

A 250 ML Aqueous Solution Contains 2.37 G Of Copper(II) Chloride. The Dissolved Copper(II) Chloride Is

A 250 ML Aqueous Solution Contains 2.37 G Of Copper(II) Chloride. The Dissolved Copper(II) Chloride Is a fundamental question in chemistry that involves understanding the nature of solutes in solutions, their molar concentrations, and their behavior in aqueous environments. This scenario provides an opportunity to explore various concepts such as molarity, molar mass, dissociation of compounds, and the properties of copper(II) chloride in water. Whether you are a student studying chemistry or a professional working in a laboratory, analyzing such solutions enhances your comprehension of solution chemistry and prepares you for practical applications, including titrations, formulation of solutions, and chemical reactions involving copper compounds.

Understanding the Composition of the Solution

Mass of Copper(II) Chloride in the Solution

The problem states that the solution contains 2.37 grams of copper(II) chloride (CuCl_2). To analyze this solution fully, the first step is to determine the molar amount of CuCl_2 present. This involves calculating the number of moles based on the molar mass of CuCl_2 .

Molar Mass of Copper(II) Chloride

To find the molar mass, sum the atomic masses of each element in the formula CuCl_2 :

- Copper (Cu): approximately 63.55 g/mol
- Chlorine (Cl): approximately 35.45 g/mol

Calculating:

$$\text{Molar mass of } \text{CuCl}_2 = 63.55 + 2 \times 35.45 = 63.55 + 70.90 = 134.45 \text{ g/mol}$$

Calculating the Number of Moles

Using the molar mass, the moles of CuCl_2 dissolved are:

$$\text{Number of moles} = \text{mass} / \text{molar mass} = 2.37 \text{ g} / 134.45 \text{ g/mol} \approx 0.01763 \text{ mol}$$

This is the amount of copper(II) chloride initially present in the solution.

Determining the Concentration of the Solution

What Is Molarity?

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

Molarity (M) = moles of solute / volume of solution in liters

Given the volume of the solution is 250 mL, which is 0.250 liters, the molarity of CuCl₂ in this solution is:

$$M = 0.01763 \text{ mol} / 0.250 \text{ L} \approx 0.07052 \text{ M}$$

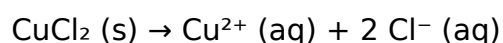
Implications of the Molarity

This molarity indicates that approximately 0.0705 moles of CuCl₂ are dissolved in every liter of the solution. Since our solution volume is only 250 mL, the actual amount dissolved is proportionally less, as calculated. This concentration has important implications for the solution's reactivity, color, and conductivity, all characteristic of copper(II) chloride in aqueous form.

The Nature of Dissolved Copper(II) Chloride in Water

How Does Copper(II) Chloride Dissolve?

Copper(II) chloride is an ionic compound, composed of Cu²⁺ cations and Cl⁻ anions. When it dissolves in water, it dissociates into these ions:



This dissociation process is essential to understanding its behavior in aqueous solutions.

Degree of Dissociation and Ionization

Since CuCl_2 is a soluble salt, it dissociates completely in water under typical conditions. The solution contains free Cu^{2+} ions and Cl^- ions, which contribute to the solution's electrical conductivity and chemical reactivity.

Properties of the Dissolved Ions

- Copper(II) ions (Cu^{2+}): These ions are responsible for the characteristic blue-green color of copper(II) chloride solutions and are involved in various redox reactions.
- Chloride ions (Cl^-): These are common halide ions that influence the solution's acidity and participate in complex formation.

Practical Applications and Significance

Uses of Copper(II) Chloride Solutions

Copper(II) chloride solutions are widely used in:

- Electroplating: As a source of copper ions for electrochemical deposition
- Water Treatment: In controlling algae and bacteria
- Analytical Chemistry: As a reagent in titrations and qualitative analysis
- Manufacturing: Production of other copper compounds and catalysts

Safety and Handling

Due to its toxicity, handling copper(II) chloride solutions requires proper safety measures:

- Use gloves and eye protection
- Avoid inhalation or ingestion
- Store in labeled, corrosion-resistant containers

Related Calculations and Concepts

Molar Concentration of Chloride Ions

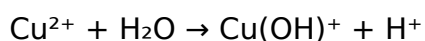
Since each mole of CuCl_2 yields two moles of Cl^- ions, the chloride ion concentration in the solution is:

$$(2 \times 0.01763 \text{ mol}) / 0.250 \text{ L} \approx 0.141 \text{ M}$$

This high chloride ion concentration influences the solution's reactivity and potential for complex formation.

pH and Acidity

Copper(II) chloride solutions are typically slightly acidic due to hydrolysis of Cu^{2+} ions:



This hydrolysis can cause the solution to have a pH slightly below neutral, affecting subsequent reactions.

