

What Is The Molarity Of A Solution In Which 0.0142 Mole Of $\text{Mn}_2(\text{SO}_4)_3$ Is Dissolved In 26ml Of Water

What Is The Molarity Of A Solution In Which 0.0142 Mole Of $\text{Mn}_2(\text{SO}_4)_3$ Is Dissolved In 26ml Of Water is a fundamental question in chemistry that helps us understand the concentration of a solution. Molarity, often denoted as M, is a measure of the number of moles of solute present in one liter of solution. It is a crucial concept in chemistry because it allows scientists and students to quantify how much solute is dissolved in a solvent, which in turn influences chemical reactions, solution properties, and titrations.

Understanding how to calculate molarity involves a few key steps: knowing the amount of solute in moles, measuring the volume of the solution in liters, and then applying the molarity formula. In this article, we will explore the process of calculating the molarity of a solution containing manganese(III) sulfate, $\text{Mn}_2(\text{SO}_4)_3$, with a given amount of solute and volume of solvent. We will also review related concepts, the importance of molarity, and practical applications in laboratory and industrial settings.

Understanding Molarity and Its Significance

What Is Molarity?

Molarity (M) is defined as the number of moles of solute divided by the volume of solution in liters:

$$M = \text{moles of solute} / \text{liters of solution}$$

This unit provides a standardized way to express concentration, making it easier to replicate experiments and compare solution strengths across different contexts.

Why Is Molarity Important?

- Chemical Reactions: Molarity influences reaction rates and equilibria.
- Titrations: Precise molarity allows accurate determination of unknown concentrations.
- Industrial Processes: Molarity calculations optimize yields and safety.
- Laboratory Preparations: Ensures consistency and reproducibility of experiments.

Calculating Molarity for $\text{Mn}_2(\text{SO}_4)_3$ Solution

To determine the molarity of the solution, we need two main pieces of data:

1. The number of moles of $\text{Mn}_2(\text{SO}_4)_3$ dissolved.
2. The volume of the solution in liters.

Given:

- Moles of $\text{Mn}_2(\text{SO}_4)_3 = 0.0142 \text{ mol}$
- Volume of water = 26 ml

Step 1: Convert Volume from Milliliters to Liters

Since molarity is expressed in mol/L, convert 26 ml to liters:

$$1 \text{ ml} = 0.001 \text{ L}$$

$$\text{Volume in liters} = 26 \text{ ml} \times 0.001 = 0.026 \text{ L}$$

Step 2: Apply the Molarity Formula

Using the formula:

$$M = \text{moles of solute} / \text{liters of solution}$$

we substitute the known values:

$$M = 0.0142 \text{ mol} / 0.026 \text{ L}$$

Calculating this gives:

$$M \approx 0.546 \text{ mol/L}$$

Therefore, the molarity of the $\text{Mn}_2(\text{SO}_4)_3$ solution is approximately 0.546 M.

Understanding the Composition of $\text{Mn}_2(\text{SO}_4)_3$

Chemical Structure and Formula

Manganese(III) sulfate, $\text{Mn}_2(\text{SO}_4)_3$, is an inorganic salt composed of manganese cations and sulfate anions. Its structure involves:

- 2 Mn^{3+} ions
- 3 sulfate (SO_4)²⁻ ions

The molar mass is calculated based on atomic masses:

- Mn $\approx 54.94 \text{ g/mol}$

- S $\approx$ 32.07 g/mol
- O $\approx$ 16.00 g/mol

Calculating the molar mass:

$$M(\text{Mn}_2(\text{SO}_4)_3) = (2 \times 54.94) + (3 \times (32.07 + 4 \times 16.00))$$

$$= 109.88 + 3 \times (32.07 + 64.00)$$

$$= 109.88 + 3 \times 96.07$$

$$= 109.88 + 288.21$$

$$\approx 398.09 \text{ g/mol}$$

This molar mass is useful for converting between mass and moles, especially in laboratory preparations.

Practical Applications of Molarity Calculations

Laboratory Preparation of Solutions

Knowing the molarity allows chemists to accurately weigh out the appropriate amount of solute and dilute it to the desired volume, ensuring reproducibility in experiments.

Industrial Chemical Processes

Molarity calculations are essential in manufacturing processes that require precise concentrations, such as in the production of chemicals, pharmaceuticals, and materials.

