An Aqueous Solution Is Made By Dissolving 29.4 Grams Of Aluminum Acetate In 433 Grams Of Water. The Molality

An Aqueous Solution Is Made By Dissolving 29.4 Grams Of Aluminum Acetate In 433 Grams Of Water. The Molality of this solution is a fundamental concept in chemistry that helps us understand the concentration of solutes in a solvent. Molality, often represented as m, is defined as the number of moles of solute per kilogram of solvent. This measure is particularly useful because it remains unaffected by temperature changes, unlike molarity, which depends on volume. In this article, we will explore the step-by-step process of calculating the molality of a solution created by dissolving a specific amount of aluminum acetate in water, while also discussing the significance of molality in chemistry, methods of calculation, and real-world applications.

Understanding the Composition of the Solution

What is Aluminum Acetate?

Aluminum acetate is a chemical compound with the formula $Al(C_2H_3O_2)_3$. It is often used in medical and cosmetic applications, as well as in chemical research. Aluminum acetate dissolves in water to form an aqueous solution, making it useful in various industrial and laboratory contexts.

Mass of Aluminum Acetate and Water

In our scenario:
- Mass of aluminum acetate = 29.4 grams
- Mass of water = 433 grams

To calculate the molality, the first step is to convert the mass of aluminum acetate into moles, which requires knowing its molar mass.

Calculating the Molar Mass of Aluminum Acetate

Atomic Weights of Elements Involved

Element	Atomic Weight (g/mol)
Aluminum (Al)	26.98
Carbon (C)	12.01
Hydrogen (H)	1.008
Oxygen (O)	16.00

Molar Mass Calculation

Aluminum acetate, $Al(C_2H_3O_2)_3$, contains:
- 1 aluminum atom
- 3 acetate groups ($C_2H_3O_2$)

Calculating the molar mass:
- Aluminum: 26.98 g/mol
- Carbon: 2 atoms per acetate × 3 acetate groups = 6 carbon atoms
- Hydrogen: 3 atoms per acetate × 3 acetate groups = 9 hydrogen atoms
- Oxygen: 2 atoms per acetate × 3 acetate groups = 6 oxygen atoms

Total molar mass:
- Aluminum: 26.98 g/mol
- Carbon: 6 × 12.01 g/mol = 72.06 g/mol
- Hydrogen: 9 × 1.008 g/mol = 9.072 g/mol
- Oxygen: 6 × 16.00 g/mol = 96.00 g/mol

Adding these:
Molar mass of aluminum acetate = 26.98 + 72.06 + 9.072 + 96.00 = 204.112 g/mol

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Calculating the Number of Moles of Aluminum Acetate

Using the molar mass:
\[
\text{Moles of aluminum acetate} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{29.4\, \text{g}}{204.112\,

\text{g/mol}} \approx 0.144\, \text{mol}
\]

This is the amount of solute present in the solution.

Converting Water Mass to Kilograms

Since molality is expressed per kilogram of solvent:
\[
\text{Mass of water} = 433\, \text{g} = 0.433\, \text{kg}
\]

Calculating the Molality of the Solution

The formula for molality (m) is:
\[
\text{Molality (m)} = \frac{\text{Moles of solute}}{\text{Kilograms of solvent}}
\]

Applying the values:
\[
m = \frac{0.144\, \text{mol}}{0.433\, \text{kg}} \approx 0.332\, \text{mol/kg}
\]

Therefore, the molality of the solution is approximately 0.332 mol/kg.

Significance of Molality in Chemistry

Why Use Molality?

Molality is a preferred concentration unit in many chemical calculations because:
- It does not change with temperature, unlike molarity.
- It provides a more consistent measure of concentration, especially in reactions sensitive to temperature variations.
- It is useful in colligative property calculations, such as boiling point elevation and freezing point depression.

Applications of Molality

Molality is widely used in:
- Solution chemistry research
- Thermodynamic calculations
- Determining colligative properties
- Analyzing concentration effects in chemical reactions

Practical Steps to Calculate Solution Molality

Here is a step-by-step guide to calculating the molality of any aqueous solution:

1. Identify the mass of the solute (in grams).

2. Calculate the molar mass of the solute.

3. Convert the mass of the solute to moles (divide by molar mass).

4. Measure or note the mass of the solvent (in grams).

5. Convert the solvent mass to kilograms.

6. Apply the molality formula: m = moles of solute / kg of solvent.

This process ensures accurate determination of solution concentration, which is vital in various chemical analyses.

Real-World Applications of Aluminum Acetate Solutions

Medical and Dermatological Uses

- Aluminum acetate solutions, such as Burow's solution, are used as astringents and anti-inflammatory agents in treating skin conditions like eczema, poison ivy, and minor skin irritations.

Industrial Applications

- Used in textile processing and as a mordant in dyeing techniques.
- Employed in water treatment processes to remove impurities.

