Determine The Total Moles Of Ions In A Solution Made By Diluting 50 Ml Of An .874 M Solution Of Sodium

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Understanding how to calculate the total moles of ions in a solution is fundamental in chemistry, especially when working with solutions of electrolytes like sodium. If you have a 50 mL sample of an .874 M sodium solution and dilute it, it's important to know how to determine the total moles of ions present after dilution. This process involves understanding molarity, dilution principles, and ion dissociation. In this article, we will explore step-by-step how to determine the total moles of ions in such a solution, providing clarity for students, educators, and chemistry enthusiasts alike.

Understanding Molarity and Solution Dilution

What Is Molarity?

Molarity (M) is a measure of concentration representing the number of moles of solute per liter of solution. For example, an .874 M sodium solution contains 0.874 moles of sodium ions per liter of solution.

Dilution Principles

Dilution involves adding solvent (usually water) to a solution to decrease its concentration without changing the amount of solute. The relationship between the initial and final solutions is described by the dilution equation:

$$
C_1 V_1 = C_2 V_2
$$

where:
- C_1 is the initial concentration
- V_1 is the initial volume
- C_2 is the final concentration
- V_2 is the final volume

This equation allows us to determine the new concentration or volume after dilution.

Calculating Moles of Sodium in the Original Solution

Step 1: Convert Volume to Liters

Since molarity is expressed in moles per liter, convert 50 mL to liters:

- 50 mL = 0.050 L

Step 2: Calculate Moles of Sodium in the Original Solution

Using the molarity equation:

$$
\text{Moles of Na} = C \times V
$$

$$
\text{Moles of Na} = 0.874\, \text{mol/L} \times 0.050\, \text{L} = 0.0437\, \text{mol}
$$

This means the original 50 mL solution contains 0.0437 moles of sodium ions.

Determining the Total Moles of Ions in the Diluted Solution

Understanding Ion Dissociation in Aqueous Solution

Sodium chloride (NaCl) is a common sodium compound that dissociates completely in water:

$$
\text{NaCl} \rightarrow \text{Na}^+ + \text{Cl}^-
$$

This dissociation results in two types of ions: sodium ions (Na^+) and chloride ions (Cl^-). Each mole of NaCl yields one mole of Na^+ and one mole of Cl^-.

Calculating Moles of Ions After Dilution

Suppose you dilute the original solution to a new volume V_2. The total moles of sodium ions remain constant because no sodium is lost during dilution, only water is added.

- Total moles of Na^+ = initial moles of sodium = 0.0437 mol
- Total moles of Cl^- = same as sodium ions = 0.0437 mol

Since sodium chloride dissociates completely, the total moles of ions in the solution are:

$$
\text{Total moles of ions} = \text{moles of } \text{Na}^+ + \text{moles of } \text{Cl}^- = 0.0437\, \text{mol} + 0.0437\, \text{mol} = 0.0874\, \text{mol}
$$

Note: This calculation assumes the sodium source is NaCl. If the original compound is different, such as sodium hydroxide (NaOH), the number of ions would differ accordingly.

Calculating Final Concentration After Dilution

Step 1: Determine Final Volume

For illustration, assume you dilute the 50 mL solution to 200 mL:

- 200 mL = 0.200 L

Step 2: Calculate Final Molarity

Using the dilution equation:

$$
C_2 = \frac{C_1 V_1}{V_2}
$$

$$
C_2 = \frac{0.874\, \text{mol/L} \times 0.050\, \text{L}}{0.200\, \text{L}} = 0.2185\, \text{mol/L}
$$

Result: The diluted solution has a sodium molarity of approximately 0.2185 M.

Step 3: Find Total Moles of Ions in the Diluted Solution

Total moles of sodium ions:

$$
\text{Moles of } \text{Na}^+ = C_2 \times V_2 = 0.2185\, \text{mol/L} \times 0.200\, \text{L} = 0.0437\, \text{mol}
$$

Total moles of chloride ions:

$$
\text{Moles of } \text{Cl}^- = 0.0437\, \text{mol}
$$

Total moles of ions:

$$
0.0437 + 0.0437 = 0.0874\, \text{mol}
$$

This confirms that dilution does not change the total moles of ions, only their concentration.

Summary: How To Determine Total Moles of Ions in Diluted Sodium Solutions

- Convert the initial volume to liters for molarity calculations.
- Calculate the initial moles of sodium using molarity and volume.
- Understand that complete dissociation of sodium salts produces equivalent moles of ions.
- During dilution, total moles of ions remain constant; only concentration changes.
- Use the dilution formula to find new concentrations after dilution.
- Sum the moles of all ions present to find the total moles of ions in the solution.

