What Mass In Grams Of Sucrose Must Be Dissolved In 2000 Grams Of Water To Make A 0. 1m Solution?

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Understanding how to prepare solutions with precise molarity is fundamental in chemistry, whether you're conducting experiments in a laboratory or preparing solutions for educational purposes. If you need to create a 0.1 molar (0.1 M) solution of sucrose in water, knowing how to calculate the exact mass of sucrose required is essential. This guide will walk you through the process step-by-step, explaining the concepts involved and providing practical tips to ensure accuracy.

Understanding Molarity and Its Significance

What Is Molarity?

Molarity (M) is a measure of concentration that indicates the number of moles of solute dissolved in one liter of solution. Specifically, a 0.1 M solution contains 0.1 moles of solute per liter of solution.

Why Is Molarity Important?

- Ensures consistency in experiments
- Facilitates calculations involving chemical reactions
- Assists in preparing solutions with precise concentrations

Key Concepts Needed for the Calculation

Molecular Weight of Sucrose

Sucrose ($C_{12}H_{22}O_{11}$) has a molecular weight of approximately 342.30 g/mol. This value is essential for converting moles to grams.

Volume of the Solution

Since molarity is based on volume, knowing how to convert grams of water to volume is necessary, especially because the question specifies grams rather than liters.

Density of Water

The density of water at room temperature (~20°C) is approximately 1 g/mL, which simplifies conversions between mass and volume.

Step-by-Step Calculation to Determine the Mass of Sucrose Needed

1. Determine the Total Volume of the Solution

- Given mass of water = 2000 grams
- Since the density of water = 1 g/mL, the volume of water = 2000 g ÷ 1 g/mL = 2000 mL
- Convert milliliters to liters: 2000 mL ÷ 1000 = 2 liters

2. Calculate the Number of Moles of Sucrose Needed

- Molarity (M) = moles of solute / liters of solution
- Rearranged: moles of sucrose = Molarity × volume in liters
- Moles of sucrose = 0.1 mol/L × 2 L = 0.2 mol

3. Convert Moles to Grams of Sucrose

- Grams of sucrose = moles × molecular weight
- Grams of sucrose = 0.2 mol × 342.30 g/mol ≈ 68.46 g

Final Answer: How Much Sucrose to Dissolve

To prepare a 0.1 M sucrose solution in 2000 grams (or approximately 2 liters) of water, you need to dissolve approximately 68.46 grams of sucrose.

Additional Considerations for Accurate Solution Preparation

Temperature and Density Variations

- The density of water slightly varies with temperature; at higher temperatures, water becomes less dense.
- For precise laboratory work, measure the volume directly rather than relying solely on mass conversions.

Measuring the Correct Mass of Sucrose

- Use a precise digital scale for weighing sucrose.
- Ensure the sucrose is dry to prevent inaccuracies due to moisture.

Mixing and Dissolution

- Add the sucrose gradually to water while stirring continuously.
- Ensure complete dissolution to achieve a uniform solution.

Adjusting for Final Volume (Optional Method)

- Alternatively, you can add sucrose to less water, dissolve it thoroughly, and then add more water to reach exactly 2 liters.

- This method can improve accuracy, especially if the solute affects the total volume.

Practical Tips for Preparing the Solution

1. **Gather Materials:** Use a clean, dry container, a precise digital scale, and a graduated cylinder or volumetric flask.
2. **Calculate First:** Confirm the amount of sucrose needed (about 68.46 grams).
3. **Weigh Sucrose:** Carefully weigh out the exact amount on the scale.
4. **Measure Water:** Use a volumetric flask or graduated cylinder to measure 2 liters of water.
5. **Dissolve Sucrose:** Slowly add sucrose to water while stirring until fully dissolved.
6. **Check Volume:** If necessary, adjust the final volume to 2 liters for precise molarity.
7. **Label the Solution:** Clearly mark the container with the concentration, date, and other relevant details.

Common Mistakes to Avoid

- **Using approximate measurements:** Always weigh precisely to ensure correct molarity.
- **Not accounting for temperature:** Remember that water density varies; measure volume directly if possible.
- **Neglecting complete dissolution:** Ensure sucrose is fully dissolved before final volume adjustment.
- **Adding water after dissolving sucrose:** Be cautious to reach the exact final volume to maintain concentration accuracy.

