Suppose You Need 100 Ml Of A 0.00046 M Solution For An Experiment. You Are Given 10 Ml Of A 4.6 M Stock

Introduction: Preparing Dilute Solutions from a Concentrated Stock

Suppose You Need 100 Ml Of A 0.00046 M Solution For An Experiment. You Are Given 10 Ml Of A 4.6 M Stock. This scenario highlights common laboratory procedures involving dilution, a fundamental process in chemistry and biochemistry experiments. Accurate dilution is crucial to ensure the integrity and reproducibility of experimental results. Whether you're working in a research lab, educational setting, or industrial environment, understanding how to prepare precise solutions from concentrated stock solutions is essential.

In this article, we'll explore the step-by-step process to dilute a high-concentration stock solution to a very dilute target concentration, focusing on the specific case provided. We'll discuss key concepts such as molarity, dilution equations, and practical tips to achieve the desired solution accurately.

Understanding Molarity and Dilution Principles

What is Molarity?

Molarity (M) is a measure of concentration representing moles of solute per liter of solution. It is expressed as:

- M = moles of solute / liters of solution

For example:
- A 4.6 M solution contains 4.6 moles of solute per liter.
- A 0.00046 M solution contains 0.00046 moles of solute per liter.

Why Dilution Matters

Dilution involves decreasing the concentration of a solute in solution, typically by adding solvent (usually water). It is a common technique to prepare solutions of specific, often very dilute, concentrations from concentrated stock solutions.

Key Dilution Equation

The relationship between the concentrations and volumes before and after dilution is given by the formula:

$$ C_1 V_1 = C_2 V_2 $$

Where:
- C_1 = initial concentration (stock solution)
- V_1 = volume of stock solution needed
- C_2 = desired concentration (target solution)
- V_2 = total volume of the diluted solution

This equation allows you to calculate the volume of stock solution required to achieve a specific dilute concentration.

Step-by-Step Calculation for the Given Scenario

Given Data

- Desired volume of dilute solution: $V_2 = 100\, \text{mL}$
- Desired concentration: $C_2 = 0.00046\, \text{M}$
- Stock solution concentration: $C_1 = 4.6\, \text{M}$
- Available stock volume: $10\, \text{mL}$

Calculating the Volume of Stock Solution Needed

Using the dilution equation:

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

Plugging in the values:

$$V_1 = \frac{0.00046\, \text{M} \times 100\, \text{mL}}{4.6\, \text{M}}$$

$$V_1 = \frac{0.046\, \text{M·mL}}{4.6\, \text{M}}$$

$$V_1 = 0.01\, \text{mL}$$

This calculation indicates that only 0.01 mL (or 10 mL) of the 4.6 M stock solution is needed to prepare 100 mL of the 0.00046 M solution.

Practical Considerations and Limitations

- Measuring Very Small Volumes: Since 0.01 mL (10 mL) is a very small volume, accurately measuring it requires precise pipettes or micro-syringes.
- Stock Volume Availability: You only have 10 mL of the stock solution, which is more than enough to prepare the required dilute solution.
- Dilution Process: Add the calculated volume (10 mL) of stock to a volumetric flask or container, then fill up to the 100 mL mark with distilled water.

Step-by-Step Protocol for Preparing the Diluted Solution

Materials Needed

- 4.6 M stock solution
- Micropipette or micro-syringe capable of measuring mL volumes
- 100 mL volumetric flask or graduated cylinder
- Distilled water
- Stirring rod or magnetic stirrer

Procedure

1. Calculate the exact volume of stock solution needed: As calculated, 10 mL.
2. Pipette the stock solution: Using a micropipette, transfer 10 mL of the 4.6 M stock solution into the 100 mL volumetric flask.
3. Add distilled water: Carefully fill the flask with distilled water up to the 100 mL mark.
4. Mix thoroughly: Cap the flask and invert multiple times or stir with a magnetic stirrer to ensure homogeneity.
5. Label the solution: Clearly mark the container with the concentration and date.

Alternative Approaches and Precautions

When Precise Measurement of Small Volumes is Difficult

- Serial Dilution: Perform multiple sequential dilutions to reach the target concentration if direct measurement is impractical.
- Dilution Series Example:
- First, dilute the stock solution to an intermediate concentration.
- Then, dilute the intermediate solution to the final target concentration.
- Precautions:
- Use calibrated pipettes and high-precision equipment.
- Avoid contamination by using clean, sterile tools.

Safety and Best Practices

- Wear appropriate personal protective equipment (PPE).
- Handle concentrated solutions carefully to prevent spills or inhalation.
- Dispose of waste solutions according to lab protocols.