Summary and Conclusions

In summary, a 250 mL aqueous solution containing 2.37 g of copper(II) chloride corresponds to approximately 0.01763 moles of CuCl_2 , resulting in a molarity of about 0.0705 M. The dissolved copper(II) chloride exists predominantly as free Cu^{2+} and Cl^- ions, which influence the solution's color, conductivity, and reactivity. Understanding these parameters is crucial for applications in laboratories, industry, and environmental science.

This analysis underscores the importance of calculating molar concentrations, understanding dissociation behavior, and recognizing the practical implications of copper(II) chloride solutions. Whether for chemical synthesis, analytical procedures, or environmental management, such detailed insights enable chemists and professionals to utilize this compound effectively and safely.

References

1. Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
2. Atkins, P., & de Paula, J. (2014). Physical Chemistry. Oxford University Press.

Frequently Asked Questions

What is the molarity of the copper(II) chloride solution described?

The molarity can be calculated by dividing the moles of CuCl_2 by the volume in liters. First, convert 2.37 g to moles: molar mass of CuCl_2 is approximately 134.45 g/mol, so $2.37 \text{ g} / 134.45 \text{ g/mol} \approx 0.0176 \text{ mol}$. The volume is 250 mL or 0.25 L, so molarity = $0.0176 \text{ mol} / 0.25 \text{ L} \approx 0.0704 \text{ M}$.

Is the copper(II) chloride fully dissolved in the solution?

Yes, since the problem states that the copper(II) chloride is dissolved in the aqueous solution, it indicates complete dissolution under the given conditions.

What is the concentration of copper ions (Cu^{2+}) in the solution?

The concentration of Cu^{2+} ions is equal to the molarity of the dissolved CuCl_2 , which is approximately 0.0704 M, because each formula unit of CuCl_2 dissociates into one Cu^{2+} ion.

How would you prepare a similar solution with double the concentration of copper(II) chloride?

To double the concentration, you would need to dissolve twice the amount of CuCl_2 (4.74 g) in the same volume of solvent (250 mL), maintaining complete dissolution to ensure the concentration is doubled.

What are the potential uses of a copper(II) chloride aqueous solution?

Copper(II) chloride solutions are commonly used in electroplating, as a fungicide, in chemical synthesis, and as a catalyst in various industrial processes.

Additional Resources

Copper(II) Chloride Solution: An In-Depth Analysis of Its Composition, Properties, and Applications

Introduction

In the realm of chemistry, solutions are fundamental to both laboratory experiments and industrial processes. Among these, aqueous solutions of metal salts stand out for their versatility, utility, and intriguing chemical behavior. One such compound is Copper(II) Chloride, a metal salt that finds applications across various sectors—from catalysis and electroplating to agriculture and analytical chemistry. This article provides a comprehensive review of a specific aqueous solution: a 250 mL solution containing 2.37 grams of Copper(II) Chloride. We explore the composition, chemical properties, preparation, and practical implications of this solution, delivering insights that are invaluable for scientists, educators, and industry professionals alike.

Understanding the Composition

The Significance of the Concentration

The provided data specifies that 250 mL of aqueous solution contains 2.37 grams of Copper(II) Chloride (CuCl_2). To appreciate the significance of this concentration, it's essential to convert this mass into molarity—a standard measure of concentration in chemistry.

Calculating the Molarity of the Solution

Step 1: Determine the molar mass of Copper(II) Chloride

The molecular formula is CuCl_2 . Calculating its molar mass involves summing the atomic masses of each element:

- Copper (Cu): 63.55 g/mol
- Chlorine (Cl): 35.45 g/mol

$$\begin{aligned} \text{Molar mass of CuCl}_2 &= 63.55 + 2 \times 35.45 = 63.55 + 70.90 = 134.45 \text{ g/mol} \end{aligned}$$

Step 2: Calculate the number of moles in 2.37 g

$$\begin{aligned} \text{Moles of CuCl}_2 &= \frac{2.37 \text{ g}}{134.45 \text{ g/mol}} \approx 0.01763 \text{ mol} \end{aligned}$$

Step 3: Compute the molarity

Since molarity (M) is moles per liter, and the solution volume is 250 mL (which is 0.25 L):

$$\begin{aligned} \text{Molarity} &= \frac{0.01763 \text{ mol}}{0.25 \text{ L}} \approx 0.07052 \text{ M} \end{aligned}$$

\]

Thus, the solution has a molarity of approximately 0.0705 M.

