A Student Combined 37. 2 Ml Of 1. 69 M Kmno Solution With 16. 10 Ml Of A 0. 891 M Kmno Solution. Calculate

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Introduction

In the realm of chemistry, solutions are fundamental components that facilitate countless reactions and processes. Understanding how to manipulate and calculate concentrations of solutions is crucial for students, researchers, and professionals alike. A common problem involves mixing different solutions and determining the resulting concentration or other relevant parameters.

In this article, we examine a typical scenario: a student combines 37.2 mL of a 1.69 M potassium permanganate ($KMnO_4$) solution with 16.10 mL of a 0.891 M $KMnO_4$ solution. The goal is to calculate the concentration of the resulting mixture. This problem not only tests understanding of molarity and solution mixing but also provides insight into practical applications such as titrations, preparation of standard solutions, and chemical reactions.

Understanding the Basics

Before delving into the calculations, it is essential to review some fundamental concepts:

What is Molarity (M)?

- Molarity is a measure of concentration, defined as the number of moles of solute per liter of solution.
- Expressed as: **M = moles of solute / liters of solution**

Key Data in the Problem

- First solution:
- Volume = 37.2 mL = 0.0372 L
- Molarity = 1.69 M
- Second solution:
- Volume = 16.10 mL = 0.01610 L
- Molarity = 0.891 M

Step-by-Step Calculation Process

Calculating the concentration of the combined solution involves several steps:

1. Calculate the number of moles of $KMnO_4$ in each solution

Since molarity (M) is moles per liter, we can find moles using:

- Moles = Molarity × Volume in liters

For the first solution:

- $Moles_1$ = 1.69 M × 0.0372 L = ?

For the second solution:

- $Moles_2$ = 0.891 M × 0.01610 L = ?

Calculations:

- $Moles_1$ = 1.69 × 0.0372 ≈ 0.062908 mol
- $Moles_2$ = 0.891 × 0.01610 ≈ 0.014355 mol

2. Find the total moles of $KMnO_4$ after mixing

- Total moles = $Moles_1$ + $Moles_2$

Calculation:

- Total moles ≈ 0.062908 + 0.014355 ≈ 0.077263 mol

3. Determine the total volume of the mixture

- Total volume = Volume of solution 1 + Volume of solution 2

Calculation:

- Total volume = 0.0372 L + 0.01610 L = 0.0533 L

4. Calculate the molarity of the mixture

- Molarity of mixture = Total moles / Total volume

Calculation:

- M = 0.077263 mol / 0.0533 L ≈ 1.448 M

Final Result and Interpretation

The concentration of the combined $KMnO_4$ solution is approximately 1.448 M. This means that after mixing, the solution contains about 1.448 moles of $KMnO_4$ per liter of solution.

Practical Applications of This Calculation

Understanding how to determine the concentration of a mixed solution has numerous real-world applications:

1. Preparing Standard Solutions

- Accurate concentration calculations are vital when preparing standard solutions for titrations, ensuring precise and reliable results.

2. Chemical Reactions and Titrations

- Knowing the concentration of a solution allows chemists to determine the amount of reactant needed or produced, crucial in reaction stoichiometry.

3. Quality Control in Industry

- Consistent solution concentrations are necessary for manufacturing pharmaceuticals, food products, and chemicals.

4. Environmental Analysis

- Monitoring pollutant levels often involves diluting samples and calculating concentrations post-mixing.

Additional Considerations and Tips

When performing such calculations, keep in mind the following:

- Always convert volumes to liters for consistency in molarity calculations.
- Be precise with measurements and calculations to avoid errors.
- Remember that the total volume after mixing is approximately the sum of individual volumes, but in some cases, volumes may not be strictly additive due to volume contraction or expansion—though for dilute aqueous solutions, this approximation is acceptable.
- Use significant figures appropriately based on the given data to ensure accuracy.

Common Mistakes to Avoid

- Forgetting to convert mL to L.
- Mixing up molarity and volume units.
- Not adding the individual moles before dividing to find the molarity.
- Overlooking that volume may slightly change upon mixing, though for dilute solutions, this is often negligible.

