What Volume Of 8.25 M Naoh Solution Must Be Diluted To Prepare 2.40 L Of 0.500 M Naoh Solution?

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When working with solutions in chemistry, one of the fundamental calculations involves diluting a concentrated stock solution to obtain a desired lower concentration. In this scenario, the goal is to determine the volume of an 8.25 M sodium hydroxide (NaOH) solution required to prepare 2.40 liters of a 0.500 M NaOH solution. Understanding how to perform this calculation is essential for students and professionals working in laboratories, ensuring precise and safe preparation of chemical solutions.

Understanding the Concept of Dilution

Dilution is the process of reducing the concentration of a solute in a solution by adding more solvent without changing the amount of solute present. The fundamental principle underlying dilution calculations is the conservation of moles of solute, which means the number of moles before and after dilution remains constant.

Key relationship:

$$ C_1 V_1 = C_2 V_2 $$

Where:

- C_1 = concentration of the stock solution (initial concentration)
- V_1 = volume of the stock solution needed
- C_2 = concentration of the diluted solution (final concentration)
- V_2 = volume of the diluted solution

This equation is the cornerstone for calculating the required volume of concentrated stock solution to achieve a desired dilute concentration.

Step-by-Step Calculation

To determine the volume of 8.25 M NaOH needed to prepare 2.40 L of 0.500 M NaOH, follow these steps:

Step 1: Write down the known values

- $C_1 = 8.25\, \text{M}$
- $C_2 = 0.500\, \text{M}$
- $V_2 = 2.40\, \text{L}$

Step 2: Apply the dilution formula

$$
V_1 = \frac{C_2 \times V_2}{C_1}
$$

Step 3: Substitute the known values

$$
V_1 = \frac{0.500\, \text{M} \times 2.40\, \text{L}}{8.25\, \text{M}}
$$

Step 4: Perform the calculation

$$
V_1 = \frac{1.20\, \text{mol}}{8.25\, \text{mol/L}} \approx 0.1455\, \text{L}
$$

or approximately 145.5 mL.

Result: To prepare 2.40 liters of a 0.500 M NaOH solution, approximately 145.5 milliliters of the 8.25 M NaOH stock solution are required.

Practical Considerations for Dilution

While the calculation provides the theoretical volume needed, practical laboratory procedures involve additional considerations to ensure safety and

accuracy.

1. Safety Precautions

NaOH is a highly caustic substance. Always wear appropriate personal protective equipment, including gloves, goggles, and lab coats. When diluting NaOH, always add the NaOH to water—not water to NaOH—to prevent vigorous reactions and splattering.

2. Accurate Measurement

Use calibrated volumetric flasks or graduated cylinders to measure the volumes precisely. For small volumes like 145.5 mL, a graduated cylinder or a volumetric pipette ensures better accuracy.

3. Mixing and Homogenization

After adding the measured NaOH to water, mix thoroughly to ensure uniform concentration throughout the solution.

4. Adjusting Final Volume

Once the solution is prepared, transfer it to a 2.40 L volumetric flask and add water up to the calibration mark to achieve the exact final volume. This ensures the concentration is as calculated.

Additional Tips for Accurate Solution Preparation

Preparing solutions with precision is crucial in experiments, titrations, and industrial applications. Here are some helpful tips:

- **Use high-quality reagents:** Always start with pure NaOH and distilled water to avoid impurities.
- **Double-check calculations:** Before measuring, verify the math to prevent errors.

- **Record observations:** Note the actual volume measured and any discrepancies.
- **Safety first:** Handle NaOH with care, and dispose of waste solutions according to safety protocols.

Understanding Concentration Units

In this calculation, we used molarity (M), which expresses the number of moles of solute per liter of solution. A clear understanding of units is vital.

Key points:

- Molarity (M): mol of solute / liter of solution
- Converting volumes: 1 L = 1000 mL
- Moles of NaOH in stock solution: $C_1 \times V_1$

Knowing these units helps in troubleshooting and ensures the calculations are consistent.

Real-World Applications of this Calculation

Understanding how to determine the volume of concentrated solutions needed for dilution has numerous practical applications:

- Laboratory titrations: Preparing standard solutions for accurate titrations.
- Industrial processes: Diluting chemicals to safe working concentrations.
- Educational demonstrations: Teaching students about solution preparation.
- Pharmaceuticals: Preparing precise drug formulations.

By mastering these calculations, chemists and lab technicians ensure accurate, safe, and effective use of chemicals.