Summary

Preparing a 0.1 M sucrose solution in 2000 grams of water requires dissolving approximately 68.46 grams of sucrose. By understanding the relationship between molarity, volume, and mass, and following precise measurement techniques, you can create solutions with accurate concentrations suitable for various scientific applications.

Frequently Asked Questions (FAQs)

Can I prepare this solution using less or more water?

Yes. The amount of sucrose required depends on the desired molarity and total volume. Adjust the calculations accordingly if you change the volume.

What if I need a different molarity?

Modify the calculation by replacing 0.1 mol/L with your desired molarity and following the same steps.

Is sucrose soluble enough in water at room temperature?

Yes. Sucrose is highly soluble in water, with about 200 g dissolving per 100 mL at room temperature, so dissolving 68 grams in 2 liters poses no issue.

How can I verify the concentration of my solution?

Use laboratory techniques such as refractometry or spectrophotometry for precise verification, or rely on accurate calculations and measurement techniques for standard preparations.

By mastering these calculations and procedures, you'll be well-equipped to prepare sucrose solutions of specific molarity for your scientific or educational needs.

Frequently Asked Questions

How do I calculate the mass of sucrose needed to prepare a 0.1 M solution in 2000 grams of water?

First, convert the mass of water to liters: 2000 g ÷ 1000 g/L = 2 L. Since molarity (M) is moles of solute per liter, multiply 0.1 mol/L by 2 L to get 0.2 mol. Then, multiply by the molar mass of sucrose (342.3 g/mol): 0.2 mol × 342.3 g/mol = 68.46 grams. So, approximately 68.46 grams of sucrose are needed.

What is the formula used to determine the mass of sucrose for a given molarity and water volume?

The formula is: Mass of sucrose (g) = Molarity (mol/L) × Volume of solution (L) × Molar mass of sucrose (g/mol).

If I only have 2000 grams of water, how much sucrose should I add to make a 0.1 M solution?

Convert 2000 grams of water to liters: 2000 g ÷ 1000 g/L = 2 L. Then, multiply the molarity by the volume and molar mass: 0.1 mol/L × 2 L × 342.3 g/mol ≈ 68.46 grams. So, you should dissolve approximately 68.46 grams of sucrose.

Does the density of water affect the calculation of sucrose needed for a 0.1 M solution?

No, since molarity is based on volume in liters, not mass. As long as you convert water mass to volume correctly, the density does not affect the calculation.

What is the significance of the molar mass of sucrose in preparing the solution?

The molar mass of sucrose (342.3 g/mol) allows you to convert moles needed for the desired molarity into grams, which is the required amount of sucrose to dissolve.

Can I use the same formula to prepare solutions of different molarities?

Yes, the same formula applies: Mass of sucrose = Molarity × Volume × Molar mass. Just substitute the desired molarity accordingly.

How accurate is this calculation if I use approximate values for molar mass and water volume?

The calculation provides an estimate. For precise preparation, use exact molar mass values and convert water mass to volume carefully. Small variations may affect the final concentration slightly.

Additional Resources

What Mass In Grams Of Sucrose Must Be Dissolved In 2000 Grams Of Water To Make A 0.1m Solution?

In the realm of chemistry, solutions are fundamental components that reveal the intricate interactions between solutes and solvents. Whether in laboratory experiments, industrial processes, or culinary applications, understanding how to prepare solutions with precise concentrations is essential. A common task involves calculating the amount of a substance—such as sucrose—that must be added to a given amount of water to achieve a specific molality.

This article explores the question: What mass in grams of sucrose must be dissolved in 2000 grams of water to make a 0.1 molal (0.1m) solution? We will delve into the concepts of molality, the molecular weight of sucrose, and the step-by-step calculation process. By the end, readers will have a thorough understanding of how to determine the required amount of sucrose for such solutions, equipping them with the knowledge to perform similar calculations in their scientific pursuits.

Understanding Molality and Its Significance

What is Molality?

Molality (m) is a measure of concentration that expresses the number of moles of solute per kilogram of solvent. Unlike molarity, which depends on the total volume of solution and can vary with temperature, molality remains constant regardless of temperature changes because it is based on mass.

