The Solubility Product Constant For Mg(OH)2 Is 1.2x10-11.a) What Is The Molar Solubility Of Mg(OH)2 In

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Understanding the solubility of ionic compounds is fundamental in chemistry, especially when dealing with reactions in aqueous solutions. Magnesium hydroxide, Mg(OH)2, is a sparingly soluble compound commonly encountered in various industrial and biological contexts. Its solubility plays a crucial role in applications like antacids, water treatment, and chemical manufacturing. The solubility product constant, or Ksp, provides valuable insight into the extent to which Mg(OH)2 dissolves in water.

In this article, we will explore what the solubility product constant (Ksp) signifies, specifically for Mg(OH)2, and how to calculate its molar solubility based on the given Ksp value of 1.2×10^{-11}. We will delve into the principles behind solubility equilibria, step-by-step calculations, and practical implications of these concepts.

Understanding Solubility and the Solubility Product Constant (Ksp)

What Is Solubility?

Solubility refers to the maximum amount of a substance that can dissolve in a solvent—typically water—at a specific temperature, to form a saturated solution. For ionic compounds like Mg(OH)2, solubility is often expressed in molarity (mol/L), indicating moles of compound dissolved per liter of solution.

What Is the Solubility Product Constant (Ksp)?

The solubility product constant, Ksp, is an equilibrium constant that measures the degree of solubility of a sparingly soluble salt in water. It is defined for the dissociation equilibrium of a salt into its constituent ions.

For Mg(OH)2, the dissociation in water can be represented as:

$Mg(OH)_2$ (s) ⇌ Mg^{2+} (aq) + $2OH^-$ (aq)

The Ksp expression is:

$Ksp = [Mg^{2+}][OH^-]^2$

Where:
- $[Mg^{2+}]$ is the molar concentration of magnesium ions
- $[OH^-]$ is the molar concentration of hydroxide ions

The smaller the Ksp value, the less soluble the compound, indicating that only a small amount dissolves in water.

Given Data and Objective

The problem provides the Ksp of Mg(OH)2 as:

$Ksp = 1.2 \times 10^{-11}$

Our goal is to determine the molar solubility of Mg(OH)2 in water, which is the molar concentration of dissolved Mg(OH)2 at saturation.

Deriving the Relationship Between Solubility and Ion Concentrations

Defining Molar Solubility (s)

Let’s define the molar solubility of Mg(OH)2 as s mol/L, representing the concentration of Mg(OH)2 that dissolves in water at equilibrium.

From the dissociation:

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

- The concentration of Mg^{2+} ions in solution will be s mol/L.
- The concentration of OH^- ions will be 2s mol/L because each formula unit produces two hydroxide ions.

Thus:

$[Mg^{2+}] = s$

$[OH^-] = 2s$

Calculating Molar Solubility

Expressing Ksp in Terms of s

Using the Ksp expression:

$Ksp = [Mg^{2+}][OH^-]^2$

Substituting the expressions for ion concentrations:

$Ksp = s \times (2s)^2 = s \times 4s^2 = 4s^3$

Therefore:

$4s^3 = 1.2 \times 10^{-11}$

Solving for s:

$s^3 = (1.2 \times 10^{-11}) / 4$

$s^3 = 3.0 \times 10^{-12}$

Taking the cube root:

$s = (3.0 \times 10^{-12})^{(1/3)}$

Performing the Cube Root Calculation

Calculating the cube root:

$s \approx (3.0)^{(1/3)} \times (10^{-12})^{(1/3)}$

Recall:

$(3.0)^{(1/3)} \approx 1.442$

and

$(10^{-12})^{(1/3)} = 10^{(-12/3)} = 10^{(-4)}$

Thus:

$s \approx 1.442 \times 10^{(-4)}$ mol/L

Final Result and Interpretation

The molar solubility of $Mg(OH)_2$ in water, given a Ksp of 1.2×10^{-11}, is approximately:

$s \approx 1.44 \times 10^{-4}$ mol/L

This means that at saturation, about 0.000144 moles of $Mg(OH)_2$ dissolve per liter of water under standard conditions.

Practical Implications of the Molar Solubility of $Mg(OH)_2$

Understanding the molar solubility of $Mg(OH)_2$ is essential in various fields:

- Medical Applications: $Mg(OH)_2$ is used as an antacid to neutralize stomach acid. Its low solubility ensures it acts locally without excessive systemic absorption.
- Water Treatment: Magnesium hydroxide can help precipitate impurities, and knowing its solubility helps in designing appropriate dosing.
- Environmental Chemistry: The solubility influences the mobility of magnesium in natural waters, affecting mineral formation and scaling.