Environmental and Analytical Chemistry

Accurate molarity measurements support environmental testing and analytical methods, such as titrations and spectrophotometry.

Additional Factors to Consider

Solution Density and Temperature

While molarity calculations generally assume the volume of the solution is additive, in reality, volume can be affected by temperature and the density

of the solvent and solute. For highly precise work, adjustments may be necessary.

Alternative Concentration Units

Apart from molarity, other units like molality, normality, and mass percent are used depending on the context. For example:

- Molality (mol/kg): concentration based on solvent mass
- Normality (eq/L): concentration based on reactive equivalents
- Mass percent (%): grams of solute per 100 grams of solution

Conclusion

Calculating the molarity of a solution involves understanding the relationship between moles of solute and the volume of solvent. In the case of dissolving 0.0142 mol of $\text{Mn}_2(\text{SO}_4)_3$ in 26 mL of water, the resulting molarity is approximately 0.546 M. This value provides a quantitative measure of the solution's concentration, which is vital for various chemical applications, from laboratory experiments to industrial processes. Mastery of molarity calculations enables chemists to prepare solutions accurately, predict reaction outcomes, and ensure consistency across different settings. Whether working with manganese sulfate or any other compound, understanding how to determine and interpret molarity is a fundamental skill in the realm of chemistry.

Frequently Asked Questions

What is the molarity of a solution containing 0.0142 moles of $\text{Mn}_2(\text{SO}_4)_3$ dissolved in 26 mL of water?

The molarity is approximately 0.548 M, calculated by dividing 0.0142 moles by 0.026 liters (26 mL).

How do you calculate the molarity of $\text{Mn}_2(\text{SO}_4)_3$ in a solution with 0.0142 mol in 26 mL?

Convert 26 mL to liters (0.026 L) and then divide the number of moles (0.0142 mol) by the volume in liters: $0.0142 \text{ mol} / 0.026 \text{ L} \approx 0.548 \text{ M}$.

Why is molarity important in chemistry, especially in solutions like $\text{Mn}_2(\text{SO}_4)_3$?

Molarity measures concentration, allowing chemists to accurately prepare and analyze solutions, such as manganese(III) sulfate, for reactions and experiments.

If I have more water added to a solution with 0.0142 mol of $\text{Mn}_2(\text{SO}_4)_3$, how does that affect the molarity?

Adding more water decreases the molarity, as the number of moles remains constant but the total volume increases.

Can you explain the steps to find molarity from given moles and volume for manganese sulfate solutions?

Yes. First, convert the volume from mL to liters. Then, divide the number of moles by the volume in liters to find the molarity: $M = \text{moles} / \text{liters}$.

Additional Resources

Molarity: Unlocking the Concentration of a Solution – A Comprehensive Guide

When it comes to chemistry, understanding the concentration of solutions is fundamental. Whether you're a student, researcher, or industry professional, knowing how to determine the molarity of a solution is essential for precise reactions, experiments, and product formulations. Today, we explore this concept through a practical example: calculating the molarity of a solution where 0.0142 mole of manganese(III) sulfate, $\text{Mn}_2(\text{SO}_4)_3$, is dissolved in 26 mL of water. This detailed analysis will not only clarify the calculation process but also provide insight into the importance of molarity in chemical contexts.

Understanding Molarity: The Foundation of Solution Concentration

What Is Molarity?

Molarity, often denoted as M , is a measure of the concentration of a solute in a solution. It is defined as the number of moles of solute dissolved in one liter (L) of solution:

$$\text{Molarity (M)} = \frac{\text{Moles of solute}}{\text{Volume of solution in liters}}$$

This unit provides a standardized way of expressing how "concentrated" a solution is, facilitating reproducibility and comparison across experiments.

Why Is Molarity Important?

- Precision in Reactions: Many chemical reactions depend on molar ratios. Accurate molarity ensures proper stoichiometry.
- Reproducibility: Scientific experiments demand consistent solution concentrations.
- Industrial Applications: In manufacturing, pharmaceuticals, and research, molarity helps maintain quality and efficacy.
- Educational Clarity: It serves as a foundational concept for understanding titrations, dilutions, and reaction kinetics.