Conclusion

Calculating the concentration of a solution after mixing is a fundamental skill in chemistry that combines understanding of molarity, solution volumes, and stoichiometry. In the specific case of combining 37.2 mL of 1.69 M $KMnO_4$ and 16.10 mL of 0.891 M $KMnO_4$, the resulting concentration is approximately 1.448 M. Mastery of these calculations enables effective preparation of solutions, accurate titrations, and reliable experimental outcomes across various chemical disciplines.

By following systematic steps—calculating moles, summing them, and dividing by the total volume—students and professionals can confidently analyze and manipulate solutions for diverse applications. Remember, attention to detail and unit consistency are key to successful chemical calculations.

Frequently Asked Questions

What is the total volume of $KMnO_4$ solution mixed in the problem?

The total volume is 37.2 mL + 16.10 mL = 53.3 mL.

How do you calculate the total moles of $KMnO_4$ in the mixture?

Convert each solution's volume to liters, then multiply by its molarity: (37.2 mL × 0.001 L/mL × 1.69 M) + (16.10 mL × 0.001 L/mL × 0.891 M).

What is the molar concentration of $KMnO_4$ in the combined solution?

First, find total moles from each solution, sum them, then divide by total volume in liters to get the combined molarity.

How do you find the number of moles in each solution before mixing?

Multiply the volume in liters by the molarity: for example, 37.2 mL = 0.0372 L; moles = 0.0372 L × 1.69 M.

What is the significance of knowing the molarity in such calculations?

Molarity allows you to determine the amount of solute ($KMnO_4$) present in each solution and in the mixture, which is crucial for stoichiometric calculations.

Can you explain how to perform the calculation step-by-step?

Yes. First, convert volumes to liters, then calculate moles for each solution. Sum the moles, then divide by total volume to find the combined molarity.

What units should be used when performing these calculations?

Use liters for volume and molarity in mol/L. Ensure all units are consistent before calculations.

What is the final step after calculating the combined molarity?

Express the result as mol/L, representing the concentration of $KMnO_4$ in the mixture.

Why is it important to pay attention to the significant figures in these calculations?

Significant figures ensure the accuracy and precision of your final answer, reflecting the precision of the measurements provided.

What practical applications might this calculation have?

Such calculations are essential in laboratory titrations, preparing solutions of specific concentrations, and chemical reaction stoichiometry.

Additional Resources

Analyzing the Mixture of Two $KMnO_4$ Solutions: A Detailed Calculation and Its Chemical Implications

In the realm of chemistry, solutions' concentrations and volumes play a crucial role in determining the outcome of reactions, especially when dealing with potent oxidizing agents like potassium permanganate ($KMnO_4$). The problem at hand involves combining two solutions of $KMnO_4$ with different volumes and molarities and calculating the resulting concentration. This scenario not only serves as a practical exercise in solution chemistry but also underscores the importance of precise measurements and understanding molarity concepts in laboratory and industrial processes. This article aims to dissect the problem thoroughly, providing a step-by-step calculation, exploring the underlying principles, and discussing the broader implications of such solutions in chemical reactions.

Understanding the Problem: The Combination of Two $KMnO_4$ Solutions

Before delving into the calculations, it is essential to clearly understand what is given and what is asked.

Given Data:

- Volume of first $KMnO_4$ solution: 37.2 mL
- Molarity of the first solution: 1.69 M
- Volume of second $KMnO_4$ solution: 16.10 mL
- Molarity of the second solution: 0.891 M

Objective:

- To find the molarity of the resultant solution after mixing these two solutions.

Key Concepts:

- Molarity (M): moles of solute per liter of solution.
- Volume conversion: mL to liters (L) for molarity calculations.
- Dilution and mixing: The total moles of solute remain conserved, and the final molarity depends on the total moles divided by the total volume.

Fundamental Principles Behind the Calculation

The calculation hinges on two primary principles:

1. Conservation of Moles of Solute

When two solutions are mixed without any chemical reaction consuming the solute, the total moles of solute before mixing equal the total moles after mixing:

Total moles of $KMnO_4$ = Moles in solution 1 + Moles in solution 2

2. Molarity and Volume Relationship

Molarity (M) relates to moles (n) and volume (V):

$$n = M \times V$$

Where:

- n = moles of solute
- M = molarity (mol/L)
- V = volume in liters

Step-by-Step Calculation

Let's proceed with detailed calculations, converting all volumes to liters and then computing the moles, followed by the final concentration.

