How Many Moles Of Ions Are Present In Exactly 150 Ml Of A 0.260 M Ammonium Phosphate Solution, (nh4)3po4(aq)?

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Understanding the number of moles of ions present in a chemical solution is fundamental in chemistry, especially in stoichiometry, solution chemistry, and analytical chemistry. When dealing with compounds like ammonium phosphate, $(NH_4)_3PO_4$, knowing how to calculate the total moles of ions from a given volume and molarity allows chemists to determine concentrations, prepare solutions accurately, and analyze reactions effectively. In this comprehensive guide, we will explore step-by-step how to determine the total moles of ions in exactly 150 mL of a 0.260 M ammonium phosphate solution, covering essential concepts, calculations, and practical applications.

Understanding the Basics: What Is Ammonium Phosphate $(NH_4)_3PO_4$?

Chemical Structure and Composition

- Ammonium phosphate, $(NH_4)_3PO_4$, is an inorganic salt composed of:
- Three ammonium ions (NH_4^+)
- One phosphate ion (PO_4^{3-})
- It is commonly used in fertilizers due to its rich nitrogen and phosphorus content.
- When dissolved in water, $(NH_4)_3PO_4$ dissociates into its constituent ions.

Solubility and Dissociation in Water

- $(NH_4)_3PO_4$ is highly soluble in water.
- Dissociation equation:

$(NH_4)_3PO_4$ (s) → 3 NH_4^+ (aq) + PO_4^{3-} (aq)

- This dissociation indicates that for each mole of ammonium phosphate that dissolves, it produces:
- 3 moles of ammonium ions
- 1 mole of phosphate ions

Calculating the Moles of Ammonium Phosphate in 150 mL of a 0.260 M Solution

Understanding Molarity

- Molarity (M) is defined as moles of solute per liter of solution.
- Given:
- Molarity (M) = 0.260 mol/L
- Volume (V) = 150 mL = 0.150 L

Calculating Moles of $(NH_4)_3PO_4$

- Moles of ammonium phosphate:

\[
\text{Moles} = \text{Molarity} \times \text{Volume}
\]

\[
\text{Moles} = 0.260\, \text{mol/L} \times 0.150\, \text{L} = 0.039\, \text{mol}
\]

- So, in 150 mL, there are 0.039 moles of ammonium phosphate molecules.

Determining the Total Moles of Ions Present

Ion Production per Mole of Ammonium Phosphate

- From the dissociation equation:

$(NH_4)_3PO_4 \rightarrow 3\ NH_4^+ + PO_4^{3-}$

- For each mole of $(NH_4)_3PO_4$:
- 3 moles of NH_4^+ ions are produced
- 1 mole of PO_4^{3-} ions is produced

Calculating Total Moles of Each Ion

- Total moles of ammonium ions:

\[

$$
3 \times 0.039\, \text{mol} = 0.117\, \text{mol}
$$

- Total moles of phosphate ions:

$$
1 \times 0.039\, \text{mol} = 0.039\, \text{mol}
$$

Calculating the Total Number of Moles of Ions

- Total moles of all ions combined:

$$
0.117\, \text{mol} + 0.039\, \text{mol} = 0.156\, \text{mol}
$$

- Therefore, exactly 150 mL of 0.260 M ammonium phosphate solution contains 0.156 moles of ions in total.

Implications and Applications of These Calculations

Practical Uses in Chemistry

- Solution preparation: Ensuring accurate ion concentrations for experimental procedures.
- Titration and analysis: Understanding ion quantities helps in quantitative analysis.
- Reaction stoichiometry: Calculating reactant and product amounts in chemical reactions.

Importance in Environmental Chemistry

- Monitoring ion levels in water bodies to assess pollution levels.
- Designing fertilizers with optimal nutrient concentrations.

Educational Significance

- Demonstrating fundamental concepts in solution chemistry.
- Providing a practical example of molarity and dissociation calculations.

Key Points Summary

- Molarity indicates the number of moles of solute per liter of solution.
- Dissociation of $(NH_4)_3PO_4$ produces 3 NH_4^+ ions and 1 PO_4^{3-} ion per mole.
- Calculation of moles from volume and molarity is straightforward:
- Moles = Molarity × Volume (in liters)
- Total ions are obtained by multiplying the moles of compound by the number of ions produced per molecule.

Additional Tips for Accurate Calculations

- Always convert volume to liters before multiplying by molarity.
- Remember the dissociation ratios to determine the number of ions.
- Use significant figures appropriately based on given data.
- Verify units throughout calculations to avoid errors.

