

Calculate The Percent By Mass Of The Solute In Each Of The Following Aqueous Solutions: (a) 5.50 G Of

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Understanding how to calculate the percent by mass of a solute in a solution is fundamental in chemistry. This calculation helps chemists determine the concentration of a substance within a mixture, which is crucial for reactions, formulations, and quality control. In this comprehensive guide, we will explore the step-by-step process of calculating the percent by mass of a solute, starting with a specific example involving 5.50 grams of a solute dissolved in an aqueous solution. Along the way, you'll learn key concepts, formulas, and practical tips to master this essential skill.

What Is Percent By Mass?

Percent by mass, also known as mass percent, describes the concentration of a solute in a solution as a percentage of the total mass of the solution. It is expressed as:

$$\text{Percent by mass} = \left(\frac{\text{Mass of solute}}{\text{Total mass of solution}} \right) \times 100\%$$

This value indicates how much of the solution's total mass is composed of the solute. For example, if a solution contains 5.50 grams of salt in 100 grams of solution, the percent by mass of salt is 5.50%.

Step-by-Step Calculation of Percent By Mass

Calculating the percent by mass involves precise measurement and understanding of the components involved. Here's a general approach:

1. Identify the Mass of the Solute

- This is the amount of the substance dissolved in the solution.
- Usually given or measured in grams (g).

2. Determine the Total Mass of the Solution

- This includes the mass of both the solute and the solvent (water in aqueous solutions).
- If not directly provided, you may need to add the mass of the solute and solvent.

3. Apply the Percent By Mass Formula

$$\text{Percent by mass} = \left(\frac{\text{Mass of solute}}{\text{Mass of solution}} \right) \times 100\%$$

4. Express the Result

- Write the answer as a percentage, rounded to appropriate significant figures.

Practical Example: Calculating the Percent By Mass of a Solute

Let's apply these steps to a specific problem involving 5.50 grams of a solute dissolved in water.

Sample Problem Statement

Suppose you have 5.50 grams of sodium chloride (NaCl) dissolved in enough water to make a total solution mass of 150.00 grams. Calculate the percent by mass of NaCl in this aqueous solution.

Solution Breakdown

Step 1: Identify the mass of the solute

- Mass of NaCl (solute) = 5.50 g

Step 2: Determine the total mass of the solution

- Total mass = 150.00 g

Step 3: Use the formula for percent by mass

$$\text{Percent by mass of NaCl} = \left(\frac{5.50 \text{ g}}{150.00 \text{ g}} \right) \times 100\%$$

Step 4: Perform the calculation

$$\frac{5.50}{150.00} = 0.03667$$

$$0.03667 \times 100\% = 3.67\%$$

Answer: The percent by mass of NaCl in the solution is approximately 3.67%.

Additional Examples and Variations

Understanding the calculation in different contexts reinforces learning. Here are some common scenarios:

Example 1: Different Solutes

- Calculating percent by mass for other solutes like sugar, ethanol, or acids.
- The process remains the same: identify the solute mass and total solution mass, then apply the formula.

Example 2: Unknown Total Solution Mass

- Sometimes only the solute mass and the concentration are known.
- You may need to calculate the total solution mass based on other data, such as volume and density.

Example 3: Using Volume and Density

- If solution volume and density are provided, convert volume to mass before calculating percent by mass.
- For example, if the solution volume is 200 mL and density is 1.2 g/mL:

$$\text{Mass of solution} = 200 \text{ mL} \times 1.2 \text{ g/mL} = 240 \text{ g}$$

- Then, proceed with the calculation.

Considerations and Tips for Accurate Calculations

Achieving precise results requires attention to detail. Here are some tips:

- **Use accurate measurements:** Use calibrated balances and volumetric tools.
- **Maintain significant figures:** Keep consistent significant figures based on measurement precision.
- **Account for all components:** Ensure the total mass includes all parts of the solution.
- **Be cautious with units:** Always convert measurements to the same unit system before calculations.
- **Double-check calculations:** Verify your arithmetic to prevent errors.