Understanding the Limitations of the Calculation

While the calculation indicates that only 10 mL of the stock solution is needed, it's essential to recognize:
- Measurement accuracy is critical: Small errors can significantly affect the final concentration.
- Stock solution stability: Ensure the stock solution remains stable and uncontaminated.
- Volume constraints: If equipment cannot measure such small volumes, serial dilutions become necessary.

Conclusion: Efficiently Preparing a Very Dilute Solution from a Concentrated Stock

In this scenario, preparing 100 mL of a 0.00046 M solution from a 4.6 M stock solution requires precise calculation and careful measurement. The key steps involve utilizing the dilution equation to determine the exact volume of stock solution needed, then diluting it with distilled water to reach the desired final volume.

This process exemplifies fundamental laboratory skills that are applicable across various scientific disciplines, including chemistry, biology, and environmental science. Mastery of these dilution techniques ensures accurate experimental results and contributes to the reliability of scientific data.

Remember:
- Always verify calculations before proceeding.

- Use appropriate tools for measuring small volumes.
- Follow safety guidelines when handling chemicals.

By understanding and applying these principles, scientists and students can confidently prepare solutions tailored to their experimental needs, ensuring precision and reproducibility in their work.

Frequently Asked Questions

How do you prepare 100 mL of a 0.00046 M solution from a 4.6 M stock solution?

Use the dilution formula $C_1V_1 = C_2V_2$. Plugging in, $V_1 = (C_2 \times V_2) / C_1 = (0.00046\ M \times 100\ mL) / 4.6\ M \approx 0.01\ mL$. Since this volume is very small, you'd need precise pipetting or consider serial dilutions to accurately prepare the solution.

Is it feasible to dilute 10 mL of 4.6 M stock solution to obtain 100 mL of 0.00046 M solution?

Yes, but since the calculated volume of stock needed (about 0.01 mL) is very small and difficult to measure accurately, it's better to perform serial dilutions or prepare a intermediate dilution step for accuracy.

What is the dilution factor needed to go from 4.6 M to 0.00046 M?

The dilution factor is $C_1 / C_2 = 4.6\ M / 0.00046\ M \approx 10{,}000$. This means the stock solution needs to be diluted 10,000 times to reach the desired concentration.

Given only 10 mL of the 4.6 M stock, can I generate the required 100 mL of the 0.00046 M solution?

Yes. You can take approximately 0.01 mL of the stock solution and dilute it to a total volume of 100 mL. Since measuring 0.01 mL precisely is challenging, performing serial dilutions is recommended for accuracy.

What are the steps to prepare 100 mL of 0.00046 M solution using 10 mL of 4.6 M stock?

First, perform a serial dilution: dilute the 4.6 M stock to an intermediate concentration, then dilute that intermediate to reach 0.00046 M. Alternatively, dilute 0.01 mL of stock into approximately 100 mL of solvent, but precise pipetting or serial dilutions are recommended for accuracy.

How can serial dilution help in preparing such a dilute solution from limited stock volume?

Serial dilution involves performing successive dilutions to reach the desired concentration gradually, making it easier to accurately dilute very small volumes of stock solution to achieve the target concentration without requiring precise measurement of tiny volumes.

Additional Resources

Preparing a Precise Dilution: How to Obtain 100 mL of a 0.00046 M Solution from a 4.6 M Stock Solution

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Introduction

In laboratory settings, preparing solutions of specific molarity is a fundamental skill that ensures accurate experiments and reproducible results. When you are asked to prepare a dilute solution—such as 100 mL of a 0.00046 M solution—from a concentrated stock, understanding the principles of dilution, molarity calculations, and proper pipetting techniques becomes essential. This guide aims to walk you through the entire process, from understanding the concepts to performing accurate calculations, and finally executing the preparation with precision.

Understanding the Key Concepts

What is Molarity?

Molarity (M) is a measure of concentration, expressed as moles of solute per liter of solution:

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

For example, a 4.6 M solution contains 4.6 moles of solute per liter of solution.

The Principle of Dilution

Dilution involves adding solvent (usually water) to a concentrated solution to reach a desired lower concentration. The key relationship is:

$$
C_1 V_1 = C_2 V_2
$$

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

This equation assumes no loss of solute during transfer and that the solution is well mixed.

Step-by-Step Calculation

1. Identifying Known Values

- Stock solution concentration (C_1): 4.6 M
- Desired solution concentration (C_2): 0.00046 M
- Final volume of solution (V_2): 100 mL = 0.1 L

Note: Always convert units to liters to match molarity units.