Chemical Properties and Dissociation

Dissociation in Water

Copper(II) Chloride, much like other ionic compounds, dissociates in water to produce copper ions (Cu^{2+}) and chloride ions (Cl^-):

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This dissociation is complete in aqueous solutions, leading to a homogeneous mixture of ions that exhibit characteristic chemical behavior.

Ionic Concentrations

In our solution:

- Copper ions (Cu^{2+}): 0.0705 mol/L
- Chloride ions (Cl^-): Twice as much, 0.141 mol/L

This ionic composition is crucial in understanding the solution's reactivity, conductivity, and potential uses.

Physical and Chemical Characteristics

Appearance and Density

Copper(II) Chloride solutions are typically colorless or pale blue-green, owing to the presence of Cu^{2+} ions, which often impart a characteristic hue to aqueous solutions. The density of this solution, owing to its concentration, is slightly higher than pure water, approximately around 1.02 g/mL, but precise measurements depend on temperature and purity.

pH and Conductivity

The solution's pH usually hovers around 4-5, indicating slight acidity—a consequence of hydrolysis of Cu^{2+} ions. Its electrical conductivity is significantly higher than distilled water due to the presence of free ions, making it suitable for electrochemical applications.

Preparation and Handling

How to Prepare a 250 mL Copper(II) Chloride Solution at 0.0705 M

To recreate this solution in a laboratory:

1. Calculate the required mass: 2.37 g of CuCl_2 .
2. Dissolution process:
 - Weigh 2.37 g of anhydrous Copper(II) Chloride.
 - Add to a clean volumetric flask containing less than 250 mL of distilled water.
 - Swirl or stir until the salt dissolves completely.
 - Top up to the 250 mL mark with distilled water.

Note: Safety measures should be observed, as Copper(II) Chloride is toxic and should be handled with gloves and eye protection.

Storage and Stability

Copper(II) Chloride solutions are relatively stable if stored in airtight containers, protected from light to prevent decomposition or unwanted reactions. They should be kept at room temperature, away from incompatible substances such as strong oxidizers.

Applications of Copper(II) Chloride Solution

The utility of copper chloride solutions stems from their ionic nature and chemical reactivity.

1. Electrochemistry and Electroplating

- Conductive medium for electrochemical cells.
- Used in electroplating to deposit copper onto surfaces, providing corrosion resistance and aesthetic finishes.

2. Catalysis

- Copper(II) chloride acts as a catalyst in organic synthesis, particularly in oxidation reactions and coupling processes.

3. Analytical Chemistry

- Serves as a reagent in qualitative and quantitative analysis for detecting and measuring chloride ions or copper content.

4. Agricultural and Antimicrobial Uses

- Copper compounds are employed as fungicides and bactericides.
- Solutions like these can be used for seed treatments or surface disinfectants.

5. Laboratory and Educational Demonstrations

- Commonly used in chemistry labs for experiments involving redox reactions, complex

formation, and solution chemistry.

Safety and Environmental Considerations

Copper(II) chloride is toxic if ingested, inhaled, or absorbed through the skin. Handling should include:

- Wearing gloves, goggles, and lab coats.
- Ensuring proper ventilation.
- Disposing of waste solutions according to hazardous waste regulations, as copper salts can be environmental pollutants.

Concluding Remarks

The 250 mL aqueous solution containing 2.37 grams of Copper(II) Chloride exemplifies a dilute, yet chemically rich, medium with a molarity of approximately 0.0705 M. Its composition, dissociation behavior, and physical properties make it a versatile reagent across scientific disciplines. Whether used in electrochemical applications, catalysis, or analytical procedures, understanding the detailed chemistry and proper handling of Copper(II) Chloride solutions ensures their effective and safe utilization.

This solution is more than just a mixture of ions; it embodies the intersection of inorganic chemistry, practical utility, and safety considerations. As research and industrial demands evolve, solutions like these continue to underpin advancements in chemistry and material science.

References

- Lide, D. R. (Ed.). (2004). CRC Handbook of Chemistry and Physics. CRC Press.
- Atkins, P., & de Paula, J. (2014). Physical Chemistry (10th ed.). Oxford University Press.
- Agency for Toxic Substances and Disease Registry (ATSDR). (2004). Toxicological Profile for Copper.
- Sigma-Aldrich Product Documentation: Copper(II) Chloride (CuCl_2)

Note: Always consult safety datasheets and institutional protocols before handling chemical solutions.

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