An Aqueous Solution Which Contains 15% By Mass Sodium Chloride Could Contain (a) 15 Grams Of Sodium Chloride

An Aqueous Solution Which Contains 15% By Mass Sodium Chloride Could Contain (a) 15 Grams Of Sodium Chloride is a statement that invites a deeper exploration into the principles of solution chemistry, particularly focusing on the concepts of concentration, mass, and solution preparation. Understanding how to interpret and manipulate these parameters is essential in fields ranging from laboratory experiments to industrial processes. This article aims to clarify what a 15% by mass sodium chloride solution means, how to determine the amount of solute contained in such solutions, and the practical applications of this knowledge.

Understanding the Concept of Percent by Mass in Solutions

What Does 15% By Mass Mean?

Percent by mass (or weight percent) is a way to express the concentration of a solute in a solution. It indicates the mass of the solute as a percentage of the total mass of the solution. In the case of a 15% sodium chloride solution:

- 15 grams of sodium chloride are present in every 100 grams of the solution.
- The rest of the solution comprises water (or another solvent), making up the remaining 85 grams.

Mathematically, this can be expressed as:
$$ \text{Mass of NaCl} = \frac{15}{100} \times \text{Total mass of solution} $$

This ratio provides a straightforward method to calculate the amount of solute in any given total solution mass.

Calculating the Amount of Sodium Chloride in a 15% Solution

Determining the Solute in a Given Total Mass

If an aqueous solution contains 15% sodium chloride by mass, calculating the actual mass of sodium chloride involves simple proportional reasoning:

- For every 100 grams of solution, 15 grams are sodium chloride.
- To find the amount of sodium chloride in a specific amount of solution, multiply the total mass by

0.15.

Example Calculation:

Suppose you have 200 grams of this solution:

$$\text{Mass of NaCl} = 200 \text{ g} \times 0.15 = 30 \text{ g}$$

Thus, in 200 grams of a 15% solution, there are 30 grams of sodium chloride.

Applying This to the Given Situation

The question asks whether a solution containing 15 grams of sodium chloride could be a 15% solution:

- To determine this, we set up the equation:

$$\text{Total solution mass} = \frac{\text{Mass of NaCl}}{0.15}$$

- Plugging in the known value:

$$\text{Total solution mass} = \frac{15 \text{ g}}{0.15} = 100 \text{ g}$$

This calculation shows that a 15% sodium chloride solution would contain 15 grams of sodium chloride in a total volume of 100 grams of solution.

Conclusion:

Yes, a solution containing 15 grams of sodium chloride can be a 15% by mass solution, provided the total mass of the solution is 100 grams.

Preparing a 15% Sodium Chloride Solution

Step-by-Step Procedure

Creating a specific concentration solution requires precise measurement and mixing:

1. Determine the desired total volume or mass of solution.
2. Calculate the required mass of sodium chloride:

$$\text{Mass of NaCl} = \left(\frac{\text{Desired concentration}}{100} \right) \times \text{Total mass of solution}$$

3. Weigh the calculated amount of sodium chloride using an accurate balance.
4. Add the sodium chloride to a container.
5. Add distilled water gradually while stirring until reaching the total desired mass or volume.
6. Ensure thorough mixing to obtain a uniform solution.

This process underscores the importance of accurate measurement in solution preparation, especially in laboratory settings.

Implications and Applications of 15% Sodium Chloride Solutions

Uses in Industry and Medicine

A 15% sodium chloride solution is commonly used in various applications:

- Medical Saline Solutions: Certain wound irrigation solutions or topical applications may utilize similar concentrations for antimicrobial effects.
- Food Industry: Brine solutions for pickling or preservation often employ specific salt concentrations.
- Laboratory Experiments: Preparing solutions with precise concentrations is essential for chemical analyses, titrations, and other research activities.
- Chemical Manufacturing: Sodium chloride solutions serve as feedstock or reagents in various chemical processes.

Safety and Handling Considerations

While sodium chloride is generally safe, handling concentrated solutions requires caution:

- Avoid ingestion or prolonged skin contact with high-concentration solutions.
- Use appropriate protective equipment, such as gloves and goggles.
- Store solutions in labeled, sealed containers to prevent contamination and accidental misuse.

Understanding the Limits of the Statement

Can a Solution with 15 Grams of Sodium Chloride Be Less or More Concentrated?

Yes, the amount of sodium chloride present in a solution depends on the total volume or mass of the solution:

- If the total solution mass is less than 100 grams, a 15-gram sodium chloride solution would have a concentration greater than 15%.
- If the total solution mass exceeds 100 grams, the concentration would be less than 15%.

