

What Is The Molality Of A Solution Containing 3.0 Moles Of NaCl And 100.0 Moles Of Water?

What Is The Molality Of A Solution Containing 3.0 Moles Of NaCl And 100.0 Moles Of Water?

Understanding the molality of a solution that contains specific amounts of solute and solvent is fundamental in chemistry, especially when dealing with solutions' properties and behaviors. In this article, we will explore how to calculate the molality of a solution with 3.0 moles of sodium chloride (NaCl) and 100.0 moles of water, delving into key concepts, formulas, and practical applications. Whether you are a student studying solution chemistry or a professional chemist, this comprehensive guide will clarify the process and significance of molality calculations.

What Is Molality in Chemistry?

Molality (denoted as "m") is a concentration measure that expresses the number of moles of solute per kilogram of solvent. Unlike molarity, which is based on volume, molality is independent of temperature and volume changes, making it especially useful in thermodynamic calculations and experiments sensitive to temperature variations.

Definition of Molality

- Molality (m): The number of moles of solute divided by the mass of solvent in kilograms.

- Mathematical expression:

\[

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

\]

Key Features of Molality

- Independent of temperature fluctuations
- Useful in calculating colligative properties such as boiling point elevation and freezing point depression
- Expressed as moles per kilogram (mol/kg)

Given Data and Objective

In our specific problem, the data provided are:

- Moles of NaCl (solute): 3.0 moles
- Moles of water (solvent): 100.0 moles

Our goal is to compute the molality of the solution, which requires converting the amount of water into kilograms and applying the molality formula.

Step-by-Step Calculation of Molality

Step 1: Convert Moles of Water to Kilograms

To calculate molality, the mass of the solvent (water) in kilograms is necessary.

- Moles of water: 100.0 mol
- Molecular weight of water: approximately 18.015 g/mol

Calculating the mass in grams:

$$\begin{aligned} & \text{Mass of water} = 100.0 \text{ mol} \times 18.015 \text{ g/mol} = 1801.5 \text{ g} \end{aligned}$$

Converting grams to kilograms:

$$1801.5 \text{ g} \div 1000 = 1.8015 \text{ kg}$$

Step 2: Apply the Molality Formula

Using the formula:

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

Plugging in the values:

$$m = \frac{3.0 \text{ mol NaCl}}{1.8015 \text{ kg water}} \approx 1.666 \text{ mol/kg}$$

\]

Therefore, the molality of the solution is approximately 1.666 mol/kg.

Understanding the Significance of Molality in Solution Chemistry

Why Is Molality Important?

Molality is a critical parameter in various aspects of chemistry, including:

- Colligative properties: Changes in boiling point, freezing point, vapor pressure, and osmotic pressure depend on molality rather than molarity.
- Thermodynamic calculations: Since molality is temperature-independent, it provides stable and reliable data for calculations involving heat transfer and reaction dynamics.
- Solution preparation: Precise control of molality ensures consistent and reproducible experimental conditions.

Applications of Molality

- Determining boiling point elevation and freezing point depression in solutions
- Calculating osmotic pressure in biological systems
- Preparing solutions with specific colligative property effects
- Analyzing electrolyte solutions and their behaviors

Comparison Between Molality and Other Concentration Units

Molality vs. Molarity

Aspect	Molality (m)	Molarity (M)
Definition	Moles of solute per kilogram of solvent	Moles of solute per liter of solution
Temperature dependence	No	Yes
Suitable for	Thermodynamic calculations	Routine laboratory measurements

Molality vs. Mole Fraction

- Mole fraction is the ratio of moles of a component to total moles in the solution, useful in vapor pressure calculations.
- Molality quantifies concentration in terms of mass and moles, more suited for colligative property calculations.

