25.0 ML Of A 0.2450 M NH4Cl Solution Is Added To 55.5 ML Of 0.1655 M FeCl3. What Is The Concentration

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Understanding the calculation of concentrations in mixed solutions is fundamental in chemistry, especially in areas such as solution chemistry, titrations, and preparing reagents. This article will explore how to determine the final concentration when a specific volume of ammonium chloride (NH4Cl) solution is combined with a ferric chloride (FeCl3) solution. We will analyze the problem step-by-step, covering concepts such as molarity, dilution, and solution mixing, to provide a comprehensive understanding suitable for students, educators, and chemistry enthusiasts alike.

Introduction to Solution Concentrations and Mixture Calculations

Before diving into the specific problem, it's essential to understand some foundational concepts:

What is Molarity?

Molarity (M) is a measure of concentration representing moles of solute per liter of solution. It is expressed as:

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

In our case, both NH4Cl and FeCl3 are solutions with known molarities, and we are asked to find the concentration after mixing.

Why Calculate Final Concentration?

Knowing the final concentration of a solution after mixing is crucial in various chemical applications, such as titrations, preparing reaction mixtures, and understanding solution equilibria.

Understanding the Problem

Let's restate the problem:

- You have 25.0 mL of a 0.2450 M NH4Cl solution.
- You add this to 55.5 mL of a 0.1655 M FeCl3 solution.
- The goal is to determine the concentration of the resulting mixture, which, depending on context, could refer to the concentration of each component or the overall solution.

Note: Typically, when asked "What is the concentration?" in such a scenario, it refers to the concentration of each component after mixing, assuming they do not react or that the question focuses on concentration calculation based on initial data.

Note: Ensure units are consistent throughout the calculation, especially converting mL to liters.

Step-by-Step Calculation of Final Concentrations

Step 1: Convert Volumes from mL to Liters

- Volume of NH4Cl solution: 25.0 mL = 0.0250 L
- Volume of FeCl3 solution: 55.5 mL = 0.0555 L

Step 2: Calculate Moles of Each Solute

Using molarity (M) and volume in liters:

$$
\text{Moles of NH4Cl} = M \times V = 0.2450\, \text{mol/L} \times 0.0250\, \text{L} = 0.006125\, \text{mol}
$$

$$
\text{Moles of FeCl3} = 0.1655\, \text{mol/L} \times 0.0555\, \text{L} = 0.009191\, \text{mol}
$$

Step 3: Calculate Total Volume After Mixing

Total volume:

$$
V_{total} = 0.0250\, \text{L} + 0.0555\, \text{L} = 0.0805\, \text{L}
$$

Step 4: Calculate Final Concentrations

Assuming the solutions are simply mixed without any reaction (or that the reaction does not affect concentrations), the concentration of each component in the mixture is:

$$
C_{NH4Cl, final} = \frac{\text{moles of NH4Cl}}{\text{total volume}} = \frac{0.006125\, \text{mol}}{0.0805\, \text{L}} \approx 0.0761\, \text{M}
$$

\]

\[
C_{FeCl3, final} = \frac{\text{moles of FeCl3}}{\text{total volume}} = \frac{0.009191\, \text{mol}}{0.0805\, \text{L}} \approx 0.1142\, \text{M}
\]

Summary of Results:

- The concentration of NH4Cl after mixing: approximately 0.0761 M
- The concentration of FeCl3 after mixing: approximately 0.1142 M

Additional Considerations in Solution Chemistry

While the above calculation provides the straightforward molar concentrations after mixing, several factors could influence the actual scenario:

1. Chemical Reactions

- NH4Cl is a weak acid and can react with certain species, but in this case, no direct reaction with FeCl3 is expected under normal conditions.
- FeCl3 is a strong Lewis acid; it can hydrolyze in water, forming complex ions, which could slightly alter concentrations or pH.

2. pH and Ionic Strength

- The mixture's pH may change based on hydrolysis and the presence of ammonium ions.
- Ionic strength affects activity coefficients, slightly modifying the effective concentrations.

3. Temperature Effects

- Temperature can influence molarity and reaction equilibria, although standard calculations assume room temperature.

Practical Applications of These Calculations

Understanding how to compute concentrations after mixing solutions has broad implications:

- Preparation of Reagents: Ensuring correct molarity for laboratory experiments.
- Titration Planning: Calculating equivalents and titrant volumes.

- Chemical Synthesis: Managing reactant ratios for desired products.
- Environmental Chemistry: Analyzing pollutant dilutions and their impacts.

Common Mistakes and Tips for Accurate Calculations

- Always convert volumes to liters when using molarity.
- Double-check molarities and volumes before calculations.
- Remember to account for all solutions' volumes to find the total mixture volume.
- Consider whether reactions occur that could change concentrations.
- Use precise calculations, especially when dealing with small differences in molarity.

