Find The Mass Of Sodium Formate That Must Be Dissolved In 290.0 Cm3cm3 Of A 1.9 Mm Solution Of Formic

Find The Mass Of Sodium Formate That Must Be Dissolved In 290.0 Cm3 Of A 1.9 mM Solution Of Formic

Understanding how to determine the mass of a solute required to prepare a specific solution is a fundamental aspect of solution chemistry. In this case, we are asked to find the mass of sodium formate that must be dissolved to create a 290.0 cm^3 solution containing formic acid at a concentration of 1.9 millimolar (mM). To solve this, we need to interpret the problem carefully, understand the relationship between molarity, volume, and mass, and apply the relevant chemical principles and calculations.

This article will guide you through the step-by-step process of solving this problem, including understanding key concepts like molarity, molar mass, and solution preparation, and performing the necessary calculations to arrive at the correct mass of sodium formate required.

Understanding Key Concepts

1. Molarity (M)

- Molarity is defined as the number of moles of solute dissolved in one liter (L) of solution.
- It is expressed as mol/L.
- In this problem, the concentration is given as 1.9 mM, which is 1.9 millimoles per liter.

2. Millimolar (mM) to Molar (M) Conversion

- 1 mM = 1 x 10^{-3} mol/L.
- Therefore, 1.9 mM = 1.9 x 10^{-3} mol/L.

3. Volume Conversion

- The volume of the solution is given as 290.0 cm^3.
- Since molarity is in liters, convert cm^3 to liters:

1 cm^3 = 1 x 10^{-3} L,

so 290.0 cm^3 = 290.0 x 10^{-3} L = 0.290 L.

4. Moles of Solute in the Solution

- The number of moles of formic acid (or the equivalent molar quantity) present is:

Moles = Molarity x Volume (in liters).

5. Relationship Between Formic Acid and Sodium Formate

- The problem mentions "formic" (likely formic acid), but asks for the mass of sodium formate to be dissolved.
- Sodium formate ($NaHCO_2$) is the sodium salt of formic acid.
- In solution, sodium formate can be used to neutralize formic acid, or as a source of formate ions in reactions.
- For this problem, it seems the goal is to prepare a sodium formate solution that corresponds to the same molar concentration as the formic acid solution, or possibly the problem is asking to find the mass of sodium formate needed to achieve a certain molar concentration equivalent to the given formic acid solution.

Step-by-Step Solution

1. Determine the Moles of Formic Acid in the Solution

Since the solution has a concentration of 1.9 mM:

- Convert the molarity to mol/L:

1.9 mM = 1.9 x 10^{-3} mol/L.

- Calculate the total moles in 0.290 L:

Moles of formic acid = 1.9 x 10^{-3} mol/L × 0.290 L = (1.9 x 10^{-3}) × 0.290 mol.

Performing the multiplication:

Moles of formic acid = 0.000551 mol.

2. Understand the Relationship Between Formic Acid and Sodium Formate

- The question asks for the mass of sodium formate to be dissolved to get a solution equivalent in some way to the formic acid solution.
- Typically, to neutralize or produce a solution with the same molarity, the molar quantities should

match if the solute and solvent are the same.
- Assuming the problem intends for us to prepare a sodium formate solution with the same molar concentration (1.9 mM), then the amount of sodium formate needed corresponds to the same number of moles as the formic acid.

3. Calculate the Mass of Sodium Formate Needed

- Molar mass of sodium formate ($NaHCO_2$):

- Na: approximately 23.0 g/mol
- H: approximately 1.0 g/mol
- C: approximately 12.0 g/mol
- O_2: 2 × 16.0 g/mol = 32.0 g/mol

Summing these:

Molar mass = 23.0 + 1.0 + 12.0 + 32.0 = 68.0 g/mol.

- To find the mass:

Mass = number of moles × molar mass.

- Using the moles calculated:

Mass = 0.000551 mol × 68.0 g/mol ≈ 0.0374 g.

Final Calculation and Conclusion

1. Summary of Calculations

- Moles of formic acid in 0.290 L of 1.9 mM solution: approximately 0.000551 mol.
- To prepare a sodium formate solution with the same molarity, the same number of moles of sodium formate must be dissolved.
- Molar mass of sodium formate: 68.0 g/mol.
- Therefore, the mass of sodium formate needed:

0.0374 grams (or approximately 37.4 milligrams).

2. Final Answer

The mass of sodium formate that must be dissolved in 290.0 cm^3 of a 1.9 mM solution of formic acid is approximately 0.0374 grams.

Additional Considerations

- Purity of the Salt: The calculation assumes pure sodium formate. If the salt contains impurities, adjustments are necessary.
- Reaction Context: If the purpose involves neutralization or preparing a buffer, additional calculations considering the acid-base reaction might be needed.
- Precision: For laboratory work, consider appropriate significant figures based on the inputs provided; here, four significant figures are used.

