The Solubility Of Ca(OH)2 Is Measured And Found To Be 0.953 G/L. Use This Information To Calculate A

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Understanding the solubility of chemical compounds is fundamental in chemistry, especially when dealing with solutions and reactions involving dissolving solids. In this article, we will explore the process of calculating the molar solubility of calcium hydroxide ($Ca(OH)_2$) using the given solubility data, and we will delve into the significance of this calculation in practical applications.

Introduction to Solubility and Its Significance

What Is Solubility?

Solubility refers to the maximum amount of a solute that can dissolve in a solvent at a specific temperature, forming a saturated solution. It is typically expressed in grams per liter (g/L), molarity (mol/L), or molar solubility (mol/L). Accurate knowledge of solubility helps chemists understand how substances behave in solutions, predict reaction outcomes, and design processes in industries such as pharmaceuticals, water treatment, and materials science.

Importance of Measuring Solubility

Measuring solubility allows for:
- Determining concentrations in solution
- Calculating equilibrium constants
- Understanding precipitation and dissolution processes
- Designing effective chemical reactions and processes

In our case, the solubility of calcium hydroxide ($Ca(OH)_2$) is given as 0.953 g/L, which serves as the basis for subsequent calculations.

Understanding the Dissolution of $Ca(OH)_2$

Chemical Equation of Dissolution

Calcium hydroxide dissolves in water according to the following equilibrium:

$Ca(OH)_2\ (s) \rightleftharpoons Ca^{2+}\ (aq) + 2OH^-\ (aq)$

This equilibrium determines how much $Ca(OH)_2$ dissolves to produce calcium and hydroxide ions in solution.

Relevance of Molar Solubility

Molar solubility (denoted as 'A') refers to the number of moles of solute that dissolve per liter of solution to reach saturation. Calculating 'A' from the given solubility allows chemists to understand the extent of dissolution at equilibrium.

Calculating the Molar Solubility (A) of $Ca(OH)_2$

Given Data and Constants

- Solubility (S) = 0.953 g/L
- Molar mass of $Ca(OH)_2$ = (40.08) (for Ca) + 2 × (16.00) (for O and H) = 74.10 g/mol

Step-by-Step Calculation

1. **Convert grams per liter to moles per liter:**
   $$
   A = \frac{S}{\text{Molar mass of Ca(OH)}_2}
   $$
   $$
   A = \frac{0.953\, \text{g/L}}{74.10\, \text{g/mol}} \approx 0.01286\, \text{mol/L}
   $$

2. **Interpretation of 'A':** The molar solubility of $Ca(OH)_2$ is approximately 0.01286 mol/L. This means that, at equilibrium, about 0.01286 moles of $Ca(OH)_2$ dissolve per liter of water to form a saturated solution.

Implications of the Molar Solubility

Knowing the molar solubility helps in:
- Calculating the concentrations of calcium and hydroxide ions in solution
- Determining the solubility product constant (Ksp)
- Understanding the pH of the saturated solution

Calculating the Solubility Product (Ksp) of $Ca(OH)_2$

Understanding Ksp

The solubility product constant (Ksp) expresses the equilibrium concentration of ions in a saturated solution. For calcium hydroxide:

$Ca(OH)_2\ (s) \rightleftharpoons Ca^{2+}\ (aq) + 2OH^-\ (aq)$

The equilibrium concentrations are:
- $[Ca^{2+}] = A$
- $[OH^-] = 2A$

Calculating Ksp

Using the molar solubility:

$$
K_{sp} = [Ca^{2+}] \times [OH^-]^2
$$

$$
K_{sp} = A \times (2A)^2 = A \times 4A^2 = 4A^3
$$

$$
K_{sp} = 4 \times (0.01286)^3 \approx 4 \times 2.13 \times 10^{-6} \approx 8.52 \times 10^{-6}
$$

This value of Ksp indicates the solubility equilibrium constant for $Ca(OH)_2$ under the given conditions.

Applications of Solubility Data in Real-World Scenarios

Industrial Processes

Understanding the solubility of $Ca(OH)_2$ is critical in industries such as:
- Water treatment: $Ca(OH)_2$ is used to remove impurities and adjust pH
- Construction: As a component in cement and plaster
- Agriculture: Soil pH adjustment and fertilizer production

Environmental Impact

The solubility influences how calcium hydroxide interacts with environmental systems, affecting water quality and soil chemistry.