Conclusion

Calculating the concentration of solutions after mixing is a fundamental skill in chemistry essential for research, laboratory work, and industrial processes. In the scenario where 25.0 mL of 0.2450 M NH_4Cl is combined with 55.5 mL of 0.1655 M $FeCl_3$, the resulting concentrations are approximately 0.0761 M for NH_4Cl and 0.1142 M for $FeCl_3$ in the total mixed volume of 80.5 mL.

By understanding and applying these principles, students and professionals can accurately predict solution behaviors, optimize reaction conditions, and ensure precise experimental results.

Keywords: NH4Cl concentration, FeCl3 concentration, solution mixing, molarity calculation, solution chemistry, dilution, molar concentration, laboratory solutions, chemistry calculations

Frequently Asked Questions

What is the total volume of the solution after mixing 25.0 mL of NH4Cl and 55.5 mL of FeCl3?

The total volume after mixing is 25.0 mL + 55.5 mL = 80.5 mL.

How do you calculate the moles of NH4Cl added to the solution?

Moles of NH_4Cl = concentration × volume = 0.2450 M × 25.0 mL = 0.2450 mol/L × 0.025 L = 6.125×10^{-3} mol.

How do you determine the moles of FeCl3 in the solution before mixing?

Moles of FeCl3 = concentration × volume = 0.1655 M × 55.5 mL = 0.1655 mol/L × 0.0555 L ≈ 9.193×10^{-3} mol.

What is the purpose of adding NH4Cl to FeCl3 solution in this context?

Adding NH4Cl can provide a source of ammonium ions to influence the equilibrium or pH, or to see how it affects the concentration of iron(III) ions in solution.

Is the question asking for the concentration of a specific ion or the entire solution after mixing?

It is asking for the concentration of a particular species, likely Fe^{3+} ions, after mixing the solutions.

How do you calculate the concentration of FeCl3 after mixing?

Assuming complete mixing and no reactions, the total moles of FeCl3 remain the same (≈9.193×10^{-3} mol), and the total volume is 80.5 mL. Therefore, concentration = moles / total volume = 9.193×10^{-3} mol / 0.0805 L ≈ 0.1142 M.

Does the presence of NH4Cl affect the concentration calculation of FeCl3?

If there is no reaction between NH4Cl and FeCl3, the concentration of FeCl3 remains based on initial moles and total volume. However, if a reaction occurs, the concentration calculation would need to account for that.

What assumptions are made in calculating the final concentration in this scenario?

The calculations assume complete mixing, no reactions, and that the total moles of each solute remain unchanged after mixing.

What is the final concentration of FeCl3 after mixing 25.0 mL of NH4Cl with 55.5 mL of FeCl3 solution?

The final concentration of FeCl3 is approximately 0.1142 M, calculated by dividing the total moles of FeCl3 (≈9.193×10^{-3} mol) by the total volume (80.5 mL or 0.0805 L).

Additional Resources

Concentration Calculation of a Mixed Solution: An In-Depth Expert Analysis

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Understanding the Scenario: A Detailed Breakdown

In the realm of solution chemistry, accurately determining the concentration of a resultant solution after mixing various components is essential for applications ranging from industrial processes to laboratory experiments. The problem at hand involves combining a specific volume of ammonium chloride (NH_4Cl) solution with a given volume of ferric chloride ($FeCl_3$) solution, and then calculating the final concentration of either component or their ions in the mixture.

Scenario Summary:

- Adding: 25.0 mL of a 0.2450 M NH_4Cl solution
- To: 55.5 mL of a 0.1655 M $FeCl_3$ solution
- Objective: Find the concentration of a certain ion or compound in the mixture (commonly, this refers to either NH_4^+, Fe^{3+}, or Cl^- ions, depending on the context).

This inquiry exemplifies core principles of solution chemistry, including molarity, dilution, and stoichiometry. To address this comprehensively, we'll first explore key foundational concepts, then proceed with the calculations, and finally interpret the results.

Foundational Concepts in Solution Chemistry

1. Molarity (M): The Core of Concentration

Molarity (M) is defined as the number of moles of solute per liter of solution:

\[
\text{Molarity} (M) = \frac{\text{moles of solute}}{\text{liters of solution}}
\]

Knowing the molarity and volume of a solution allows calculation of the total moles of solute present, which is crucial when mixing solutions.

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2. Calculating Moles of Solute

Given molarity M and volume V (in mL), the number of moles n is:

$$
n = M \times \frac{V}{1000}
$$

since 1 L = 1000 mL.

---

3. Dilution and Final Concentration

When solutions are mixed, the total moles of solute are conserved (assuming no reactions or precipitations), and the final concentration depends on the total volume:

$$
\text{Final concentration} (M_{final}) = \frac{\text{Total moles of solute}}{\text{Total volume in liters}}
$$

Step-by-Step Calculation of Final Concentration

The core process involves:

1. Calculating the moles of NH_4Cl added.
2. Calculating the moles of $FeCl_3$ present.
3. Determining the total volume after mixing.
4. Calculating the final concentrations of ions or compounds of interest.

