH solution calculation, molarity, solution preparation, analytical chemistry, molar mass, laboratory safety, solution dilution, chemical solution preparation

Frequently Asked Questions

How do you calculate the mass of NaOH needed to

prepare 750.0 mL of a 6.00 M solution?

First, convert the volume to liters: 750.0 mL = 0.750 L. Then, use the formula mass = molarity × volume (L) × molar mass. So, mass = 6.00 mol/L × 0.750 L × 40.00 g/mol = 180.0 g of NaOH.

What is the molar mass of sodium hydroxide (NaOH)?

The molar mass of NaOH is approximately 40.00 g/mol, calculated as Na (22.99 g/mol) + O (16.00 g/mol) + H (1.01 g/mol).

Why is it important to know the molarity and volume when preparing a solution?

Knowing the molarity and volume allows precise calculation of the amount of solute needed to prepare a solution at a desired concentration, ensuring accuracy in analytical procedures.

What are common units used for concentration in solution preparation?

Common units include molarity (M, mol/L), molality (mol/kg), percent by weight (%), and normality (N). Molarity is most often used for solutions like NaOH.

How does the purity of NaOH affect the amount needed to prepare the solution?

If NaOH is not 100% pure, the actual mass required must be adjusted based on its purity percentage to achieve the desired molarity.

What safety precautions should be taken when handling NaOH for solution preparation?

NaOH is caustic; always wear gloves, eye protection, and a lab coat. Work in a well-ventilated area and add NaOH to water slowly to prevent splashing.

Can you use the same calculation method for preparing solutions of other substances?

Yes, the general approach involves using molarity, volume, and molar mass, applicable to any solute, with adjustments based on the specific substance's molar mass and purity.

What is the significance of accurate solution

preparation in analytical chemistry?

Accurate solution preparation ensures reliable and reproducible results in experiments, calibrations, and analyses, which is critical for valid scientific conclusions.

If the molar mass of NaOH was given as 39.99 g/mol, how would the calculation change?

The mass needed would be slightly adjusted: 6.00 mol/L × 0.750 L × 39.99 g/mol ≈ 179.9 g of NaOH, a minor difference from using 40.00 g/mol.

Additional Resources

Analyzing the Preparation of a 6.00 M Sodium Hydroxide Solution: A Step-by-Step Guide for the Analytical Chemist

Creating a precise and accurate sodium hydroxide (NaOH) solution is a fundamental task in analytical chemistry, essential for titrations, standardizations, and various laboratory experiments. When an analytical chemist aims to prepare 750.0 mL of a 6.00 M NaOH solution, understanding the calculations, procedures, and considerations involved is critical. This comprehensive review explores every facet of this process, from fundamental concepts to practical implementation, ensuring accuracy and safety.

Understanding the Fundamentals of Solution Preparation

1. Molarity and Its Significance

- Definition: Molarity (M) is defined as the number of moles of solute (NaOH) dissolved in one liter (L) of solution.
- Mathematically: M = moles of solute / liters of solution
- Relevance: Precise molarity ensures reproducibility in titrations and analytical procedures.

2. The Target Volume and Concentration

- Target volume: 750.0 mL = 0.750 L
- Desired molarity: 6.00 M

- Implication: The chemist must calculate the total moles of NaOH required and then determine the corresponding mass.

Calculating the Required Moles of NaOH

1. Basic Calculation

- Using the formula:
$$ \text{moles of NaOH} = \text{molarity} \times \text{volume in liters} $$
- Substituting values:
$$ \text{moles} = 6.00\, \text{mol/L} \times 0.750\, \text{L} $$
- Calculation:
$$ \text{moles} = 4.50\, \text{mol} $$

This indicates that 4.50 moles of NaOH are necessary to prepare the desired solution.

Determining the Mass of NaOH Needed

1. Molar Mass of NaOH

- Composition:
- Sodium (Na): approximately 22.99 g/mol
- Oxygen (O): approximately 16.00 g/mol
- Hydrogen (H): approximately 1.008 g/mol
- Calculation:
$$ \text{Molar mass of NaOH} = 22.99 + 16.00 + 1.008 = 40.00\, \text{g/mol} $$

Note: For simplicity, the molar mass can be rounded to 40.00 g/mol, but in high-precision work, more exact values may be used.