Applications of Percent By Mass Calculations

Knowing how to calculate and interpret percent by mass is essential across various fields:

1. **Pharmaceuticals:** Formulating medications with precise concentrations.
2. **Food Industry:** Ensuring product consistency and labeling accuracy.
3. **Environmental Science:** Analyzing pollutant concentrations in water samples.
4. **Chemical Manufacturing:** Preparing solutions and mixtures with specified concentrations.

Summary

Calculating the percent by mass of a solute in an aqueous solution involves understanding the relationship between the mass of the solute and the total mass of the solution. The process is straightforward: measure or identify the required masses, apply the percent by mass formula, and interpret the results. Mastery of this calculation supports accurate formulation, analysis, and quality control in various scientific and industrial applications.

Final Tips for Mastery

- Practice with different problems to reinforce understanding.
- Familiarize yourself with conversions between volume, mass, and density.
- Always consider the context and additional data available for complex problems.
- Use calculator functions carefully to avoid computational errors.

By following these steps and guidelines, you can confidently calculate the percent by mass of any solute in aqueous solutions, enabling precise control and understanding of solution concentrations in your scientific endeavors.

Frequently Asked Questions

How do you calculate the percent by mass of a solute in an aqueous solution?

To calculate the percent by mass of a solute, divide the mass of the solute by the total mass of the solution and multiply by 100%. Formula: $(\text{mass of solute} / \text{total mass of solution}) \times 100\%$.

What is the percent by mass of a solute if 5.50 g is dissolved in 100 g of solution?

The percent by mass is $(5.50 \text{ g} / 100 \text{ g}) \times 100\% = 5.50\%$.

If a solution contains 5.50 g of solute and the total solution mass is 250 g, what is the percent by mass?

Percent by mass = $(5.50 \text{ g} / 250 \text{ g}) \times 100\% = 2.2\%$.

How does the mass of solute affect the percent by mass

in an aqueous solution?

An increase in the mass of solute, while keeping the total solution mass constant, increases the percent by mass. Conversely, decreasing the solute mass decreases the percent by mass.

Why is calculating the percent by mass important in preparing solutions?

Calculating the percent by mass helps ensure accurate concentration for reactions, quality control, and standardization in laboratory and industrial processes.

Additional Resources

Calculate The Percent By Mass Of The Solute In Each Of The Following Aqueous Solutions:
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Understanding the composition of solutions is fundamental in chemistry, especially when it comes to preparing mixtures with precise concentrations. One key measure used to describe the concentration of a solute within a solvent is the percent by mass. This metric provides insight into how much of a particular substance (the solute) is present relative to the total mass of the solution. In this article, we delve into how to calculate the percent by mass of a solute in aqueous solutions, beginning with a specific example: a solution containing 5.50 grams of solute. We will explore the concept thoroughly, step-by-step, and extend our understanding to various scenarios.

Understanding Percent By Mass: The Concept and Its Significance

Before diving into calculations, it's essential to grasp what percent by mass represents and why it is important in chemistry.

Definition of Percent By Mass

Percent by mass, often expressed as "% w/w" (weight/weight percent), indicates the proportion of a solute within a solution relative to the total mass of the solution. It is calculated using the formula:

$$\text{Percent by mass (\%)} = (\text{Mass of solute} / \text{Total mass of solution}) \times 100$$

This measure allows chemists and students to compare concentrations across different solutions easily and to prepare solutions with desired concentrations.

Importance in Laboratory and Industrial Settings

- Precision and Reproducibility: Accurate percent by mass calculations enable the preparation of solutions with consistent properties, crucial for experiments and manufacturing.
- Safety: Knowing the concentration helps assess potential hazards, especially when dealing with toxic or reactive substances.
- Cost-Effectiveness: Proper calculations prevent waste of materials and ensure efficient use of chemicals.
- Regulatory Compliance: Many regulations specify allowable concentrations; accurate measurements ensure compliance.

Step-by-Step Calculation of Percent By Mass

Calculating the percent by mass involves clear steps, especially when given the mass of the solute and the total solution.

Step 1: Identify the Mass of the Solute

In our example, the mass of the solute is given as 5.50 grams.

Step 2: Determine or Obtain the Total Mass of the Solution

The total mass of the solution comprises the solute and the solvent. If the problem provides only the mass of the solute, the total solution mass must be known or calculated. For example:

- If the solvent's mass is given, add it to the solute's mass.
- If only the total solution mass is given, use it directly.