Formula:

$$ m = \frac{\text{moles of solute}}{\text{kilograms of solvent}} $$

In our case, a 0.1 molal solution contains 0.1 moles of sucrose per 1 kilogram (1000 grams) of water.

Why Use Molality?

Molality is particularly useful in situations where temperature stability is crucial, such as in colligative property calculations or when preparing solutions that require precise molar ratios. It also simplifies calculations involving mass, which is more straightforward in many laboratory settings.

Properties of Sucrose and Its Molecular Weight

Sucrose: Composition and Structure

Sucrose, commonly known as table sugar, is a disaccharide composed of glucose and fructose units linked together. Its molecular formula is $C_{12}H_{22}O_{11}$.

Molecular Weight of Sucrose

Calculating the molar mass of sucrose involves summing the atomic weights:

- Carbon (C): approximately 12.01 g/mol
- Hydrogen (H): approximately 1.008 g/mol
- Oxygen (O): approximately 16.00 g/mol

Calculation:

$$
\text{Molecular weight} = (12 \times 12.01) + (22 \times 1.008) + (11 \times 16.00)
$$

$$
= 144.12 + 22.176 + 176.00 = 342.30\, \text{g/mol}
$$

For simplicity, we often round to 342.30 grams per mole.

Step-by-Step Calculation of Sucrose Needed

To determine the mass of sucrose required, we follow a structured approach:

1. Identify the total amount of solvent

Given: 2000 grams of water

Convert grams to kilograms:

$$
2000\, \text{g} = 2\, \text{kg}
$$

2. Determine the number of moles of sucrose needed

Using the molality formula:

$$
m = \frac{\text{moles of sucrose}}{\text{kg of water}}
$$

Rearranged to find moles:

$$
\text{moles of sucrose} = m \times \text{kg of water}
$$

Plugging in the values:

$$
= 0.1\, \text{mol/kg} \times 2\, \text{kg} = 0.2\, \text{mol}
$$

3. Convert moles to grams

Using the molar mass:

$$
\text{Mass of sucrose} = \text{moles} \times \text{molar mass}
$$

$$
= 0.2\, \text{mol} \times 342.30\, \text{g/mol} = 68.46\, \text{g}
$$

4. Final answer

Approximately 68.46 grams of sucrose must be dissolved in 2000 grams of water to prepare a 0.1 molal sucrose solution.

Practical Considerations and Additional Insights

Measuring and Dissolving Sucrose

- Accurate weighing: Use a precise balance to measure approximately 68.5 grams of sucrose.
- Dissolution process: Add sucrose gradually into the water while stirring continuously to ensure complete dissolution.
- Temperature influence: While molality remains unaffected by temperature, the solubility of sucrose in water increases with temperature. For most laboratory purposes, room temperature is assumed unless specified otherwise.

Scaling and Adjustments

The calculation can be scaled for larger or smaller quantities:

- For 1 liter (approximately 1000 grams) of water, half the amount of sucrose (around 34.2 grams) would be needed.
- For different concentrations, simply adjust the molality and repeat the calculations accordingly.

Applications and Relevance

Understanding how to prepare solutions with precise molality is vital in:

- Pharmaceutical formulations: where exact dosages are critical.
- Chemical experiments: involving colligative properties like boiling point elevation or freezing point depression.
- Food science: controlling sugar concentrations for texture and sweetness.

Final Remarks

Preparing a 0.1 molal sucrose solution in 2000 grams of water requires dissolving approximately 68.5 grams of sucrose. This calculation, rooted in understanding molality and molecular weight, exemplifies the importance of fundamental chemistry principles in practical applications. Whether for laboratory experiments, industrial processes, or culinary creations, mastering such calculations ensures precise, reproducible results.

In summary, the key steps involve:

- Recognizing the molality definition.
- Calculating the number of moles based on solvent mass.
- Converting moles to grams using sucrose's molar mass.
- Measuring and dissolving the precise amount for the desired concentration.

By applying these principles, chemists and students alike can confidently prepare solutions tailored to their specific needs, advancing their scientific and practical endeavors with accuracy and confidence.

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