Summary

To summarize, the key steps in determining the volume of 8.25 M NaOH needed to prepare a 2.40 L solution of 0.500 M NaOH are:

- Use the dilution equation $C_1 V_1 = C_2 V_2$.
- Substitute the known values.
- Calculate the required volume, which is approximately 145.5 mL.
- Carefully measure and dilute the solution following safety protocols.

This process exemplifies the practical application of stoichiometry and solution chemistry, foundational skills in the field of chemistry.

Conclusion

Calculating the volume of a concentrated solution required for dilution is a fundamental skill for chemists. In this case, understanding the relationship between concentrations and volumes allows for precise preparation of solutions necessary for experiments, industrial applications, and educational purposes. Always remember to handle chemicals safely, measure accurately, and verify calculations to ensure successful and safe laboratory practices.

References:

- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Harris, D. C. (2015). Quantitative Chemical Analysis. W. H. Freeman.
- Safety Data Sheets (SDS) for NaOH.

Frequently Asked Questions

How do you determine the volume of 8.25 M NaOH needed to prepare 2.40 L of 0.500 M NaOH solution?

Use the dilution formula $M_1V_1 = M_2V_2$, where M_1 and V_1 are the initial concentration and volume, and M_2 and V_2 are the final concentration and volume. Rearranged, $V_1 = (M_2 \times V_2) / M_1$. Plugging in the values: $V_1 = (0.500 \text{ M} \times 2.40 \text{ L}) / 8.25 \text{ M} \approx 0.1455 \text{ L}$ or 145.5 mL.

What is the formula used to find the initial volume of NaOH solution needed for dilution?

The formula is $V_1 = (M_2 \times V_2) / M_1$, where V_1 is the initial volume, M_1 is the initial molarity, M_2 is the final molarity, and V_2 is the final volume.

Why is the dilution formula important in preparing solutions?

It allows you to determine the exact volume of a concentrated solution needed to prepare a desired volume and concentration of a diluted solution accurately.

How much of the 8.25 M NaOH solution is required to prepare 2.40 L of 0.500 M NaOH?

Approximately 145.5 milliliters of the 8.25 M NaOH solution are required.

Can you explain step-by-step how to calculate the volume of NaOH needed for dilution?

Yes. First, identify the known values: $M_1 = 8.25$ M, $M_2 = 0.500$ M, $V_2 = 2.40$ L. Then, apply the formula $V_1 = (M_2 \times V_2) / M_1$: $V_1 = (0.500 \times 2.40) / 8.25 \approx 0.1455$ L. Convert to milliliters if needed: 0.1455 L × 1000 = 145.5 mL.

What precautions should be taken when diluting concentrated NaOH solutions?

Wear appropriate protective gear, such as gloves and safety goggles, add NaOH slowly to water to prevent splashing, and perform the dilution in a well-ventilated area.

If you only have 100 mL of 8.25 M NaOH, can you prepare 2.40 L of 0.500 M solution?

No, because 100 mL is less than the required 145.5 mL needed for the dilution, so you would need a larger volume of the concentrated NaOH.

What is the significance of molarity in solution preparation?

Molarity indicates the concentration of solute per liter of solution, which is essential for accurately preparing solutions with desired chemical properties.

How does the concentration of the initial solution affect the volume needed for dilution?

Higher initial concentration requires a smaller volume to be diluted to a specific lower concentration, following the direct proportionality in the dilution formula.

What are common units used in solution concentration calculations, and why are they important?

Common units include molarity (M), liters (L), and milliliters (mL). Consistent units are important to ensure accurate calculations and proper scaling during solution preparation.

Additional Resources

What Volume Of 8.25 M NaOH Solution Must Be Diluted To Prepare 2.40 L Of 0.500 M NaOH Solution?

When working in a chemistry laboratory or preparing solutions for various applications, understanding how to dilute a concentrated stock solution to a desired molarity and volume is an essential skill. In this context, determining what volume of 8.25 M NaOH solution must be diluted to prepare 2.40 L of 0.500 M NaOH solution involves applying the fundamental principles of solution dilution. This process, often guided by the concept of molarity and the dilution equation, allows chemists to accurately obtain solutions of precise concentration for experiments, titrations, or industrial processes.

Understanding NaOH Solutions and Their Concentrations

Sodium hydroxide (NaOH), a strong base, is commonly supplied in concentrated solutions for ease of storage and handling. The concentration of these stock solutions is expressed in molarity (M), which is moles of solute per liter of solution. For example:

- Stock NaOH solution: 8.25 M
- Desired NaOH solution: 0.500 M

The goal here is to dilute the concentrated 8.25 M NaOH to obtain 2.40 liters of a much less concentrated 0.500 M solution.