Laboratory Uses

- Aluminum acetate solutions serve as reagents in chemical experiments and research, especially in studies involving complex formation and solution behavior.

Additional Considerations in Solution Chemistry

Factors Affecting Dissolution

- Temperature: Generally increases solubility.
- Agitation: Enhances the rate of dissolution.
- Particle size: Smaller particles dissolve faster.

Limitations and Safety

- Aluminum acetate, while generally safe in small quantities, should be handled with care to avoid ingestion or skin irritation.
- Proper disposal methods should be followed according to safety guidelines.

Conclusion

Calculating the molality of a solution provides insight into its concentration, which is crucial for both scientific understanding and practical applications. In our example, dissolving 29.4 grams of aluminum acetate in 433 grams of water results in a solution with a molality of approximately 0.332 mol/kg. This measure allows chemists to standardize solutions, predict behaviors, and ensure precise reactions. Understanding the process of calculating molality, along with its significance, empowers students and professionals in chemistry to analyze and utilize solutions effectively. Whether in laboratory research, industrial processes, or medical treatments, molality remains a fundamental concept that bridges theoretical chemistry with real-world applications.

Keywords for SEO Optimization:
- aqueous solution
- aluminum acetate
- molality calculation
- chemical concentration
- molar mass aluminum acetate
- solution chemistry
- molality formula
- solution preparation
- colligative properties
- industrial applications of aluminum acetate

Frequently Asked Questions

What is the molality of the aqueous solution made by dissolving 29.4 grams of aluminum acetate in 433 grams of water?

To calculate molality, first determine moles of aluminum acetate: Molar mass of aluminum acetate ($Al(C_2H_3O_2)_3$) ≈ 204.1 g/mol. Moles = 29.4 g / 204.1 g/mol ≈ 0.1439 mol. Convert water to kg: 433 g = 0.433 kg. Molality = 0.1439 mol / 0.433 kg ≈ 0.332 mol/kg.

How do you calculate the molar mass of aluminum acetate used in this problem?

The molar mass of aluminum acetate ($Al(C_2H_3O_2)_3$) is calculated as: Al = 26.98 g/mol, C = 12.01 g/mol, H = 1.008 g/mol, O = 16.00 g/mol. Molar mass = $26.98 + 3\times(2\times12.01 + 3\times1.008 + 16) = 26.98 + 3\times(24.02 + 3.024 + 16) = 26.98 + 3\times43.044 = 26.98 + 129.132 \approx 156.11$ g/mol.

What is the significance of molality in describing the solution's properties?

Molality measures the concentration of solute in a solvent based on moles of solute per kilogram of solvent. It is temperature-independent, making it useful for studying colligative properties like boiling point elevation and freezing point depression.

If more aluminum acetate is dissolved in water, how does that affect the molality?

Adding more aluminum acetate increases the number of moles of solute, thus increasing the molality of the solution, assuming the amount of water remains constant.

Why is water used as the solvent in this aqueous solution, and how does its mass impact molality calculations?

Water is a common solvent due to its polarity and ability to dissolve many salts like aluminum acetate. Its mass in kilograms directly influences molality calculations since molality is expressed as moles of solute per kilogram of solvent.

What are some practical applications of calculating molality in chemistry?

Calculating molality helps in preparing solutions with precise concentrations, studying colligative properties, understanding solution behaviors at different temperatures, and in industrial processes like formulation of pharmaceuticals and chemicals.

Additional Resources

An aqueous solution is made by dissolving 29.4 grams of aluminum acetate in 433 grams of water. The molality is a fundamental concept in chemistry that describes the concentration of a solution, specifically representing the number of moles of solute per kilogram of solvent. Understanding how to calculate molality from given quantities is essential for chemists and students alike, as it influences reaction rates, solubility, and solution properties. This article explores the detailed process of deriving molality from the specified quantities, delves into the characteristics of aluminum acetate solutions, and discusses the broader implications of molality in aqueous chemistry.

Understanding the Fundamentals: What is Molality?

Definition and Significance

Molality (m) is a measure of concentration that indicates the number of moles of solute present in one kilogram of solvent. Unlike molarity, which depends on volume and can vary with temperature, molality remains unaffected by temperature changes, making it highly reliable for thermodynamic calculations.

Formally:

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

This property makes molality especially useful in situations where temperature variations are involved, such as in boiling point elevation or freezing point depression analyses.

Why Use Molality?

- Temperature Independence: Since molality depends solely on mass, it remains constant regardless of temperature fluctuations.
- Thermodynamic Calculations: Essential in calculating colligative properties like vapor pressure lowering, boiling point elevation, and osmotic pressure.
- Precise Concentration Measurement: Provides a consistent standard for concentration in experimental chemistry.