Conclusion

Calculating the number of moles of ions in a solution like ammonium phosphate involves understanding the compound's dissociation behavior, molarity, and solution volume. In the case of 150 mL of a 0.260 M ammonium phosphate solution, we find that there are approximately 0.156 moles of ions in total—comprising 0.117 moles of ammonium ions and 0.039 moles of phosphate ions. Mastery of these calculations is essential for chemists, students, and professionals involved in solution chemistry, environmental monitoring, and laboratory experiments. Whether you're preparing solutions, analyzing reactions, or studying chemical equilibria, understanding ion quantities at this level provides a solid foundation for accurate and effective chemical work.

Keywords for SEO Optimization:
- Moles of ions in ammonium phosphate solution
- How to calculate ion moles in solution
- $(NH_4)_3PO_4$ dissociation
- Molarity and ion concentration
- Solution chemistry calculations
- Stoichiometry of ammonium phosphate
- Total ions in solution
- Practical chemistry calculations
- Moles of ions in water solutions

Frequently Asked Questions

How do you calculate the number of moles of ions in a given volume of ammonium phosphate solution?

First, determine the total number of moles of ammonium phosphate using molarity and volume, then multiply by the number of ions produced per formula unit to find the total moles of each ion.

What is the molarity of ammonium ions in a 0.260 M $(NH_4)_3PO_4$ solution?

Since each formula unit of $(NH_4)_3PO_4$ produces 3 ammonium ions, the molarity of NH_4^+ is 3 × 0.260 M = 0.780 M.

How many moles of phosphate ions are present in 150 mL of a 0.260 M $(NH_4)_3PO_4$ solution?

Number of moles of PO_4^{3-} = molarity × volume in liters = 0.260 mol/L × 0.150 L = 0.039 mol.

How many moles of ammonium ions are in 150 mL of the solution?

Moles of NH_4^+ = 3 × moles of $(NH_4)_3PO_4$ = 3 × 0.039 mol = 0.117 mol.

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

Total moles of ions = moles of NH_4^+ + moles of PO_4^{3-} = 0.117 mol + 0.039 mol = 0.156 mol.

How do you convert a volume of solution from milliliters to liters for molarity calculations?

Divide the volume in milliliters by 1000 to get liters; for example, 150 mL = 0.150 L.

Why does ammonium phosphate produce multiple moles of ions per formula unit?

Because the chemical formula $(NH_4)_3PO_4$ contains 3 ammonium ions and 1 phosphate ion, leading to multiple ions in solution.

What assumptions are made when calculating moles of ions in dilute solutions?

It is assumed that the solution is ideal, complete dissociation occurs, and activity coefficients are close to 1.

Can the number of moles of ions be used to determine the ionic strength of the solution?

Yes, knowing the moles and concentrations of ions allows calculation of the ionic strength, which affects properties like conductivity and solubility.

Additional Resources

Ions in Solution: Unraveling the Chemistry of Ammonium Phosphate in 150 mL of 0.260 M Solution

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Introduction

When exploring the world of chemistry, understanding how molecules dissociate and the number of ions present in a solution is fundamental. Whether you're a student tackling a homework problem or a researcher analyzing experimental data, accurately determining the number of moles of ions in a solution is crucial. Today, we delve into an instructive example: calculating how many moles of ions are present in exactly 150 mL of a 0.260 M ammonium phosphate, $(\mathrm{NH}_4)_3\mathrm{PO}_4$, solution.

This analysis not only offers insight into the behavior of ionic compounds in aqueous environments but also reinforces essential concepts such as molarity, molar mass, dissociation, and stoichiometry. Let's explore this problem step-by-step, highlighting key principles and calculations along the way.

Understanding the Substance: Ammonium Phosphate $(\mathrm{NH}_4)_3\mathrm{PO}_4$

Before diving into calculations, it’s vital to understand what ammonium phosphate is and how it behaves in water.

Chemical Structure and Composition

- The chemical formula, $(\mathrm{NH}_4)_3\mathrm{PO}_4$, indicates that each formula unit contains:
- 3 ammonium ions (NH_4^+)
- 1 phosphate ion (PO_4^{3-})

- The compound is ionic and highly soluble in water, dissociating into its constituent ions:

$$
(\mathrm{NH}_4)_3\mathrm{PO}_4 \rightarrow 3\, \mathrm{NH}_4^+ + \mathrm{PO}_4^{3-}
$$

Molar Mass Calculation

Calculating the molar mass is essential for converting molarity and volume into moles.