Final Thoughts

Knowing how to determine the total moles of ions in a diluted solution is crucial in many chemical applications, including preparing solutions, titrations, and analyzing solution composition. By understanding the principles of molarity, solution dilution, and ion dissociation, you can accurately calculate the number of ions present at any stage. Remember that the key steps involve converting volumes to liters, calculating initial moles, applying dilution principles, and accounting for dissociation to find total ion content.

Whether you're a student studying chemistry, a researcher working with solutions, or an educator teaching solution chemistry, mastering these calculations enhances your understanding of solution behavior and prepares you for more complex chemical analyses.

Frequently Asked Questions

How do you calculate the total moles of ions in a diluted sodium solution?

First, determine the moles of sodium salt initially present by multiplying the concentration (0.874 M) by the volume in liters (0.05 L). Then, identify the number of ions produced per formula unit (Na^+ and Cl^- for NaCl), and multiply the moles of each ion accordingly to find the total moles of ions.

What is the initial number of moles of sodium salt in 50 mL of 0.874 M solution?

The initial moles = concentration × volume = 0.874 mol/L × 0.05 L = 0.0437 mol.

How many moles of sodium ions are present in the solution after dilution?

Since each formula unit of sodium salt produces one sodium ion, there are 0.0437 moles of Na^+ ions in the solution.

How many moles of chloride ions are present in the solution?

Similarly, each formula unit yields one chloride ion, so there are also 0.0437 moles of Cl^- ions in the solution.

What is the total number of moles of ions in the solution after dilution?

Total moles of ions = moles of Na+ + moles of Cl- = 0.0437 + 0.0437 = 0.0874 mol.

Does diluting the solution change the total moles of ions present?

No, dilution only decreases the concentration but does not change the total number of moles of ions present in the solution.

How does the molarity change upon dilution from the original solution to the final solution?

The molarity decreases proportionally to the dilution factor. Since the volume increased from 50 mL to a larger volume, the concentration decreases, but the total moles of ions remain the same.

If the solution is diluted to 200 mL, what is the new molarity of sodium salt?

New molarity = total moles / new volume in liters = 0.0437 mol / 0.2 L = 0.2185 M.

Why is it important to consider the number of ions per formula unit when calculating total moles of ions?

Because each formula unit of the compound dissociates into specific ions, knowing the ionization helps accurately determine the total moles of each ion in solution.

Additional Resources

Determine The Total Moles Of Ions In A Solution Made By Diluting 50 mL Of An .874 M Solution Of Sodium

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Introduction

Understanding the behavior of ions in aqueous solutions is fundamental to both analytical chemistry and various applied sciences. The process of diluting solutions and accurately determining the total moles of ions present is critical for laboratory procedures, industrial applications, and scientific research. This article provides a comprehensive investigation into how to determine the total moles of ions in a solution formed by diluting 50 mL of a 0.874 M sodium solution. The discussion will encompass chemical principles, detailed calculations, potential sources of error, and practical implications.

The Fundamental Chemistry: Sodium in Aqueous Solution

Sodium, a highly reactive alkali metal, is most commonly encountered in its ionic form, Na^+, when dissolved in water. The initial solution's concentration, molarity, and volume directly influence the total number of moles of sodium ions present.

In aqueous solutions, sodium typically exists as:

$Na(s) \rightarrow Na^+(aq) + e^-$

The dissociation of sodium compounds, especially sodium chloride (NaCl), is nearly complete in water, making the calculation straightforward when the compound is known.

Step 1: Clarifying the Starting Conditions

- Initial concentration (C_1): 0.874 M
- Initial volume (V_1): 50 mL = 0.050 L
- Target: Determine the total moles of ions after dilution.

It’s crucial to note that the initial solution’s molarity indicates that in 1 liter of solution, there are 0.874 moles of sodium ions (assuming the solution is sodium chloride or similar soluble sodium salt).

Step 2: Calculating the Moles of Sodium in the Original Solution

The initial moles of sodium ions in the 50 mL solution are:

$$
\text{Moles of Na} = C_1 \times V_1
$$

$$
\text{Moles of Na} = 0.874\, \text{mol/L} \times 0.050\, \text{L} = 0.0437\, \text{mol}
$$

This calculation assumes that the sodium salt dissociates completely and that all sodium is present in ionic form.

Step 3: Understanding Dilution and Its Effect on Ion Concentration

Dilution involves adding solvent (usually water) to decrease the concentration of solutes without removing any ions or molecules from the solution.