Calculating Moles of Aluminum Acetate

Determining the Molar Mass of Aluminum Acetate

Aluminum acetate is an ionic compound with the formula $\mathrm{Al(C_2H_3O_2)_3}$. Its molar mass is calculated by summing the atomic masses:

Element	Atomic Mass (g/mol)	Quantity in formula	Total Mass (g/mol)
Aluminum (Al)	26.98	1	26.98
Carbon (C)	12.01	6 (2 per acetate times 3)	72.06
Hydrogen (H)	1.008	9 (3 acetate groups × 3 H each)	9.072
Oxygen (O)	16.00	6 (2 per acetate × 3)	96.00

Adding these up:

$$
26.98 + 72.06 + 9.072 + 96.00 = 204.112\, \text{g/mol}
$$

So, the molar mass of aluminum acetate is approximately 204.11 g/mol.

Calculating Moles of Aluminum Acetate

Given the mass:

$$
\text{Mass of aluminum acetate} = 29.4\, \text{g}
$$

Number of moles:

$$
\text{Moles} = \frac{\text{Mass}}{\text{Molar mass}} = \frac{29.4}{204.11} \approx 0.144\, \text{mol}
$$

This indicates that the solution contains approximately 0.144 moles of aluminum acetate.

Determining the Mass of Water in Kilograms

Given:

$$
\text{Mass of water} = 433\, \text{g}
$$

Convert grams to kilograms:

$$
\frac{433\, \text{g}}{1000} = 0.433\, \text{kg}
$$

The solvent mass, in kilograms, is 0.433 kg.

Calculating the Molality of the Solution

Using the molality formula:

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

Substituting the values:

$$
m = \frac{0.144}{0.433} \approx 0.332\, \text{mol/kg}
$$

Thus, the molality of the solution is approximately 0.33 mol/kg.

Implications and Applications of the Calculated Molality

Understanding Solution Concentration

The molality value indicates a relatively dilute aluminum acetate solution. Such concentrations might be useful in various experimental or industrial contexts, such as in textile processing, water treatment, or as a reagent in chemical synthesis.

Impact on Solution Properties

- Boiling and Freezing Points: The molality directly influences colligative properties; a molality of 0.33 mol/kg would produce measurable but modest changes in boiling and freezing points.
- Conductivity: Since aluminum acetate is ionic, increasing molality enhances the solution's electrical conductivity.
- Stability: Aluminum acetate solutions are typically stable at moderate concentrations, but high molality might lead to precipitation or hydrolysis.

Features, Pros, and Cons of Aluminum Acetate Solutions

Features:
- Ionic nature makes it useful in applications requiring a source of aluminum ions.
- Soluble in water, forming clear solutions.
- Can act as a mordant in dyeing processes or as an astringent in medicinal formulations.

Pros:
- Biocompatibility: Used in medicinal and cosmetic applications.
- Versatility: Suitable for various industrial and laboratory purposes.
- Stable in dilute solutions: Maintains integrity without rapid decomposition.

Cons:
- Potential for Hydrolysis: At higher concentrations, aluminum acetate can hydrolyze, affecting solution stability.
- Precipitation Risks: Excessive concentration may lead to insoluble aluminum hydroxide formation.
- Environmental Concerns: Disposal requires care due to aluminum content.

Broader Context: Importance of Accurate Concentration Calculations

Understanding how to accurately compute molality from given masses is critical in both academic and industrial chemistry. Precise concentration measurements influence reaction yields, purity, and safety. For instance, in pharmaceutical formulations, knowing the exact molality ensures consistent therapeutic effects, while in environmental chemistry, it helps assess pollutant concentrations.

The example of aluminum acetate illustrates key points:
- Correct molar mass determination is foundational.
- Conversion between grams and moles is straightforward but essential.
- Maintaining proper units (kg vs. g) prevents calculation errors.
- Recognizing the molecular formula's impact on molar mass.

Conclusion

The process of determining the molality of an aqueous solution—dissolving 29.4 grams of aluminum acetate in 433 grams of water—demonstrates fundamental principles of solution chemistry. By calculating molar mass, converting grams to moles and kilograms, and applying the molality formula, we arrive at a concentration of approximately 0.33 mol/kg. This value provides insights into the solution's properties, potential applications, and stability considerations.

Mastering these calculations is crucial for chemists aiming to tailor solutions for specific purposes, whether in research, industry, or education. The detailed understanding of solution concentration not only enhances theoretical knowledge but also ensures practical accuracy in laboratory and real-world settings.

In summary:
- The molality of the solution is approximately 0.33 mol/kg.
- Accurate calculation involves understanding molecular formulas, unit conversions, and fundamental concentration formulas.
- Aluminum acetate solutions have diverse applications, but their stability and properties depend heavily on concentration.
- Mastery of molality calculations supports precise experimental design and effective application in various fields of chemistry.

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