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1. Calculating Moles of NH_4Cl

Given:

- Volume of NH_4Cl solution: 25.0 mL
- Molarity of NH_4Cl: 0.2450 M

Calculate:

$$
n_{NH_4Cl} = 0.2450 \times \frac{25.0}{1000} = 0.2450 \times 0.025 = 0.006125\, \text{moles}
$$

---

2. Calculating Moles of $FeCl_3$

Given:

- Volume of $FeCl_3$ solution: 55.5 mL
- Molarity of $FeCl_3$: 0.1655 M

Calculate:

$$
n_{FeCl_3} = 0.1655 \times \frac{55.5}{1000} = 0.1655 \times 0.0555 \approx 0.009188\, \text{moles}
$$

---

3. Determining Total Volume After Mixing

Total volume:

$$
V_{total} = 25.0\, \text{mL} + 55.5\, \text{mL} = 80.5\, \text{mL}
$$

Convert to liters for concentration calculations:

$$
V_{total} = 80.5\, \text{mL} \times \frac{1\, \text{L}}{1000\, \text{mL}} = 0.0805\, \text{L}
$$

---

4. Calculating Final Concentrations of Key Ions

Depending on the specific ion interest, calculations will differ. For this analysis, we'll consider the concentrations of:

- NH_4^+ ions from NH_4Cl
- Fe^{3+} ions from $FeCl_3$

- Cl^- ions from both salts

Final Concentrations of Ions in the Mixture

1. Ammonium Ion (NH_4^+)

Since NH_4Cl dissociates completely:

$$
\text{NH}_4\text{Cl} \rightarrow \text{NH}_4^+ + \text{Cl}^-
$$

Total moles of NH_4^+:

$$
n_{NH_4^+} = n_{NH_4Cl} = 0.006125\, \text{moles}
$$

Final concentration:

$$
[NH_4^+] = \frac{0.006125\, \text{moles}}{0.0805\, \text{L}} \approx 0.0761\, \text{M}
$$

---

2. Ferric Ion (Fe^{3+})

$FeCl_3$ dissociates as:

$$
\text{FeCl}_3 \rightarrow \text{Fe}^{3+} + 3\text{Cl}^-
$$

Total moles of Fe^{3+}:

$$
n_{Fe^{3+}} = 0.009188\, \text{moles}
$$

Final concentration:

\[

$$
[Fe^{3+}] = \frac{0.009188}{0.0805} \approx 0.1141\, \text{M}
$$

---

3. Chloride Ions (Cl^-)

Total moles of Cl^- coming from both salts:

- From NH_4Cl: 0.006125 moles (since 1:1 dissociation)
- From $FeCl_3$: 3 times the moles of $FeCl_3$:

$$
3 \times 0.009188 = 0.027564\, \text{moles}
$$

Total Cl^-:

$$
n_{Cl^-} = 0.006125 + 0.027564 = 0.033689\, \text{moles}
$$

Final chloride concentration:

$$
[Cl^-] = \frac{0.033689}{0.0805} \approx 0.4186\, \text{M}
$$

Interpreting the Results: What Do These Concentrations Imply?

The calculated concentrations reflect the molarities of key ions in the mixture after combining the solutions. These are essential parameters in various reaction and process considerations:

- NH_4^+ (0.0761 M): This ion is relevant in acid-base chemistry, especially considering its conjugate acid NH_4^+ can act as a weak acid.
- Fe^{3+} (0.1141 M): A highly reactive species, often involved in complex formation or oxidation-reduction reactions.
- Cl^- (0.4186 M): A common counter-ion, influencing ionic strength and reaction pathways.

Additional Considerations and Practical Applications

Potential Reactions and Equilibria:

- Complex Formation: Fe^{3+} can form complexes with chloride ions, such as $[FeCl_4]^-$, affecting solubility and reactivity.
- Precipitation: Under certain conditions, Fe^{3+} can precipitate as $Fe(OH)_3$ or other hydroxides depending on pH.
- Buffering Effects: NH_4^+ can act as a weak acid, influencing pH in subsequent reactions.

Practical Applications:

- Industrial Processes: Understanding ion concentrations informs processes like wastewater treatment, where $FeCl_3$ is used as a coagulant.
- Laboratory Experiments: Accurate molarity calculations ensure reproducibility and precise control over reaction conditions.
- Educational Demonstrations: This example illustrates core concepts like molarity, dissociation, and solution mixing in an accessible context.

Conclusion: Mastery of Solution Mixture Calculations

This detailed exploration underscores the importance of meticulous calculation in solution chemistry. By understanding how to convert volumes and molarities into moles, sum these values appropriately, and divide by total volume, chemists can accurately determine the concentrations of individual ions after mixing solutions.

Whether applied in research, industry, or education, such calculations form the backbone of quantitative chemical analysis. The example examined here not only emphasizes the practical steps involved but also illuminates broader concepts of solution behavior, dissociation, and ionic interactions vital to the discipline.

In essence, the precise calculation of concentrations following solution mixing is a fundamental skill

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