For example:

- 50 grams solution with 15 grams NaCl:

$$ \frac{15}{50} \times 100 = 30\% $$

- 200 grams solution with 15 grams NaCl:

$$ \frac{15}{200} \times 100 = 7.5\% $$

This demonstrates that the concentration depends on both the amount of solute and the total solution mass.

Summary and Key Takeaways

- A 15% sodium chloride solution contains 15 grams of sodium chloride per 100 grams of solution.
- To determine if a solution containing 15 grams of NaCl is 15%, calculate the total solution mass:

$$ \text{Total mass} = \frac{15 \text{ g}}{0.15} = 100 \text{ g} $$

- Precise measurement and calculation are essential in preparing solutions with desired concentrations.
- Such solutions are widely used in medical, industrial, and laboratory contexts.
- The concentration of a sodium chloride solution can vary significantly depending on the total solution mass.

By understanding the relationship between mass, concentration, and solution preparation, scientists and technicians can accurately produce and utilize sodium chloride solutions tailored to their specific needs.

Frequently Asked Questions

What is the mass of the aqueous solution if it contains 15 grams of sodium chloride at 15% concentration by mass?

The total mass of the solution is 100 grams because 15 grams represents 15% of the solution's mass (since 15 g is 15% of 100 g).

How do you calculate the total mass of the aqueous solution containing 15 grams of NaCl at 15% concentration?

Use the formula: Total mass = mass of solute / (percentage as a decimal). So, Total mass = 15 g / 0.15 = 100 g.

If the solution contains 15 grams of sodium chloride, what is the volume of the solution assuming the density is similar to

water?

Assuming the density is approximately 1 g/mL, the volume is roughly 100 mL because the total mass is 100 grams.

Can 15 grams of sodium chloride be dissolved in 100 mL of water to make a 15% solution?

Yes, dissolving 15 grams of NaCl in approximately 85 mL of water will result in a solution close to 15% by mass, totaling about 100 mL in volume, assuming negligible volume change.

What are the practical applications of preparing a 15% sodium chloride aqueous solution?

Such solutions are used in medical saline solutions, food preservation, and laboratory experiments requiring precise salt concentrations.

If you have less than 100 grams of solution, can it contain 15 grams of sodium chloride at 15%?

No, because at 15%, 15 grams of NaCl requires a total solution mass of 100 grams. Less than 100 grams would mean a higher percentage of NaCl, which is not consistent with the 15% concentration.

Additional Resources

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In the realm of chemistry and solution sciences, understanding the precise composition of aqueous solutions is fundamental, especially when dealing with solutes like sodium chloride (NaCl). The phrase “An aqueous solution which contains 15% by mass sodium chloride” serves as a gateway into discussions about concentration calculations, solution preparation, and the practical implications of such compositions. This article aims to dissect the concept thoroughly, focusing on whether an aqueous solution with a 15% by mass NaCl can contain exactly 15 grams of sodium chloride under different circumstances. Through a detailed exploration of solution concentration metrics, preparation techniques, and real-world applications, we intend to clarify this common point of confusion and provide a comprehensive understanding suitable for researchers, educators, and students alike.

Understanding Concentration Metrics in Aqueous Solutions

Before delving into specific calculations or scenarios, it is essential to establish a foundational understanding of how solutions are characterized in terms of concentration. The primary metrics include mass percent (mass%), molarity, molality, and mole fraction, each serving different purposes depending on the context.

Mass Percent (Mass%)

Mass percent is defined as the mass of solute divided by the total mass of the solution, multiplied by 100 to express as a percentage:

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

For a 15% NaCl solution:

$$
\frac{\text{Mass of NaCl}}{\text{Total mass of solution}} \times 100 = 15
$$

This implies that for every 100 grams of solution, 15 grams are NaCl, and 85 grams are solvent (water).

Molarity and Molality

While less directly relevant for mass-based questions, these metrics are crucial in accuracy and solution preparation:

- Molarity (M): Moles of solute per liter of solution.
- Molality (m): Moles of solute per kilogram of solvent.

They are particularly useful in lab settings where solutions are prepared with specific molar concentrations.

The Practical Question: Can a 15% NaCl Solution

Contain 15 Grams of NaCl?

The core inquiry hinges on the relationship between the mass percent and the actual mass of NaCl in a given volume or mass of solution. Specifically, the question asks whether a solution labeled as “15% NaCl by mass” can contain exactly 15 grams of NaCl.