Factors Affecting Solubility

Several factors can influence the solubility of $Mg(OH)_2$, including:

- pH of the Solution: Increasing acidity (lower pH) increases solubility by shifting equilibrium toward dissolution.
- Temperature: Typically, solubility varies with temperature; for $Mg(OH)_2$, higher temperatures can increase or decrease solubility depending on thermodynamic factors.
- Common Ion Effect: Presence of additional Mg^{2+} or OH^- ions in solution can suppress solubility due to Le Chatelier's principle.

Summary

- The solubility product constant (Ksp) quantifies the solubility of ionic compounds like $Mg(OH)_2$.
- Given Ksp = 1.2×10^{-11}, the molar solubility of $Mg(OH)_2$ is approximately 1.44×10^{-4} mol/L.
- The calculation involves expressing the dissolution equilibrium, defining molar solubility, and

solving for s.
- This information is vital for practical applications across medicine, environmental science, and industry.

Conclusion

The molar solubility of magnesium hydroxide, $Mg(OH)_2$, determined from its Ksp value, provides critical insight into how much of this compound can dissolve in water under standard conditions. With a low Ksp, $Mg(OH)_2$ is sparingly soluble, which aligns with its use in antacids and other applications where controlled solubility is essential. Understanding these fundamental principles allows chemists and engineers to optimize processes involving magnesium hydroxide and similar compounds, ensuring safety, efficiency, and environmental compatibility.

Keywords: $Mg(OH)_2$ solubility, Ksp of $Mg(OH)_2$, molar solubility calculation, solubility equilibrium, ionic compound solubility, magnesium hydroxide, aqueous solutions, solubility product constant, chemistry, solubility analysis

Frequently Asked Questions

What is the molar solubility of $Mg(OH)_2$ given its solubility product constant (Ksp) of 1.2×10^{-11}?

The molar solubility of $Mg(OH)_2$ is approximately 2.0×10^{-4} mol/L.

How do you calculate the molar solubility of $Mg(OH)_2$ using its Ksp value?

By setting up the solubility equilibrium expression, where $Ksp = [Mg^{2+}][OH^-]^2$, and solving for molar solubility (s), considering that $[Mg^{2+}] = s$ and $[OH^-] = 2s$, leading to $s = \sqrt{(Ksp/4)}$.

What is the significance of the solubility product constant (Ksp) for $Mg(OH)_2$?

Ksp indicates the maximum amount of $Mg(OH)_2$ that can dissolve in water at equilibrium; a smaller Ksp means lower solubility.

Can the molar solubility of $Mg(OH)_2$ be affected by pH or

common ions in solution?

Yes, the presence of common ions like OH^- can shift the equilibrium and decrease solubility due to the common ion effect.

If the solubility product constant for $Mg(OH)_2$ increases, what happens to its molar solubility?

An increase in Ksp would result in higher molar solubility, meaning more $Mg(OH)_2$ can dissolve in water.

Additional Resources

Understanding the Solubility Product Constant (Ksp) for $Mg(OH)_2$ and Its Molar Solubility

When exploring the realm of aqueous chemistry, one of the fundamental concepts that arises is solubility, particularly the solubility product constant, often symbolized as Ksp. Magnesium hydroxide, $Mg(OH)_2$, is a classic example used to illustrate principles of solubility equilibrium, ionic dissociation, and the mathematical relationship between solubility and Ksp. In this comprehensive review, we will delve into what the Ksp value signifies for $Mg(OH)_2$, how to interpret it, and how to determine its molar solubility from the given data.

What is the Solubility Product Constant (Ksp)?

Before focusing on $Mg(OH)_2$ specifically, it's essential to understand the concept of the solubility product constant.

Definition of Ksp

- Ksp is the equilibrium constant for the dissolution of a slightly soluble ionic compound in water.
- It quantifies the extent to which a compound dissolves to produce its constituent ions.
- For a generic salt AB_2(s), dissolving in water as:

$$
AB_2 (s) \leftrightarrow A^{2+} (aq) + 2 B^- (aq)
$$

the Ksp expression would be:

$$
K_{sp} = [A^{2+}][B^-]^2
$$

- The value of Ksp is temperature-dependent; higher values indicate higher solubility.

Significance of Ksp

- It helps predict whether a salt will precipitate or remain dissolved under certain conditions.
- When the ionic product exceeds Ksp, the solution is supersaturated, leading to precipitation.
- When it is less, the salt tends to remain undissolved.

Understanding the Ksp of $Mg(OH)_2$

The given value:

$$
K_{sp} = 1.2 \times 10^{-11}
$$

is specific to magnesium hydroxide at a particular temperature (commonly 25°C unless otherwise specified).