Element	Atomic Mass (g/mol)	Number in formula	Total contribution (g/mol)
Nitrogen (N)	14.01	3 (from 3 NH_4^+)	14.01 × 3 = 42.03
Hydrogen (H)	1.008	12 (from 3 NH_4^+)	1.008 × 12 = 12.096
Phosphorus (P)	30.97	1	30.97
Oxygen (O)	16.00	4	16.00 × 4 = 64.00

Adding these:

$$
\text{Molar mass} = 42.03 + 12.096 + 30.97 + 64.00 = \boxed{149.096\, \mathrm{g/mol}}
$$

For simplicity, we can approximate this as 149.10 g/mol.

Calculating the Total Moles of the Compound in the Given Solution

Given data:

- Volume of solution = 150 mL = 0.150 L
- Molarity (M) = 0.260 mol/L

The total moles of ammonium phosphate in this volume:

$$
\text{Moles of } (\mathrm{NH}_4)_3\mathrm{PO}_4 = \text{Molarity} \times \text{Volume (L)} = 0.260 \times 0.150 = 0.039\, \text{mol}
$$

This is the number of formula units present in the solution, which forms the basis of our ion calculation.

Dissociation and Ion Population

How Does $(\mathrm{NH}_4)_3\mathrm{PO}_4$ Dissociate?

In aqueous solution, ammonium phosphate dissociates completely into its ions:

$$
(\mathrm{NH}_4)_3\mathrm{PO}_4 \rightarrow 3\, \mathrm{NH}_4^+ + \mathrm{PO}_4^{3-}
$$

This dissociation is assumed to be complete because ammonium phosphate is highly soluble.

Number of Ions Formed

- Per mole of $(\mathrm{NH}_4)_3\mathrm{PO}_4$:

- 3 moles of NH_4^+
- 1 mole of PO_4^{3-}

- Total ions per mole:

$$
3 + 1 = 4\, \text{moles of ions}
$$

- Total moles of ions:

$$
\text{Total ion moles} = 0.039\, \text{mol} \times 4 = 0.156\, \text{mol}
$$

- Breakdown:

- Ammonium ions (NH_4^+):

$$
3 \times 0.039 = 0.117\, \text{mol}
$$

- Phosphate ions (PO_4^{3-}):

$$
1 \times 0.039 = 0.039\, \text{mol}
$$

Summarizing the Ion Count

Ion Type	Moles of Ions	Explanation
NH_4^+	0.117 mol	3 mol per formula unit × total moles of compound
PO_4^{3-}	0.039 mol	1 mol per formula unit

Total moles of ions in the solution:

$$
\boxed{0.156\, \text{mol}}
$$

This comprehensive calculation indicates that in 150 mL of 0.260 M ammonium phosphate solution, approximately 0.156 moles of ions are present, distributed among ammonium and phosphate ions.

Practical Implications and Additional Considerations

Ionic Strength and Conductivity

Understanding the number of ions is vital for applications like calculating ionic strength — a key factor influencing solution behavior, electrochemistry, and conductivity. The high number of ions in solution typically results in high electrical conductivity, making such solutions suitable for various industrial and laboratory applications.

Role in Titrations and Reactions

Knowing the molar quantities of ions helps in designing titrations and predicting reaction outcomes. For example, in a scenario where ammonium phosphate reacts with a strong acid or base, knowing the initial ion concentration guides stoichiometric calculations and reaction completeness.

Limitations and Assumptions

- Complete Dissociation: The calculations assume full dissociation, which is valid for highly soluble salts like ammonium phosphate.
- Ideal Behavior: Real solutions might show slight deviations due to ion pairing or activity coefficients, especially at higher concentrations.
- Temperature Effects: Molarity can vary with temperature; however, for typical laboratory conditions, these calculations hold well.

Final Thoughts

This detailed analysis underscores the importance of fundamental principles in chemistry—molarity, molar mass, dissociation, and stoichiometry—in quantifying ions in solution. By carefully dissecting the problem, we've demonstrated that in 150 mL of 0.260 M ammonium phosphate, approximately 0.117 mol of \(\mathrm{NH}_4^+\) and 0.039 mol of \(\mathrm{PO}_4^{3-}\) ions are present, summing to a total of 0.156 mol of ions.

Such calculations are essential tools for chemists, enabling precise control and understanding of chemical systems, whether for academic research, industrial processes, or quality control. Mastering these concepts empowers professionals to predict behaviors, optimize reactions, and innovate with confidence in the complex world of solution chemistry.

In essence, understanding how many moles of ions are in a solution transforms abstract molarity and volume data into tangible insights, paving the way for informed decision-making and advanced chemical manipulation.

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