2. Calculating the Required Volume of Stock Solution (V_1)

Using the dilution formula:

$$
\[

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

Substituting the known values:

$$
V_1 = \frac{0.00046 \text{ M} \times 0.1 \text{ L}}{4.6 \text{ M}}
$$

Calculating numerator:

$$
0.00046 \times 0.1 = 4.6 \times 10^{-5}
$$

Dividing:

$$
V_1 = \frac{4.6 \times 10^{-5}}{4.6} = 1 \times 10^{-5} \text{ L}
$$

Converting to milliliters:

$$
1 \times 10^{-5} \text{ L} = 0.01 \text{ mL}
$$

Result: You need 0.01 mL (10 mL) of the 4.6 M stock solution.

Practical Considerations in the Laboratory

1. Handling Very Small Volumes

- Measurement Challenges: Measuring 10 mL precisely requires a high-quality micropipette.
- Best Practice: Use a pipette capable of accurately measuring 10 mL, such as a P10 micropipette, and ensure it is properly calibrated.

2. Transfer Technique

- Pipetting the Stock Solution:
- Use a clean, dry pipette tip.
- Pre-wet the tip by aspirating and dispensing the stock solution a few times to improve accuracy.
- Aspirate exactly 10 mL of the stock solution.
- Dispense the 10 mL into a clean volumetric container or flask.

3. Dilution Volume and Final Adjustment

- Since the required volume of stock solution is just 0.01 mL, the remaining volume is made up with solvent:
- Add distilled or deionized water to reach a total volume of 100 mL.
- Method:
- Transfer the 10 mL of stock solution into a 100 mL volumetric flask.
- Add distilled water gradually until the bottom of the meniscus reaches the 100 mL mark.
- Mix thoroughly by inverting or swirling the flask.

Addressing the Given Given Volume of Stock Solution (10 mL of 4.6 M)

The problem states you are given 10 mL of a 4.6 M stock solution, and the goal is to prepare 100 mL of a 0.00046 M solution.

Is the provided stock volume sufficient?

- The calculated required volume of stock solution is 0.01 mL, which is much less than the 10 mL available.
- Therefore, you have an abundance of stock solution, making the process straightforward and allowing for multiple dilutions if needed.

Alternative Approaches and Practical Tips

1. Using the Entire 10 mL Stock Solution

If you wish to prepare a larger volume or reduce the number of transfers:

- Calculate how much of the stock solution is needed for larger volumes.
- For example, to prepare 1 L (1000 mL) of the same dilute solution:

$$
V_1 = \frac{0.00046 \times 1}{4.6} = 0.0001 \text{ L} = 0.1 \text{ mL}
$$

- Since you have 10 mL of stock, you can easily prepare many liters of the dilute solution by scaling up.

2. Using Serial Dilutions

When working with very dilute solutions, serial dilutions are often employed:

- Prepare an intermediate dilution to make handling easier.
- For instance, dilute the stock solution to a higher concentration (say, 0.046 M), then perform further dilutions stepwise.

3. Ensuring Accuracy

- Always use calibrated pipettes and volumetric flasks.
- Mix solutions thoroughly after each dilution step.
- Label all solutions clearly.

Safety and Handling Precautions

- Chemical Safety: Even dilute solutions can be hazardous; always wear gloves and eye protection.
- Waste Disposal: Dispose of solutions according to your institution's guidelines.
- Accuracy: Avoid contamination by using clean equipment.

Summary of the Procedure

1. Calculate the volume of stock solution needed:

$$
V_1 = \frac{C_2 \times V_2}{C_1} = 0.01 \text{ mL}
$$

2. Measure 10 mL (0.01 mL) of the 4.6 M stock solution using a calibrated micropipette.

3. Transfer the measured volume into a 100 mL volumetric flask.

4. Add distilled water gradually until the 100 mL mark is reached.

5. Mix thoroughly to ensure homogeneity.

6. Verify the solution's concentration if necessary, using appropriate analytical techniques.

Final Remarks

Preparing a solution with such a low molarity from a highly concentrated stock might seem daunting at first, but with the right calculations and meticulous technique, it becomes straightforward. The key is understanding the principles of molarity and dilution, precise measurement, and proper mixing. Remember that accuracy in measurement is paramount to ensure the integrity of your experiment.

This detailed approach not only helps you achieve the desired concentration but also reinforces fundamental laboratory skills that are vital for successful scientific work. Whether for research, quality control, or educational purposes, mastering solution preparation ensures reliable and reproducible results across all chemical disciplines.

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