2. Calculating the Mass

- Using the relation:
$$ \text{mass} = \text{moles} \times \text{molar mass} $$
- Substituting values:

$$ \text{mass} = 4.50\, \text{mol} \times 40.00\, \text{g/mol} $$
- Calculation:
$$ \text{mass} = 180.0\, \text{g} $$

Therefore, 180.0 grams of NaOH are needed to prepare 750.0 mL of a 6.00 M solution.

Practical Considerations in Solution Preparation

1. Handling and Safety Precautions

- Corrosiveness: NaOH is highly caustic; proper personal protective equipment (PPE) is essential.
- Protective gear:
- Safety goggles
- Lab coat
- Chemical-resistant gloves
- Ventilation: Conduct the procedure in a well-ventilated area or under a fume hood.

2. Material Selection

- Use a clean, dry, and appropriately sized volumetric flask (preferably 1 L for ease of measurement).
- Use high-quality analytical reagents, preferably reagent-grade NaOH pellets.

3. Dissolution of NaOH

- Step-by-step process:
1. Weigh approximately 180.0 g of NaOH pellets using an analytical balance.
2. Pour a small volume (about 100-200 mL) of distilled or deionized water into the volumetric flask.
3. Slowly add NaOH pellets to the water while stirring gently to facilitate dissolution.
4. Caution: NaOH dissolves exothermically, releasing heat; add pellets gradually to prevent splattering.
5. Continue stirring until all pellets are fully dissolved, resulting in a clear solution.

Adjusting the Final Volume and Ensuring Solution Accuracy

1. Dilution to Final Volume

- After complete dissolution, carefully dilute the solution to the 750.0 mL mark on the volumetric flask.
- Use a pipette or dropper to add more water to reach exactly the calibration line.
- Ensure the solution is mixed thoroughly by inverting or swirling gently.

2. Calibration and Verification

- For critical applications, verify the molarity by titration against a primary standard.
- Store the solution in a properly labeled, airtight container to prevent contamination and evaporation.
- Record the date of preparation and concentration for quality control.

Additional Factors Affecting Solution Preparation

1. Purity of NaOH

- Impurities: NaOH pellets may contain moisture or impurities affecting concentration.
- Drying: Use dry pellets and store in a desiccator if necessary.
- Correction factor: If moisture content is known, adjust the mass accordingly.

2. Temperature Effects

- Molarity can vary with temperature; standard conditions are typically 20°C.
- For high-precision work, measure temperature and correct molarity if

needed.

3. Storage and Stability

- NaOH solutions are hygroscopic and can absorb moisture from the air.
- Store in airtight, corrosion-resistant containers (e.g., glass or certain plastics).

Safety and Disposal Considerations

- Disposal:
- Neutralize excess NaOH with dilute acids (e.g., acetic acid) before disposal.
- Follow institutional and environmental regulations for waste disposal.

- Emergency procedures:
- In case of skin contact, rinse immediately with plenty of water.
- In case of eye contact, rinse with sterile water and seek medical attention.

Summary and Final Remarks

Preparing a 6.00 M NaOH solution requires a thorough understanding of molarity calculations, meticulous weighing, careful dissolution, and precise volume adjustment. The chemist must consider safety protocols, material purity, and environmental conditions to ensure the solution's accuracy and stability.

The key steps include:

- Calculating the total moles of NaOH needed (4.50 mol)
- Converting moles to mass (180.0 g)
- Weighing the NaOH pellets accurately
- Dissolving them in a small volume of water with controlled addition
- Diluting to the final volume of 750.0 mL
- Mixing thoroughly and storing properly

Through diligent attention to detail and safety, the resulting solution will serve as a reliable reagent for various analytical applications, maintaining high standards of quality and reproducibility.

In conclusion, the preparation of a 6.00 M NaOH solution is a straightforward process rooted in fundamental chemical principles, yet it demands precision and care. Mastery over such procedures underscores an analytical chemist's expertise and commitment to scientific rigor.

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