Conclusion

In this detailed analysis, we've demonstrated how to determine the mass of sodium formate required to prepare a solution with a specified molarity in a given volume. The key steps involved converting the volume to liters, calculating the moles of the desired concentration, and then translating that into mass using the molar mass of sodium formate. This methodology is fundamental in solution chemistry, enabling accurate preparation of solutions for analytical and experimental purposes.

Frequently Asked Questions

What is the primary goal when calculating the mass of sodium formate in this solution problem?

The primary goal is to determine the amount of sodium formate (in grams) that must be dissolved to prepare a solution with the specified concentration and volume.

How do you interpret a 1.9 M solution of formic acid in this context?

A 1.9 M solution of formic acid contains 1.9 moles of formic acid per liter of solution, which helps determine the moles of formic acid in the given volume to relate to sodium formate.

What is the significance of the 290.0 cm^3 volume in the calculation?

The volume of 290.0 cm^3 (or 0.290 L) is used to calculate the total moles of formic acid or formate present in that specific volume, based on the molarity.

How do you convert 290.0 cm^3 to liters for molarity calculations?

Divide the volume in cubic centimeters by 1000: 290.0 cm^3 ÷ 1000 = 0.290 L.

What is the relationship between formic acid and sodium formate in this problem?

Sodium formate is the salt form of the conjugate base of formic acid; in this context, it is often used to prepare solutions or in titrations involving formic acid.

How do you determine the moles of formic acid in 0.290 L of a 1.9 M solution?

Multiply the molarity by the volume in liters: 1.9 mol/L × 0.290 L = 0.551 mol of formic acid.

What is the molar mass of sodium formate needed for the calculation?

The molar mass of sodium formate (NaHCOO) is approximately 68.01 g/mol.

How do you calculate the mass of sodium formate from the moles obtained?

Multiply the number of moles (0.551 mol) by the molar mass of sodium formate: 0.551 mol × 68.01 g/mol ≈ 37.45 grams.

Additional Resources

Find The Mass Of Sodium Formate That Must Be Dissolved In 290.0 Cm^3 Of A 1.9 M Solution Of Formic Acid

Understanding the precise quantities of chemicals involved in solution preparation is crucial in both academic and industrial chemical processes. Among these, the calculation of the mass of sodium formate needed to neutralize a given volume and concentration of formic acid is a fundamental example of stoichiometry in action. This article provides a detailed, comprehensive analysis of how to determine the required mass of sodium formate to achieve a specific molar concentration in a given volume of formic acid solution, considering the underlying chemical principles, calculations, and practical implications.

Introduction: The Importance of Accurate Chemical Quantification

Accurate measurement of chemical quantities is foundational to laboratory experiments, industrial manufacturing, and quality control processes. In chemical reactions, especially those involving titrations or neutralizations, the precise amount of reagent added directly influences the outcome's accuracy and reproducibility. Specifically, in acid-base chemistry, understanding the relationship between molar concentrations, volumes, and masses allows chemists to control reactions, synthesize compounds, and analyze reaction efficiencies.

The problem at hand involves calculating the mass of sodium formate (HCOONa) necessary to neutralize a specific volume of formic acid ($HCHO_2$) solution with known concentration. This calculation hinges on the principles of molarity, molar ratios from balanced equations, and the concept of molar mass.

Understanding the Chemistry: From Formic Acid to Sodium Formate

1. The Chemical Interaction

The key reaction involved is a typical acid-base neutralization:

$$\text{HCOOH} + \text{HCOONa} \rightarrow \text{H}_2\text{CO}_3 + \text{Na}^+$$

However, more precisely, when formic acid reacts with sodium formate, the primary concern is the equilibrium between the acid and its conjugate base:

$$\text{HCOOH} \leftrightarrow \text{H}^+ + \text{HCOO}^-$$

Adding sodium formate introduces the conjugate base ($HCOO^-$) into the solution, which can neutralize the acid through:

$$\text{HCOOH} + \text{HCOO}^- \rightarrow \text{H}_2\text{CO}_3 + \text{HCOO}^-$$

But more practically, in the context of titration or neutralization, the main points are:

- Sodium formate acts as the conjugate base of formic acid.
- When sodium formate is added, it can react with free acid (if present) to neutralize it.
- The primary reaction in neutralization scenarios involves the proton transfer from formic acid to the conjugate base, or vice versa, depending on the conditions.

In many cases, the calculation simplifies to considering the molar ratio of acid to base as 1:1,

assuming complete neutralization.

2. Molarity and Volume of the Acid Solution

The given data specifies:

- Volume of formic acid solution V_{acid} = 290.0 cm³ = 0.2900 L (since 1,000 cm³ = 1 L)
- Concentration of formic acid C_{acid} = 1.9 M (moles per liter)

From these, the total moles of formic acid present are calculated as:

$$ n_{\text{acid}} = C_{\text{acid}} \times V_{\text{acid}} $$

which provides the basis for the amount of sodium formate needed, assuming a 1:1 molar ratio.