The Fundamental Dilution Equation

At the heart of solution preparation lies the dilution equation:

$$ C_1 V_1 = C_2 V_2 $$

Where:

- C_1 = concentration of the stock solution (initial molarity)
- V_1 = volume of stock solution needed
- C_2 = concentration of the diluted solution (final molarity)
- V_2 = volume of the diluted solution

This equation is derived from the principle that the number of moles of solute remains constant during dilution:

$$ \text{moles in stock} = \text{moles in diluted solution} $$

Rearranged to solve for V_1:

$$ V_1 = \frac{C_2 V_2}{C_1} $$

Applying this to our specific problem allows us to determine the exact volume of the concentrated NaOH solution required.

Step-by-Step Calculation

Given Data:

- $C_1 = 8.25\, \text{M}$
- $C_2 = 0.500\, \text{M}$
- $V_2 = 2.40\, \text{L}$

Calculation:

$$
V_1 = \frac{C_2 V_2}{C_1} = \frac{(0.500\, \text{M}) \times (2.40\, \text{L})}{8.25\, \text{M}}
$$

$$
V_1 = \frac{1.20\, \text{mol}}{8.25\, \text{mol/L}} \approx 0.1455\, \text{L}
$$

Expressed in milliliters:

$$
V_1 \approx 145.5\, \text{mL}
$$

Interpretation: To prepare 2.40 liters of a 0.500 M NaOH solution, you need approximately 145.5 milliliters of the 8.25 M stock solution, which should then be diluted with distilled water to reach the final volume.

Practical Steps in Solution Preparation

Preparing a dilute NaOH solution involves more than just measurements; safety, precision, and proper technique are crucial.

1. Gather Materials and Safety Equipment
- Concentrated NaOH stock solution (8.25 M)
- Distilled or deionized water
- Volumetric flask (at least 2.50 L capacity)
- Graduated cylinder or pipette for precise measurement
- Protective gear: gloves, goggles, lab coat
- Stirring rod or magnetic stirrer

2. Measuring the Stock Solution
- Use a graduated cylinder or a pipette to carefully measure approximately 145.5 mL of the 8.25 M NaOH.
- Always add NaOH to water, not water to NaOH, to prevent splashing and ensure safety.

3. Dilution Process
- Transfer the measured NaOH into a large volumetric flask.
- Add distilled water gradually while swirling or stirring to mix thoroughly.
- Continue adding water until the total volume reaches 2.40 L.
- Mix thoroughly to ensure homogeneity.

4. Final Checks
- Verify the volume if using graduated cylinders or volumetric flasks.
- Label the solution with concentration, date, and safety information.
- Store the solution properly, following safety guidelines.

Additional Considerations and Tips

- Accuracy in Measurement: Use calibrated equipment for precise measurements, especially when preparing solutions for analytical procedures.

- Safety Precautions: NaOH is caustic; always wear appropriate protective gear. Handle solutions carefully and add NaOH to water slowly.

- Temperature Effects: Molarity can be temperature-dependent. Prepare solutions at a controlled temperature if high precision is required.

- Dilution Factors: Understand that larger or smaller dilutions may require adjusting the initial volume of stock solution accordingly.

- Record Keeping: Document the preparation process, including measurements and calculations, for reproducibility and quality control.

Why Precise Dilution Matters

Accurately diluting NaOH solutions is crucial in many contexts:

- Titrations: Precise molarity ensures accurate determination of analyte concentrations.
- Industrial Processes: Consistent solution concentrations are vital for quality control.
- Research: Proper dilutions affect experimental reliability and reproducibility.

Errors in measurement or calculation can lead to incorrect concentrations, affecting experimental outcomes or process efficiency.

Summary of Key Points

- Use the dilution equation $C_1 V_1 = C_2 V_2$ to determine the volume of concentrated solution needed.
- For this specific problem, approximately 145.5 mL of 8.25 M NaOH must be diluted to 2.40 L to achieve a 0.500 M solution.
- Follow proper safety procedures when handling concentrated NaOH.
- Ensure thorough mixing and precise measurement to obtain a homogeneous, accurately diluted solution.

Final Thoughts

Mastering the calculation of solution dilutions like what volume of 8.25 M NaOH solution must be diluted to prepare 2.40 L of 0.500 M NaOH solution is fundamental in chemistry. Whether you're preparing solutions for titrations, calibrations, or industrial applications, understanding the principles behind dilution equations and applying them accurately is essential. With careful measurement, safety awareness, and attention to detail, you can confidently prepare solutions that meet your specific concentration requirements — a cornerstone of successful laboratory practice.

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