Suppose, in this case, the total solution mass is known or provided separately. For illustration, let's assume the total mass of the solution is 100.00 grams.

Step 3: Apply the Percent by Mass Formula

Using the formula:

$$\text{Percent by mass (\%)} = (\text{Mass of solute} / \text{Total mass of solution}) \times 100$$

Substituting the values:

$$\text{Percent by mass (\%)} = (5.50 \text{ g} / 100.00 \text{ g}) \times 100 = 5.50\%$$

This indicates that the solution contains 5.50 grams of solute per 100 grams of solution.

Practical Example: Calculating Percent By Mass of a Specific Solution

Let's consider a concrete example to deepen understanding.

Example:

Suppose you prepare an aqueous solution by dissolving 5.50 grams of sodium chloride (NaCl) in enough water to make a total solution mass of 100 grams. What is the percent by mass of NaCl in this solution?

Solution:

- Mass of NaCl (solute) = 5.50 g
- Total mass of solution = 100.00 g

Applying the formula:

$$\text{Percent by mass NaCl} = (5.50 \text{ g} / 100.00 \text{ g}) \times 100 = 5.50\%$$

Therefore, the solution is 5.50% NaCl by mass.

Implications:

- This concentration is typical for saline solutions used in medical settings.
- Such calculations are vital for ensuring solutions meet required specifications.

Extending the Calculation to Other Scenarios

While our example considers a known total solution mass, in practical situations, the total mass might be unknown or need to be calculated based on other data.

Scenario 1: Given the mass of the solute and the volume of the solution

If the density of the solution is known, the total mass can be derived:

$$\text{Total mass} = \text{Volume} \times \text{Density}$$

For example, if a solution contains 5.50 g of solute dissolved in 200 mL of water, and the

density of the solution is approximately 1.0 g/mL (assuming dilute solutions), then:

$$\text{Total mass} = 200 \text{ mL} \times 1.0 \text{ g/mL} = 200 \text{ g}$$

Percent by mass:

$$(5.50 \text{ g} / 200 \text{ g}) \times 100 = 2.75\%$$

Scenario 2: When the mass of the solvent is provided

If the solvent's mass is known and the solute's mass is given, the total solution mass is:

$$\text{Total mass} = \text{Solvent mass} + \text{Solute mass}$$

For example, if 94.50 g of water is used with 5.50 g of solute:

$$\text{Total mass} = 94.50 \text{ g} + 5.50 \text{ g} = 100 \text{ g}$$

Percent by mass:

$$(5.50 / 100) \times 100 = 5.50\%$$

Common Pitfalls and Tips for Accurate Calculations

Achieving precise calculations requires attention to detail. Here are some tips:

- Ensure consistent units: Always keep masses in grams when calculating percent by mass.
- Double-check the total solution mass: If not provided, calculate it accurately using the solvent's mass and the solute's mass.
- Use proper significant figures: Reflect the precision of the measurements in your final answer.
- Beware of approximations: For solutions with high concentrations, density may deviate from water's density, affecting calculations.

Real-World Applications of Percent By Mass Calculations

Understanding how to calculate percent by mass extends beyond academic exercises and into real-world applications:

- Pharmaceuticals: Precise concentrations are critical for drug formulations.
- Food Industry: Nutritional information often relies on percent by mass.

- Environmental Monitoring: Water quality assessments depend on knowing pollutant concentrations.
- Industrial Manufacturing: Producing chemicals with specific concentrations ensures product quality and safety.

Conclusion: The Essential Skill of Concentration Calculation

Calculating the percent by mass of a solute in aqueous solutions is a fundamental skill in chemistry, underpinning everything from laboratory experiments to industrial processes. Whether starting with simple data like the mass of a solute or working with more complex measurements involving volume and density, the core concept remains consistent: understanding the ratio of solute to total solution. By mastering these calculations, students and professionals can ensure the accuracy and effectiveness of their work, making informed decisions in research, manufacturing, and safety protocols. As demonstrated with our example involving 5.50 grams of solute, a methodical approach and attention to detail are crucial for reliable results, ultimately enabling better control over chemical compositions and their applications in everyday life.

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