How Many Ions Are Produced From A 14.3 G Sample Of Calcium Nitrate

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Understanding the number of ions produced from a specific mass of a compound like calcium nitrate is fundamental in chemistry, especially when dealing with solutions, reactions, and molar calculations. In this comprehensive guide, we will explore how to determine the number of ions generated from a 14.3 g sample of calcium nitrate, covering essential concepts such as molar mass, dissociation in water, and stoichiometry. By the end of this article, you will have a clear understanding of the process involved in converting grams of calcium nitrate into individual ions, an essential skill in analytical chemistry and related fields.

Introduction to Calcium Nitrate and Its Dissociation

Calcium nitrate, with the chemical formula $Ca(NO_3)_2$, is an inorganic compound commonly used in fertilizers, explosives, and as a dehydrating agent. When dissolved in water, calcium nitrate dissociates into its constituent ions, calcium ions (Ca^{2+}) and nitrate ions (NO_3^-). This dissociation process is vital because it determines the number of ions present in the solution, which influences properties like conductivity and reactivity.

The dissociation equation for calcium nitrate in water is:

$$Ca(NO_3)_2\ (s) \rightarrow Ca^{2+}\ (aq) + 2\ NO_3^-\ (aq)$$

This implies that one mole of calcium nitrate produces three moles of ions—one calcium ion and two nitrate ions.

Calculating the Moles of Calcium Nitrate in a 14.3 g Sample

Before determining the number of ions, we need to convert the given mass of calcium nitrate into moles. This process involves calculating the molar mass of calcium nitrate.

Molar Mass of Calcium Nitrate ($Ca(NO_3)_2$)

To find the molar mass, sum the atomic masses of all constituent atoms:

- Calcium (Ca): approximately 40.08 g/mol
- Nitrogen (N): approximately 14.01 g/mol
- Oxygen (O): approximately 16.00 g/mol

Calculations:

1. Mass of calcium: 1 × 40.08 g/mol = 40.08 g/mol
2. Mass of nitrogen: 2 × 14.01 g/mol = 28.02 g/mol
3. Mass of oxygen: 6 × 16.00 g/mol = 96.00 g/mol

Total molar mass:

40.08 + 28.02 + 96.00 = 164.10 g/mol

Converting grams to moles

Using the molar mass:

Number of moles = (mass of sample) / (molar mass)

Given sample mass: 14.3 g

Calculation:

Number of moles of $Ca(NO_3)_2$ = 14.3 g / 164.10 g/mol ≈ 0.0872 mol

Therefore, the 14.3 g sample contains approximately 0.0872 moles of calcium nitrate.

Determining the Total Number of Ions Produced

Having established the moles of calcium nitrate, the next step is to determine how many ions are produced upon complete dissociation.

Understanding Ion Production per Mole

From the dissociation equation:

$Ca(NO_3)_2$ (s) → Ca^{2+} (aq) + 2 NO_3^- (aq)

- 1 mole of calcium nitrate produces:
- 1 mole of calcium ions (Ca^{2+})
- 2 moles of nitrate ions (NO_3^-)

Total ions per mole:

1 + 2 = 3 moles of ions

Calculating Total Moles of Ions

Total moles of ions:

Total ions = moles of calcium nitrate × 3

Total ions = 0.0872 mol × 3 ≈ 0.2616 mol

Converting Moles of Ions to Number of Ions

Using Avogadro's number (approximately 6.022×10^{23} particles/mol):

Number of ions = moles of ions × Avogadro's number

Calculation:

Number of ions = 0.2616 mol × 6.022×10^{23} ions/mol ≈ 1.575×10^{23} ions

Thus, approximately 1.58×10^{23} ions are produced from a 14.3 g sample of calcium nitrate.

Step-by-Step Summary of the Calculation Process

To clarify, here is a step-by-step breakdown of the entire process:

1. Calculate the molar mass of calcium nitrate ($Ca(NO_3)_2$): 164.10 g/mol
2. Determine the number of moles in 14.3 g: 14.3 g / 164.10 g/mol ≈ 0.0872 mol
3. Understand the dissociation: 1 mol $Ca(NO_3)_2$ → 3 mol ions
4. Calculate total moles of ions: 0.0872 mol × 3 ≈ 0.2616 mol
5. Convert moles of ions to total number of ions: 0.2616 mol × 6.022×10^{23} ≈ 1.58×10^{23} ions

Additional Insights and Practical Applications

Understanding the number of ions produced from a given mass of calcium nitrate has numerous applications in chemistry and industry.

Applications in Solution Chemistry

- Conductivity: The number of ions directly influences the electrical conductivity of the solution. More ions mean higher conductivity.
- Reaction Stoichiometry: Knowing the number of ions helps in predicting reaction outcomes, such as precipitation or complex formation.
- Buffer Preparation: In preparing buffer solutions, ion concentrations are crucial, and knowing ion quantities aids in precise formulation.