Deciphering the Components of Our Example Solution

Before delving into calculations, it's vital to understand what each component in the example entails.

Molecular Formula: $\text{Mn}_2(\text{SO}_4)_3$

- Manganese (Mn): Transition metal, central to various oxidation states.
- Sulfate (SO_4): A polyatomic ion with a charge of -2.
- Stoichiometry: The formula $\text{Mn}_2(\text{SO}_4)_3$ indicates:
 - 2 manganese atoms per formula unit.
 - 3 sulfate ions per formula unit.

Understanding Moles and Mass

- The solution contains 0.0142 moles of $\text{Mn}_2(\text{SO}_4)_3$.
- The solvent volume is 26 mL, which needs to be converted into liters for molarity calculations.

Step-by-Step Calculation of Molarity

The primary goal is to find the molarity, which requires:

1. Converting the volume of water from milliliters to liters.
2. Applying the molarity formula with the known moles and volume.

Step 1: Convert Volume from Milliliters to Liters

Since molarity is expressed per liter, first convert:

$$26 \text{ mL} = \frac{26}{1000} = 0.026 \text{ L}$$

Step 2: Use the Molarity Formula

Plug in the known values:

$$M = \frac{0.0142 \text{ mol}}{0.026 \text{ L}}$$

Perform the division:

$$M \approx 0.546 \text{ M}$$

Thus, the molarity of the solution is approximately 0.546 mol/L.

Interpreting the Result: What Does 0.546 M Mean?

A molarity of 0.546 M indicates that in every liter of this solution, there are approximately 0.546 moles of $\text{Mn}_2(\text{SO}_4)_3$ dissolved. Given our initial volume of only 26 mL, the amount of solute is relatively dilute but precisely quantified.

Key Takeaways:

- The solution is moderately concentrated, suitable for various chemical applications.
- The molarity provides an exact measure to replicate or adjust the solution as needed.

Additional Considerations in Molarity Calculations

While the calculation appears straightforward, several factors can influence the accuracy and interpretation:

1. Purity of the Solute

- Impurities in $\text{Mn}_2(\text{SO}_4)_3$ can affect the actual molar amount.
- Always use high-purity reagents for precise work.

2. Volumetric Accuracy

- Precise measurement of volume is crucial.
- Using calibrated volumetric flasks or pipettes ensures accuracy.

3. Dissolution Completeness

- Ensure $\text{Mn}_2(\text{SO}_4)_3$ is fully dissolved to maintain the integrity of molarity calculations.
- Partial dissolution can lead to underestimation of concentration.

4. Temperature Effects

- Volume of liquids can vary with temperature.
- Conduct measurements at a consistent temperature, or apply temperature corrections.

Broader Context: Molarity in Chemical Practice

Understanding how to calculate and interpret molarity is more than an academic exercise; it's a practical skill with wide-ranging implications.

Applications of Molarity:

- Titration Procedures: Precise molarity allows for accurate determination of unknown concentrations.
- Reaction Stoichiometry: Ensures correct ratios of reactants for optimal yields.
- Dilution Calculations: Preparing solutions of desired molarity from stock solutions.
- Industrial Synthesis: Maintaining consistent product quality during large-

scale manufacturing.

Related Concepts:

- Normality: Considers equivalents instead of moles; useful for acid-base and redox reactions.
- Molality: Moles per kilogram of solvent; less affected by temperature changes.
- Percent Composition: Expressed as a percentage; useful for solid mixtures.

Conclusion: Mastering Molarity for Precise Chemistry

Calculating the molarity of a solution, such as one containing 0.0142 mole of $\text{Mn}_2(\text{SO}_4)_3$ dissolved in 26 mL of water, exemplifies a fundamental yet powerful skill in chemistry. The result—approximately 0.546 M—serves as a quantitative measure that underpins countless applications, from laboratory experiments to industrial processes.

By understanding the principles behind molarity, appreciating the importance of precise measurements, and considering factors that influence concentration, chemists can design, reproduce, and optimize reactions with confidence. Whether you are preparing solutions for research or manufacturing, mastering such calculations ensures accuracy, consistency, and ultimately, success in your chemical endeavors.

In essence, molarity is not just a number; it's a key to unlocking the predictable behavior of solutions and the reliable progression of chemical processes.

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