Dissociation of $Mg(OH)_2$

The dissolution of $Mg(OH)_2$ in water can be represented as:

$$
Mg(OH)_2 (s) \leftrightarrow Mg^{2+} (aq) + 2 OH^- (aq)
$$

The corresponding Ksp expression:

$$
K_{sp} = [Mg^{2+}] [OH^-]^2
$$

This equilibrium expression means that the molar concentrations of magnesium ions and hydroxide ions are directly related to the solubility of $Mg(OH)_2$.

Calculating Molar Solubility of $Mg(OH)_2$

Molar solubility refers to the number of moles of $Mg(OH)_2$ that dissolve in a liter of water to reach equilibrium.

Step-by-Step Approach

Given:

$$
K_{sp} = 1.2 \times 10^{-11}
$$

- Let s be the molar solubility of $Mg(OH)_2$, i.e., the molarity of $Mg(OH)_2$ that dissolves.

From the dissolution:

- $[Mg^{2+}] = s$
- $[OH^-] = 2s$

Because each mole of $Mg(OH)_2$ produces 2 moles of hydroxide ions, the hydroxide concentration is twice the molar solubility.

Deriving the Expression for Molar Solubility

Substituting into the Ksp expression:

$$
K_{sp} = [Mg^{2+}] [OH^-]^2 = s \times (2s)^2
$$

$$
K_{sp} = s \times 4s^2 = 4s^3
$$

Rearranged:

$$
s^3 = \frac{K_{sp}}{4}
$$

$$
s^3 = \frac{1.2 \times 10^{-11}}{4} = 3.0 \times 10^{-12}
$$

Now, find s:

$$
s = \sqrt[3]{3.0 \times 10^{-12}}
$$

Using cube root:

$$
s \approx \sqrt[3]{3.0} \times 10^{-\frac{12}{3}} = 1.44 \times 10^{-4}
$$

Thus, the molar solubility:

$$
\boxed{
s \approx 1.44 \times 10^{-4} \text{ mol/L}
}
$$

Interpretation of the Result

- Molar solubility of $Mg(OH)_2$: approximately 1.44×10^{-4} mol/L.
- This indicates that at equilibrium, about 0.000144 moles of $Mg(OH)_2$ dissolve per liter of water under standard conditions.

Implications and Additional Considerations

Understanding the molar solubility provides insights into how $Mg(OH)_2$ behaves in aqueous environments.

Precipitation and Saturation

- When the concentration of Mg^{2+} and OH^- in solution exceeds these calculated levels, $Mg(OH)_2$ will tend to precipitate out.
- This is relevant in natural waters, biological systems, and industrial processes where $Mg(OH)_2$ formation might be a concern or utilized.

pH and Solubility

- The solubility of $Mg(OH)_2$ is also affected by pH.
- In more basic solutions (higher hydroxide concentration), $Mg(OH)_2$ is less soluble, as the equilibrium shifts to form more solid.
- In acidic solutions, increased H^+ ions can react with OH^-, decreasing hydroxide concentration and shifting dissolution equilibrium to increase $Mg(OH)_2$ solubility.

Temperature Dependence

- The Ksp value is temperature-dependent.
- Typically, as temperature increases, solubility and Ksp values increase for most salts.
- For $Mg(OH)_2$, data at different temperatures can be used to determine how molar solubility varies

with temperature.

Practical Applications and Relevance

Understanding the solubility of $Mg(OH)_2$ has several practical implications across different fields:

Environmental Chemistry

- Magnesium hydroxide is used in water treatment to neutralize acidic waters.
- Knowledge of its molar solubility helps in designing effective neutralization systems.

Industrial Uses

- $Mg(OH)_2$ is used as a flame retardant, filler in plastics, and in pharmaceutical formulations.
- Control over its solubility ensures proper formulation and stability.

Biological Systems

- Magnesium plays vital roles in biological systems.
- Its hydroxide form's solubility influences biological availability and mineral deposition.

Summary and Final Thoughts

In summary, the solubility product constant (Ksp) serves as a crucial parameter in understanding the equilibrium between a solid ionic compound and its aqueous ions. For $Mg(OH)_2$, with a Ksp of 1.2×10^{-11}, the molar solubility in water at standard conditions is approximately 1.44×10^{-4} mol/L. This low solubility reflects $Mg(OH)_2$'s nature as a sparingly soluble salt, which readily precipitates out of solution when ionic concentrations exceed this equilibrium threshold.

This calculation underscores the importance of thermodynamic principles in predicting solubility behavior, essential for chemists working across environmental, industrial, and biological spheres. By mastering the relationship between Ksp and molar solubility, scientists and engineers can better anticipate how magnesium hydroxide interacts within complex systems, optimize processes, and develop effective applications.

In conclusion, the detailed exploration of $Mg(OH)_2$'s solubility highlights the interconnectedness of equilibrium constants, molar concentrations, and real-world applications—fundamental concepts that are central to advancing knowledge in chemistry and related sciences.

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