Practical Examples and Real-World Applications

Example 1: Preparing a Molal Solution of NaCl

Suppose a chemist wants to prepare a solution with a molality of approximately 1.666 mol/kg of NaCl. Knowing that the solvent is water, they would measure 1.8015 kg of water and add 3.0 moles of NaCl. This precise measurement ensures the solution has the desired concentration for experiments involving colligative properties or thermodynamic studies.

Example 2: Calculating Colligative Property Changes

Using the molality calculated, scientists can predict how the solution's boiling point or freezing point will shift relative to pure water. For instance, the boiling point elevation (ΔT_b) can be calculated using the formula:

$$\Delta T_b = i \times K_b \times m$$

where i is the van't Hoff factor for NaCl (approximately 2), K_b is the ebullioscopic constant for water, and m is molality.

Summary and Key Takeaways

- The molality of a solution provides a precise measure of concentration based on moles of solute per kilogram of solvent.
- For 3.0 moles of NaCl dissolved in approximately 1.8015 kg of water, the molality is approximately 1.666 mol/kg.
- Understanding and calculating molality is essential for thermodynamic calculations, solution preparation, and analyzing colligative properties.
- Molality remains constant regardless of temperature changes, making it a reliable concentration measure for various scientific applications.

Final Thoughts

Whether you're studying solution chemistry, preparing solutions in the lab, or analyzing thermodynamic properties, understanding how to calculate and interpret molality is crucial. This detailed exploration of a NaCl-water solution demonstrates the practical steps involved and highlights the importance of precise measurement in achieving accurate scientific results. By mastering molality calculations, you enhance your ability to work confidently with solution concentrations and their implications in broader chemical contexts.

Frequently Asked Questions

How do you calculate the molality of a solution given the moles of solute and solvent?

Molality is calculated by dividing the moles of solute by the mass of solvent in kilograms. It is given by $\text{molality (m)} = \text{moles of solute} / \text{kilograms of solvent}$.

What information do you need to find the molality of a NaCl solution if you know its molarity and the moles of water?

You need to convert molarity into moles of solute, and know the mass or moles of solvent (water) to use the molality formula. In this case, since the moles of water are given, you can directly calculate molality.

Given 3.0 Moles of NaCl and 100.0 moles of water, what is the molality of the solution?

First, convert moles of water to kilograms: $100.0 \text{ moles} \times 18.015 \text{ g/mol} = 1801.5 \text{ g} = 1.8015 \text{ kg}$. Then, $\text{molality} = 3.0 \text{ mol NaCl} / 1.8015 \text{ kg water} \approx 1.666 \text{ mol/kg}$.

Why is molality a useful concentration measure compared to molarity?

Molality is useful because it remains constant with temperature changes, unlike molarity which depends on volume and can vary with temperature fluctuations.

Additional Resources

What Is The Molality Of A Solution Containing 3.0 Moles Of NaCl And 100.0 Moles Of Water?

Understanding the molality of a solution containing 3.0 moles of NaCl and 100.0 moles of water is an essential concept in solution chemistry. Molality is a measure of concentration that relates the amount of solute to the mass of solvent, providing a different perspective than molarity, which relates the amount of solute to the volume of solution. In this guide, we will walk through the process of calculating the molality step-by-step, clarifying key concepts, and illustrating the importance of this measurement in chemistry.

What is Molality and Why Does It Matter?

Before diving into calculations, it's important to understand what molality is and why it's a useful unit of concentration.

Molality (m) is defined as:

>
$$\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Kilograms of solvent}}$$

This measurement is temperature-independent because it relies on mass, which does not change with temperature, unlike volume. Molality is particularly useful in colligative property calculations, such as boiling point elevation and freezing point depression, because it provides a consistent measure of solute concentration.

Key Concepts Needed for the Calculation

To determine the molality of the solution, we need to understand and gather the following information:

- Number of moles of solute (NaCl): Given as 3.0 mol.
- Number of moles of solvent (water): Given as 100.0 mol.
- Mass of solvent in kilograms: Since molality is expressed per kilogram of solvent, we need to convert moles of water to mass in kg.
- Molar mass of water: Approximately 18.015 g/mol.
- Molar mass of NaCl: Approximately 58.44 g/mol (not directly needed for molality calculation but essential for understanding solution composition).