Pharmaceutical Industry

Precise solubility measurements guide formulation development and ensure proper dosing of calcium hydroxide-based medicines.

Factors Affecting Solubility

Temperature

Solubility generally varies with temperature. For $Ca(OH)_2$, increased temperature can increase or decrease solubility depending on the system.

pH and Ionic Strength

High ionic strength or pH can influence the solubility through common ion effects or complex formation.

Presence of Other Ions

Additional ions in solution can shift equilibrium, affecting the amount of $Ca(OH)_2$ that dissolves.

Summary and Key Takeaways

- The measured solubility of $Ca(OH)_2$ is 0.953 g/L.
- This solubility corresponds to a molar solubility (A) of approximately 0.01286 mol/L.
- Using this molar solubility, we can calculate the solubility product constant (Ksp) as roughly 8.52×10^{-6}.
- These calculations are essential for predicting the behavior of calcium

hydroxide in various chemical and industrial processes.
- Understanding solubility and related parameters ensures better control and optimization in applications ranging from water treatment to construction.

Conclusion

Accurate measurement and calculation of solubility are vital in chemistry for both theoretical understanding and practical applications. The example of calcium hydroxide illustrates how a given solubility value can be transformed into meaningful parameters like molar solubility and Ksp. Such insights enable scientists and engineers to design better processes, ensure safety, and optimize resource use across multiple industries.

Whether you're a student learning about solubility equilibria or a professional applying this knowledge in industry, grasping the relationship between solubility, molar calculations, and equilibrium constants is fundamental to mastering aqueous chemistry.

Frequently Asked Questions

What is the solubility of $Ca(OH)_2$ in water as given in the problem?

The solubility of $Ca(OH)_2$ is 0.953 g/L.

How do you convert the solubility of $Ca(OH)_2$ from grams per liter to molar solubility?

By dividing the solubility in grams per liter by the molar mass of $Ca(OH)_2$ to get molar solubility (A).

What is the molar mass of $Ca(OH)_2$?

The molar mass of $Ca(OH)_2$ is approximately 74.09 g/mol.

How is the molar solubility (A) related to the solubility in g/L?

Molar solubility A is calculated as (solubility in g/L) divided by molar mass of $Ca(OH)_2$, yielding mol/L.

Calculate the molar solubility A of $Ca(OH)_2$ based on

the given data.

A = 0.953 g/L ÷ 74.09 g/mol ≈ 0.01286 mol/L.

What is the significance of knowing the molar solubility A of $Ca(OH)_2$?

It helps in understanding the extent to which $Ca(OH)_2$ dissolves in water and is useful in equilibrium calculations.

How does temperature affect the solubility of $Ca(OH)_2$?

Generally, increasing temperature can increase solubility, but specific data for $Ca(OH)_2$ should be referenced for precise effects.

What next steps can be taken to determine the solubility product (Ksp) of $Ca(OH)_2$ using this molar solubility?

Using the molar solubility, Ksp can be calculated based on the dissociation equilibrium of $Ca(OH)_2$ into Ca^{2+} and OH^- ions.

Additional Resources

The Solubility Of Ca(OH)2 Is Measured And Found To Be 0.953 G/L. Use This Information To Calculate A

Understanding the solubility of calcium hydroxide, Ca(OH)2, is essential in various scientific and industrial contexts, from water treatment to construction materials. Recently, measurements have indicated that the solubility of Ca(OH)2 in water is approximately 0.953 grams per liter (G/L). This piece of data opens the door to a deeper exploration: how can this information be used to determine the solubility product constant, Ksp, a fundamental parameter in aqueous chemistry? This article delves into the methods and calculations involved, providing a comprehensive view of how solubility measurements translate into insights about chemical equilibria.

The Significance of Measuring Solubility

Solubility refers to the maximum amount of a substance that can dissolve in a solvent at a given temperature, forming a saturated solution. For ionic compounds like calcium hydroxide, solubility influences phenomena such as precipitation, corrosion, and biological processes. Accurate solubility data serve as a foundation for calculating equilibrium constants, designing chemical processes, and understanding environmental impacts.

In the case of Ca(OH)2, knowing its solubility allows chemists to determine its solubility product constant (Ksp), which quantifies the extent of its dissolution equilibrium:

$Ca(OH)_2(s) \rightleftharpoons Ca^{2+}(aq) + 2OH^-(aq)$

The value of Ksp is crucial because it indicates how much of the compound can dissolve before the solution becomes saturated and precipitation begins.