Key principle:

$$
C_1 V_1 = C_2 V_2
$$

where:

- C_1 = initial concentration
- V_1 = initial volume
- C_2 = final concentration
- V_2 = final volume

The total moles of ions remain constant during dilution because no ions are lost; they are merely dispersed over a larger volume.

Step 4: Determining the Final Volume and Concentration

Suppose the solution is diluted to a specific final volume, such as 250 mL (0.250 L). The final concentration (C_2) would be:

$$
C_2 = \frac{C_1 V_1}{V_2} = \frac{0.874\, \text{mol/L} \times 0.050\, \text{L}}{0.250\, \text{L}} = 0.1748\, \text{mol/L}
$$

In this scenario, the total moles of sodium ions remain 0.0437 mol, but the concentration decreases due to the increased volume.

Step 5: Calculating Total Moles of Ions in the Final Solution

The total moles of ions depend on the ionic species present. For sodium chloride, the dissociation yields:

$NaCl \rightarrow Na^+ + Cl^-$

Thus, for every mole of NaCl dissolved, there is:

- 1 mole of Na^+
- 1 mole of Cl^-

Total moles of ions in the solution = moles of Na^+ + moles of Cl^- = 2 × moles of NaCl

Given that the initial sodium molarity is 0.874 M, and assuming all sodium is from NaCl:

- Moles of NaCl initially = 0.0437 mol

After dilution, total moles of ions:

$$
\text{Total ions} = 2 \times 0.0437\, \text{mol} = 0.0874\, \text{mol}
$$

This total remains unchanged during dilution, regardless of the final volume.

Deep Dive: Considering Other Ionic Species and Complexes

While the calculations above assume pure sodium chloride, real-world solutions often involve other sodium salts or ionic species. For example, sodium bicarbonate, sodium sulfate, or organic sodium salts may be present, each contributing different ions and molar ratios.

Implications for total molar ion calculation:

- Multiple salts: The total moles of ions depend on the composition.
- Dissociation factors: Some salts may dissociate partially or form complexes.
- Presence of counter-ions: These influence the total ionic strength and molar count.

Analytical Techniques for Confirming Ion Concentration

While calculations provide theoretical values, experimental validation is paramount.

Common methods include:

- Titration: Using titrants to determine ion concentrations.
- Spectrophotometry: Detecting specific ions via absorbance.
- Ion chromatography: Precise separation and quantification of ions.
- Conductivity measurements: Correlate ionic strength with molar concentrations.

These techniques can verify the total moles of ions present post-dilution.

Potential Sources of Error and Limitations

Accurate determination hinges on controlling various factors:

- Measurement inaccuracies: Volumetric measurements, especially at small scales.
- Incomplete dissociation: Some salts may not fully dissociate, affecting ion counts.
- Chemical impurities: Contaminants can alter ionic composition.
- Temperature effects: Dissociation and conductivity are temperature-dependent.
- Assumption of ideal behavior: Real solutions exhibit activity coefficients differing from ideality.

These factors necessitate careful experimental procedures and calibration.

Practical Implications in Laboratory and Industrial Contexts

Understanding the total moles of ions in a solution informs multiple applications:

- Preparation of reagents: Ensuring correct molarity for reactions.
- Pharmaceutical formulations: Accurate dosing based on ionic content.
- Environmental monitoring: Assessing ionic pollution levels.
- Chemical manufacturing: Controlling process parameters to maintain product quality.

Accurate calculations enable precise control over chemical processes, ensuring safety, efficacy, and compliance.

Summary and Conclusions

In summary, determining the total moles of ions in a solution initially prepared by dissolving 50 mL of a 0.874 M sodium salt solution involves fundamental principles of molarity, dilution, and dissociation. The key steps include:

1. Calculating initial moles of sodium ions: 0.0437 mol.
2. Recognizing that total ion moles are twice the sodium molar amount in case of NaCl: 0.0874 mol.
3. Understanding that dilution changes concentration but not total moles.
4. Considering the specific ionic composition and dissociation behavior.

This investigation underscores the importance of precise measurement, awareness of chemical behavior, and the need for experimental validation. Proper comprehension and application of these principles enable chemists and scientists to manage solutions effectively across various domains.

Final Remarks

The process of determining total moles of ions in diluted solutions is a cornerstone of analytical chemistry. Whether for research, industrial applications, or educational purposes, mastering these calculations ensures accuracy and reliability. As chemical systems become more complex, integrating theoretical understanding with empirical data remains essential for advancing scientific knowledge and practical applications.

Determine The Total Moles Of Ions In A Solution Made By Diluting 50 Ml Of An 874 M Solution Of Sodium

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