Calculating the Moles of Formic Acid

1. Determine the Total Moles of Acid

Applying the molarity formula:

$$ n_{\text{acid}} = 1.9\, \text{mol/L} \times 0.2900\, \text{L} $$

$$ n_{\text{acid}} = 0.551\, \text{mol} $$

This means that in 290.0 cm³ of a 1.9 M formic acid solution, there are approximately 0.551 moles of acid molecules available for neutralization.

2. Establishing the Molar Ratio

In typical neutralization reactions between a weak acid and its conjugate base, the stoichiometry is 1:1. Therefore, the moles of sodium formate required to neutralize the formic acid are also approximately 0.551 mol, assuming complete neutralization.

Determining the Mass of Sodium Formate Needed

1. Molar Mass of Sodium Formate

Calculating the molar mass of sodium formate (HCOONa):

- Hydrogen (H): 1.008 g/mol
- Carbon (C): 12.011 g/mol
- Oxygen (O): 16.00 g/mol (there are two oxygen atoms)
- Sodium (Na): 22.990 g/mol

Total molar mass:

$$\text{Molar mass of HCOONa} = 1.008 + 12.011 + (2 \times 16.00) + 22.990$$

$$= 1.008 + 12.011 + 32.00 + 22.990$$

$$= 68.009\, \text{g/mol}$$

For simplicity, we can approximate this as 68.01 g/mol.

2. Calculating the Required Mass

Using the number of moles and molar mass:

$$\text{Mass} = n \times \text{Molar mass}$$

$$\text{Mass} = 0.551\, \text{mol} \times 68.01\, \text{g/mol}$$

$$\text{Mass} \approx 37.45\, \text{g}$$

Thus, approximately 37.45 grams of sodium formate are required to neutralize 290.0 cm^3 of 1.9 M formic acid solution.

Practical Considerations and Implications

1. Purity and Measurement Accuracy

In laboratory practice, the purity of sodium formate and the precision of measurement tools influence the actual amount needed. Purity levels less than 100% necessitate corrections to account for impurities.

2. Reaction Completeness and Equilibrium

While the calculation assumes complete neutralization, real-world factors such as incomplete reactions, side reactions, or deviations from ideal behavior can affect the actual amount required.

3. Use in Titration and Buffer Preparation

This calculation is fundamental in titration experiments, where precise reagent amounts are necessary for accurate titration curves. Additionally, sodium formate can be used in buffer solutions, where the ratio of acid to conjugate base influences pH.

4. Industrial Scale and Environmental Impact

In industrial applications, such calculations inform large-scale manufacturing processes, ensuring cost efficiency and regulatory compliance. Proper handling and disposal of sodium formate are also critical due to environmental considerations.

Conclusion: Summarizing the Calculation and Its Significance

Accurately determining the mass of sodium formate needed to neutralize a given volume and concentration of formic acid is a straightforward application of stoichiometry, yet it encapsulates fundamental principles essential in chemistry. By calculating the moles of acid present and applying the molar ratio, chemists can determine the exact amount of sodium formate required—in this case, approximately 37.45 grams for 290.0 cm^3 of 1.9 M solution.

This exercise underscores the importance of molarity, molar mass calculations, and reaction stoichiometry in laboratory and industrial contexts. It also highlights the need to consider practical factors such as purity, measurement accuracy, and environmental impact when translating theoretical calculations into real-world applications. Mastery of such calculations not only ensures experimental precision but also advances safer, more efficient chemical processes across diverse fields.

References:

- Brown, T. L., LeMay, H. E., Bursten, B. E., Murphy, C., & Woodward, J. (2012). Chemistry: The Central Science. Pearson.
- Atkins, P., & de Paula, J. (2014). Atkins' Physical Chemistry. Oxford University Press.
- Lide, D. R. (Ed.). (2004). Handbook of Chemistry and Physics. CRC Press.

Note: These references provide foundational knowledge on stoichiometry, molarity, and chemical calculations, essential for understanding the processes detailed in this article.

Find The Mass Of Sodium Formate That Must Be Dissolved In 290 0 Cm3cm3 Of A 1 9 Mm Solution Of Formic

Find The Mass Of Sodium Formate That Must Be Dissolved In 290 0 Cm3cm3 Of A 1 9 Mm Solution Of Formic

Related Articles

- External Diameter D = 50 Mm, Effective Diameter D= 46 Mm, The Screw Jack Used To Lift The Load W Uses
- Colin Thinks He Can Reasonably Expect To Buy A House In Five Years. He Would Like To Have Accumulated
- Consider The Following Mutations To The Nucleotide Sequence Of A Gene. Which Of These Mutations Would

Back to Home