From Solubility to Ion Concentrations

The first step in leveraging solubility data to find Ksp involves translating the given solubility into molar concentrations of the ions produced upon dissolution.

Converting grams per liter to molarity

Given:
- Solubility of $Ca(OH)_2$ = 0.953 g/L
- Molar mass of $Ca(OH)_2$:

- Calcium (Ca): 40.08 g/mol
- Oxygen (O): 16.00 g/mol
- Hydrogen (H): 1.008 g/mol

Total molar mass:
40.08 + (2 × 16.00) + (2 × 1.008) = 74.096 g/mol

Calculating molar concentration:

$$ \text{Moles of Ca(OH)}_2 \text{ per liter} = \frac{0.953\, \text{g}}{74.096\, \text{g/mol}} \approx 0.01286\, \text{mol/L} $$

Determining ion concentrations in saturated solution

Since $Ca(OH)_2$ dissociates as:

$$ \text{Ca(OH)}_2 (s) \rightleftharpoons \text{Ca}^{2+} (aq) + 2 \text{OH}^- (aq) $$

- For every mole of $Ca(OH)_2$ that dissolves, 1 mole of Ca^{2+} ions and 2 moles of OH^- ions are produced.

Therefore:
- Concentration of Ca^{2+}:

$$[\text{Ca}^{2+}] = 0.01286\, \text{mol/L}$$

- Concentration of OH^-:

$$[\text{OH}^-] = 2 \times 0.01286\, \text{mol/L} \approx 0.02572\, \text{mol/L}$$

These ion concentrations form the basis for calculating the solubility product.

Calculating the Solubility Product Constant (Ksp)

The solubility product constant, Ksp, for $Ca(OH)_2$ is expressed as:

$$K_{sp} = [\text{Ca}^{2+}] \times [\text{OH}^-]^2$$

Substituting the ion concentrations:

$$K_{sp} = (0.01286) \times (0.02572)^2$$

Calculating:

$$(0.02572)^2 \approx 0.000662$$

$$K_{sp} \approx 0.01286 \times 0.000662 \approx 8.52 \times 10^{-6}$$

Thus, the solubility product constant for calcium hydroxide at this temperature is approximately 8.52×10^{-6}.

Implications and Applications of the Calculated Ksp

Understanding the Ksp of $Ca(OH)_2$ has practical implications across multiple fields:

- Water Treatment: $Ca(OH)_2$ is used to neutralize acidic waters. Knowledge of its solubility and Ksp helps optimize dosing to achieve desired pH levels without excessive precipitation.
- Construction Industry: Calcium hydroxide is a component of lime mortar and plasters. Its solubility influences setting times and durability.
- Environmental Chemistry: In natural waters, $Ca(OH)_2$ can influence hardness and alkalinity, affecting aquatic life and water quality.
- Chemical Manufacturing: Precise Ksp calculations guide processes involving precipitate control and removal.

Furthermore, the calculated Ksp provides insights into the temperature dependence of solubility. Typically, solubility and Ksp values vary with temperature, so these calculations are most accurate under controlled conditions.

Limitations and Considerations

While the calculation offers valuable insight, several factors can influence the accuracy:

- Temperature Effect: The given solubility is temperature-dependent; without specific temperature data, the Ksp is approximate.
- Purity of the Sample: Impurities or incomplete dissolution could skew measurements.
- Activity Coefficients: In dilute solutions, activities approximate concentrations, but at higher ionic strengths, activity coefficients become significant.
- Measurement Precision: Minor errors in weighing or volume measurement can impact the molar calculations.

It is also worth noting that the equilibrium assumption is valid only if the system has reached saturation and no other reactions interfere.

Conclusion: Bridging Measurement and Theory

The measured solubility of $Ca(OH)_2$ at 0.953 G/L enables chemists to calculate its solubility product constant, approximately 8.52×10^{-6}. This value not only enhances our understanding of calcium hydroxide's behavior in aqueous environments but also underpins practical applications across industries. Accurate solubility and Ksp data inform process optimization, environmental assessments, and material design. As research advances and measurement techniques improve, these fundamental constants will continue to serve as vital tools in unraveling the complex interactions within aqueous chemistry.

In essence, a simple measurement of solubility opens a window into the dynamic equilibrium of ionic compounds, illustrating the profound connection between experimental data and theoretical chemistry.

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