Scenario 1: Based on a Fixed Total Mass of Solution

Suppose you have a solution with a total mass of 100 grams. By definition:

$$
\text{Mass of NaCl} = 15\% \times 100\, \text{g} = 15\, \text{g}
$$

Thus, in this specific case, the solution contains exactly 15 grams of NaCl. The question then becomes: Is it always possible to prepare or find such a solution?

Answer: Yes. If you prepare 100 grams of a solution with 15% NaCl by mass, it will contain 15 grams of NaCl.

Implication: The statement “An aqueous solution which contains 15% by mass NaCl could contain 15 grams of NaCl” is true when referring to a solution with a total mass of 100 grams.

Scenario 2: Variable Total Mass of the Solution

What if the total mass of the solution is different? For example, if you have a solution with a total mass of 200 grams:

$$
\text{Mass of NaCl} = 15\% \times 200\, \text{g} = 30\, \text{g}
$$

In this case, the solution contains 30 grams of NaCl, not 15 grams.

Conversely, if the total mass is only 50 grams:

$$
\text{Mass of NaCl} = 15\% \times 50\, \text{g} = 7.5\, \text{g}
$$

Here, the solution contains 7.5 grams of NaCl.

Conclusion: The key factor is the total mass of the solution, which determines how much NaCl it contains, given a fixed mass percent.

Preparing a Solution with 15% NaCl That Contains 15 Grams of NaCl

Given the above, a straightforward way to produce a solution containing 15 grams of NaCl at 15% mass concentration involves simple calculations:

$$
\text{Total mass of solution} = \frac{\text{Mass of NaCl}}{\text{Mass \% (as decimal)}}
$$

Substituting values:

$$
\text{Total mass} = \frac{15\, \text{g}}{0.15} = 100\, \text{g}
$$

Preparation steps:

1. Weigh 15 grams of pure NaCl.
2. Add distilled water to reach a total mass of 100 grams.
3. Mix thoroughly until NaCl dissolves completely.

This process guarantees that the resulting solution is 15% by mass and contains exactly 15 grams of NaCl.

Implications for Laboratory and Industrial Practices

Understanding the relationship between concentration and mass is vital in various contexts:

- Laboratory experiments: Precise measurements ensure reproducibility.
- Industrial formulations: Accurate concentration control impacts product quality.
- Medical applications: Saline solutions for injections require strict concentration standards.

The clarity that a 15% NaCl solution can contain any specific mass of NaCl—provided the total solution mass is adjusted accordingly—is essential for accurate preparation and quality assurance.

Common Misconceptions and Clarifications

While the basic calculations seem straightforward, several misconceptions often arise:

- Misconception 1: “A 15% solution always contains 15 grams of NaCl.”

Clarification: Only if the total solution mass is 100 grams. For different total masses, the amount varies proportionally.

- Misconception 2: “You cannot have exactly 15 grams of NaCl in a 15% solution.”
Clarification: You can, but only if the total solution mass is 100 grams.

- Misconception 3: “The concentration is fixed regardless of total solution volume.”
Clarification: Concentration depends on the ratio, so changing total mass or volume alters the actual amount of solute.

Real-World Applications and Significance

Understanding these principles is not merely academic; it has practical importance:

- Medical saline solutions: Typically prepared at specific concentrations (e.g., 0.9% NaCl). Knowing how to scale solutions accurately is crucial for patient safety.
- Food industry: Salting processes depend on precise salt concentrations.
- Chemical manufacturing: Producing solutions with exact concentrations ensures consistency and compliance with standards.

In all these cases, the key takeaway is that the amount of solute in a solution at a given mass percent can be precisely controlled by adjusting the total solution mass.

Conclusion

In summary, an aqueous solution which contains 15% by mass sodium chloride can indeed contain 15 grams of sodium chloride, but this is specifically true when the total mass of the solution is exactly 100 grams. The core principle is straightforward: the mass of solute in a solution is directly proportional to the total mass of the solution based on the percentage concentration.

This understanding underscores the importance of clear definitions and precise calculations in solution chemistry. Whether preparing laboratory solutions or designing industrial processes, appreciating the relationship between concentration and total mass ensures accuracy, safety, and consistency. Recognizing that concentration metrics are flexible and adaptable to different total solution masses enables chemists and technicians to tailor solutions precisely to their needs, making this knowledge foundational for both academic and practical applications in chemistry.

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Note: Always confirm solution concentrations with precise measurements, especially in critical applications, to ensure safety and efficacy.

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