Step 1: Convert Volumes from mL to Liters

- Volume of first solution:

$$V_1 = 37.2\, \text{mL} = 0.0372\, \text{L}$$

- Volume of second solution:

$$V_2 = 16.10\, \text{mL} = 0.01610\, \text{L}$$

Step 2: Calculate Moles of $KMnO_4$ in Each Solution

- Moles in solution 1:

$$n_1 = M_1 \times V_1 = 1.69\, \text{mol/L} \times 0.0372\, \text{L}$$

$$n_1 = 1.69 \times 0.0372 = 0.062868\, \text{mol}$$

- Moles in solution 2:

$$ n_2 = M_2 \times V_2 = 0.891\, \text{mol/L} \times 0.01610\, \text{L} $$

$$ n_2 = 0.891 \times 0.01610 = 0.014355\, \text{mol} $$

Step 3: Calculate Total Moles of $KMnO_4$ in the Mixture

$$ n_{total} = n_1 + n_2 = 0.062868 + 0.014355 = 0.077223\, \text{mol} $$

Step 4: Calculate Total Volume of the Mixture

$$ V_{total} = V_1 + V_2 = 0.0372\, \text{L} + 0.01610\, \text{L} = 0.0533\, \text{L} $$

Step 5: Determine the Final Molarity

$$ M_{final} = \frac{n_{total}}{V_{total}} = \frac{0.077223\, \text{mol}}{0.0533\, \text{L}} $$

$$ M_{final} \approx 1.447\, \text{M} $$

Implications and Significance of the Result

The resulting molarity of approximately 1.447 M signifies the concentration of the mixed solution of $KMnO_4$. Several important insights can be drawn from this:

1. Concentration Adjustment in Chemical Reactions

The ability to accurately determine the concentration of a combined solution is crucial in titrations and redox reactions. $KMnO_4$, being a strong oxidizer, is often used in quantitative analysis. Knowing the exact molarity allows chemists to precisely calculate the amount of reducing agent required or to standardize solutions.

2. Dilution Strategies and Laboratory Practice

This calculation exemplifies how dilution and mixing influence solution concentrations. It underscores the importance of meticulous measurements and calculations in laboratory settings to ensure reaction consistency and accuracy.

3. Industrial and Environmental Applications

In large-scale processes, solutions are often mixed to achieve desired concentrations for manufacturing, water treatment, or analytical purposes. The principles outlined here are directly applicable in designing these processes.

Further Considerations and Chemical Context

1. Reaction with Reducing Agents

$KMnO_4$ commonly reacts with various reducing agents in redox reactions. The molarity determines the amount of reactant needed to fully consume the oxidizer, which is vital in titration procedures for analyte quantification.

Example Reaction:

$$\text{MnO}_4^- + 8 \text{H}^+ + 5 \text{e}^- \rightarrow \text{Mn}^{2+} + 4 \text{H}_2\text{O}$$

Understanding the concentration helps in calculating the equivalents involved in such reactions.

2. Safety and Handling

$KMnO_4$ solutions are highly oxidizing and can cause burns or stains. Accurate concentration calculations help in preparing solutions that are both effective and safe to handle.

3. Limitations and Assumptions

The calculation assumes ideal mixing and no chemical reactions occurring during mixing. In real scenarios, factors such as temperature, impurities, and measurement errors can influence the actual concentration.

Conclusion: The Significance of Precise Solution Calculations

Combining two solutions of $KMnO_4$ with different concentrations and volumes is a common task in chemical laboratories that requires careful calculation and understanding of molarity principles. The final molarity of approximately 1.447 M reflects the combined strength of the solutions, providing essential data for subsequent reactions, titrations, or industrial processes.

This exercise highlights the importance of fundamental chemistry concepts—unit conversions, molarity calculations, and conservation of moles—in practical applications. Accurate solution preparation ensures reaction efficiency, safety, and reproducibility, which are cornerstones of quality scientific work. As chemistry continues to underpin advances across fields—from environmental science to pharmaceuticals—the ability to perform such calculations accurately remains a foundational skill for chemists and scientists alike.

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