Industrial and Agricultural Significance

- Fertilizer Usage: Calcium nitrate supplies calcium and nitrate ions essential for plant growth. Quantifying ions helps in dosing and environmental impact assessments.
- Environmental Chemistry: Understanding ion dissociation assists in predicting pollutant behavior and treatment processes.

Factors Affecting Ion Production and Dissociation

While the calculations above assume complete dissociation, real-world scenarios may involve factors that influence ionization.

Solubility and Dissociation Efficiency

- Calcium nitrate is highly soluble in water, usually dissociating entirely at typical concentrations.
- However, temperature, presence of other ions, and solution conditions can affect dissociation extent.

Impurities and Contaminants

- Impurities in the sample can alter the number of ions produced.
- Pure samples yield more predictable ion counts compared to contaminated or impure samples.

Conclusion

In summary, from a 14.3 g sample of calcium nitrate, approximately 1.58×10^{23} ions are produced

upon complete dissociation in water. This calculation involves understanding molar mass, stoichiometry of the dissociation reaction, and the use of Avogadro's number. Mastering such conversions is fundamental in chemistry, enabling accurate analysis and application in various scientific and industrial contexts.

By following the outlined steps, anyone can determine the number of ions produced from any given mass of calcium nitrate or similar compounds, enhancing their understanding of solution chemistry and the behavior of ionic compounds in aqueous environments.

Frequently Asked Questions

How many moles of calcium nitrate are present in a 14.3 g sample?

The molar mass of calcium nitrate ($Ca(NO_3)_2$) is approximately 164.10 g/mol. Therefore, the number of moles is 14.3 g ÷ 164.10 g/mol ≈ 0.0872 mol.

How many calcium ions are produced from 14.3 g of calcium nitrate?

Each formula unit of calcium nitrate produces 1 calcium ion upon dissociation. Therefore, about 0.0872 mol of calcium ions are produced, which is approximately 0.0872 mol × 6.022×10^{23} ≈ 5.25×10^{22} ions.

How many nitrate ions are produced from a 14.3 g sample of calcium nitrate?

Each calcium nitrate molecule produces 2 nitrate ions. Thus, 0.0872 mol of calcium nitrate yields 2 × 0.0872 mol = 0.1744 mol of nitrate ions, approximately 1.05×10^{23} ions.

What is the total number of ions produced when calcium nitrate

dissociates in solution?

Dissociation yields 1 calcium ion and 2 nitrate ions per formula unit, totaling 3 ions per molecule. Therefore, total ions = 3 × 0.0872 mol × 6.022×10^{23} ≈ 1.57×10^{23} ions.

How do you calculate the number of ions from a given mass of calcium nitrate?

First, determine the number of moles by dividing the mass by molar mass. Then, multiply the moles by Avogadro's number and the number of ions produced per formula unit (1 calcium and 2 nitrates).

Why does calcium nitrate produce more nitrate ions than calcium ions in solution?

Because each calcium nitrate molecule contains two nitrate ions, dissociation produces twice as many nitrate ions as calcium ions per formula unit.

If the sample of calcium nitrate is fully dissociated, how many total ions are present in the solution?

From 0.0872 mol of calcium nitrate, there are 0.0872 mol of calcium ions and 0.1744 mol of nitrate ions, totaling approximately 0.2616 mol of ions, which is about 1.58×10^{23} ions.

What assumptions are made when calculating the number of ions from calcium nitrate mass?

It is assumed that calcium nitrate dissociates completely in solution and that all the sample is pure and reacts fully without any losses.

How does molar mass influence the calculation of ions produced from

a given mass of calcium nitrate?

The molar mass allows converting mass to moles, which is essential for calculating the number of ions produced, since the number of ions is directly proportional to the number of moles.

Additional Resources

How Many Ions Are Produced From A 14.3 G Sample Of Calcium Nitrate

Understanding the number of ions produced from a given amount of a compound like calcium nitrate is a fundamental concept in chemistry, bridging the gap between molar quantities and particle counts. When dealing with ionic compounds, it’s crucial to grasp how they dissociate in aqueous solutions, as this directly impacts the number of ions generated. In this guide, we'll explore how many ions are produced from a 14.3 g sample of calcium nitrate, walking through the necessary calculations, chemical principles, and conversions involved. By the end, you'll have a clear understanding of how to approach similar problems and appreciate the fascinating world of ions and their quantities.

Introduction to Calcium Nitrate and Its Dissociation

Calcium nitrate, with the chemical formula $Ca(NO_3)_2$, is a common inorganic salt used in fertilizers, explosives, and other industrial applications. It’s an ionic compound composed of calcium cations (Ca^{2+}) and nitrate anions (NO_3^-). When dissolved in water, calcium nitrate dissociates into its constituent ions, producing a specific number of ions in total.

What Happens When Calcium Nitrate Dissolves?