Step-by-Step Calculation

Let's now proceed with the calculation of molality for this solution.

Step 1: Convert Moles of Water to Mass in Kilograms

Given:

- Moles of water = 100.0 mol
- Molar mass of water = 18.015 g/mol

Calculate the mass of water in grams:

$$> \text{Mass of water (g)} = \text{Moles of water} \times \text{Molar mass of water}$$

$$> \text{Mass of water (g)} = 100.0 \text{ mol} \times 18.015 \text{ g/mol} = 1801.5 \text{ g}$$

Convert grams to kilograms:

$$> \text{Mass of water (kg)} = 1801.5 \text{ g} / 1000 = 1.8015 \text{ kg}$$

Step 2: Calculate Molality

Using the formula:

$$> \text{Molality (m)} = \text{Moles of solute} / \text{Kilograms of solvent}$$

Plug in the known values:

$$> m = 3.0 \text{ mol} / 1.8015 \text{ kg} \approx 1.666 \text{ mol/kg}$$

So, the molality of the solution is approximately 1.67 mol/kg.

Additional Considerations

While the calculation appears straightforward, there are some important points to consider:

- The initial concentration of NaCl (3.0 M) is a molarity, which relates moles of solute to volume of solution, not mass. To connect molarity to molality, additional information about the solution volume would be needed.
- In this case, the problem provides the moles of water directly, simplifying the process.
- The molality is a more accurate measure of solute concentration in situations where temperature fluctuations occur, as it relies on mass rather than volume.

Why Is Molality Important?

Molality serves as a crucial parameter in many chemical processes:

- Colligative Properties: Because molality remains constant with temperature, it is used in calculating boiling point elevation and freezing point depression.
- Solution Preparations: When precise concentrations are needed, especially in non-aqueous or temperature-variable environments.
- Chemical Equilibria: Accurate concentration measurements help in understanding and predicting reaction behavior.

Practical Applications

Understanding how to calculate molality allows chemists and students to:

- Prepare solutions with specific molality for laboratory experiments.
- Interpret experimental data involving colligative properties.
- Convert between different concentration units based on the needs of the experiment.

Summary of the Calculation

Step	Description	Calculation	Result
1	Convert moles of water to grams	$100.0 \text{ mol} \times 18.015 \text{ g/mol}$	1801.5 g
2	Convert grams to kilograms	$1801.5 \text{ g} \div 1000$	1.8015 kg
3	Calculate molality	$3.0 \text{ mol} \div 1.8015 \text{ kg}$	~1.67 mol/kg

Final Thoughts

In conclusion, the molality of a solution containing 3.0 moles of NaCl and 100.0 moles of water is approximately 1.67 mol/kg. This value provides a clear understanding of the concentration of NaCl in terms of the mass of water, rather than its volume. Mastery of molality calculations enhances your ability to analyze solutions accurately, especially in contexts where temperature and volume may vary.

Whether you're studying colligative properties, preparing solutions, or analyzing experimental data, understanding and calculating molality is an essential skill in the chemist's toolkit.

[What Is The Molality Of A Solution Containing 3 0 Moles Of Nacl And 100 0 Moles Of Water](#)

What Is The Molality Of A Solution Containing 3 0 Moles Of Nacl And 100 0 Moles Of Water

Related Articles

- [The Crumple Zone Is The Portion Of The Vehicle That Is Designed To Give Upon Impact.T/F](#)
- [I Need A Topic Sentence Any Thing You Want I Just Need A Topic Sentence Not A Paragraph](#)
- [What Would Be The Population Proportion Of Number Of Times That Bats Would Follow The Point?](#)

[Back to Home](#)