The dissociation process for calcium nitrate in aqueous solution can be summarized as:

$$ \text{Ca(NO}_3)_2 \rightarrow \text{Ca}^{2+} + 2 \text{NO}_3^- $$

This balanced chemical equation indicates that:

- Each formula unit of calcium nitrate produces one calcium ion (Ca^{2+})
- Each formula unit produces two nitrate ions (NO_3^-)

Thus, per mole of calcium nitrate, the total number of ions produced is 3 moles of ions (1 Ca^{2+} + 2 NO_3^-).

Step 1: Determine the Molar Mass of Calcium Nitrate

To convert grams to moles, we first need the molar mass of calcium nitrate.

Atomic masses (approximate):

- Calcium (Ca): 40.08 g/mol
- Nitrogen (N): 14.01 g/mol
- Oxygen (O): 16.00 g/mol

Calculating molar mass of $Ca(NO_3)_2$:

$$
\begin{aligned}
\text{Molar mass} &= \text{Ca} + 2 \times \text{N} + 6 \times \text{O} \\
&= 40.08 + 2 \times 14.01 + 6 \times 16.00 \\
&= 40.08 + 28.02 + 96.00 \\
&= 164.10 \text{ g/mol}
\end{aligned}
$$

Therefore, the molar mass of calcium nitrate is approximately 164.10 g/mol.

Step 2: Calculate Moles of Calcium Nitrate in 14.3 g

Using the molar mass, convert grams to moles:

$$
\text{Moles of Ca(NO}_3)_2 = \frac{\text{Mass in grams}}{\text{Molar mass}} = \frac{14.3}{164.10}
$$

$$
\approx 0.0872 \text{ mol}
$$

This is the amount of calcium nitrate present in the sample.

Step 3: Determine Total Number of Ions Produced

From the dissociation equation, each mole of calcium nitrate produces 3 moles of ions. So:

$$
\text{Moles of ions} = 3 \times \text{moles of Ca(NO}_3)_2
$$

$$
= 3 \times 0.0872 \approx 0.2616 \text{ mol of ions}
$$

Converting Moles of Ions to Number of Particles

Using Avogadro's number (6.022×10^{23} particles per mole):

$$
\text{Number of ions} = 0.2616 \times 6.022 \times 10^{23}
$$

$$
\approx 1.575 \times 10^{23} \text{ ions}
$$

Thus, from a 14.3 g sample of calcium nitrate, approximately 1.58×10^{23} ions are produced in solution.

Additional Considerations

Ionic Composition and Distribution

- Calcium Ions (Ca^{2+}): The sample produces approximately 0.0872 mol of calcium ions.
- Nitrate Ions (NO_3^-): The sample produces $2 \times 0.0872 = 0.1744$ mol of nitrate ions.

Total Ions

Adding these:

$$
0.0872 \text{ mol } (Ca)^{2+}) + 0.1744 \text{ mol } (NO)_3^-) = 0.2616 \text{ mol of ions}
$$

which matches our earlier calculation.

How Many Particles in Practice?

- In the solution: The ions are dispersed evenly, with roughly 1.58×10^{23} ions per mole of calcium nitrate initially dissolved.
- In the entire sample: Since the sample contains 0.0872 mol of calcium nitrate, the total ions are as calculated.

Potential Variations

- Incomplete Dissociation: The calculations assume complete dissociation, which is valid for calcium nitrate in aqueous solutions.
- Temperature and Solvent Effects: These factors can influence solubility and dissociation efficiency but are generally consistent under standard conditions.

Summary: Key Steps to Find Number of Ions

1. Calculate the molar mass of the compound.
2. Convert grams to moles using the molar mass.
3. Determine the number of moles of ions produced per mole of compound (from the dissociation equation).
4. Multiply to find total moles of ions.
5. Use Avogadro's number to convert moles of ions into the total number of ions.

Practical Applications and Relevance

Knowing the number of ions produced from a given mass of calcium nitrate is crucial in various contexts:

- Chemical Reactions: Accurate stoichiometry in reactions involving calcium nitrate.
- Industrial Processes: Estimating ion concentrations in fertilizers and solutions.
- Research and Development: Designing experiments where ion counts influence outcomes.
- Educational Purposes: Understanding mole concept, dissociation, and particle counts.

Final Thoughts

Calculating how many ions are produced from a specific mass of an ionic compound like calcium nitrate beautifully illustrates the power of fundamental chemistry principles. It involves understanding molar mass, dissociation, and Avogadro's number—tools that allow chemists to scale from the macroscopic (grams) to the microscopic (particles). From a 14.3 g sample, over 1.58×10^{23} ions are generated, highlighting the immense scale of atomic and molecular interactions in everyday chemistry.

Whether you're a student tackling homework, a researcher designing experiments, or a professional in industry, grasping these calculations empowers you to interpret and manipulate chemical systems with confidence.

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