Rank The Species From Most To Least Soluble In Water. I. . Ba(NO3)2, Ksp = 4.64x10-3 II. . Ca(OH)2. Ksp

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Understanding the solubility of various compounds in water is fundamental in chemistry, especially in fields like environmental science, pharmaceuticals, and industrial processes. The solubility determines how much of a substance can dissolve in water at a given temperature, influencing reactions, solution stability, and material design. This article provides a comprehensive analysis of how to rank specific chemical species—Barium nitrate ($Ba(NO_3)_2$) and Calcium hydroxide ($Ca(OH)_2$)—from most to least soluble in water, based on their solubility product constants (Ksp). By examining their Ksp values and chemical properties, we will establish their relative solubility levels and explain the underlying principles governing their behavior in aqueous solutions.

Understanding Solubility and the Role of Ksp

What Is Solubility?

Solubility refers to the maximum amount of a substance that can dissolve in a solvent (water, in this case) at a specific temperature to form a saturated solution. It is typically expressed in grams per liter (g/L) or molarity (mol/L). The higher the solubility, the more of the compound can dissolve in water under equilibrium conditions.

What Is the Solubility Product Constant (Ksp)?

The Ksp is an equilibrium constant that measures the extent to which a salt dissolves in water. For a general salt AB that dissociates into A^+ and B^- ions:

$AB(s) \rightleftharpoons A^+(aq) + B^-(aq)$

The Ksp expression is:

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

The value of Ksp indicates the solubility of the salt:
- Larger Ksp values mean higher solubility.
- Smaller Ksp values suggest lower solubility.

Ksp is temperature-dependent; thus, the solubility comparison applies specifically at the same temperature.

Examining the Solubility of Ba(NO3)2 and Ca(OH)2

I. Barium Nitrate (Ba(NO3)2)

- Ksp = 4.64×10^{-3}
- Dissociation in water:

$Ba(NO_3)_2(s) \rightleftharpoons Ba^{2+}(aq) + 2\ NO_3^{-}(aq)$

- Implication:

Since each formula unit produces one Ba^{2+} ion and two NO_3^{-} ions, the solubility is directly related to the concentration of Ba^{2+} ions, with nitrate ions being abundant from other sources.

II. Calcium Hydroxide (Ca(OH)2)

- Ksp value (not provided explicitly, but known to be approximately 4.7×10^{-6} at 25°C)
- Dissociation in water:

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

- Implication:

The solubility involves calcium ions and hydroxide ions, with the hydroxide's basic nature influencing solubility behavior.

Calculating and Comparing Solubilities Using Ksp

Step 1: Express the Dissolution Equilibria

For Ba(NO3)2:

- Let s be the molar solubility (mol/L) of Ba(NO3)2.
- Dissociation:

$Ba(NO_3)_2(s) \rightleftharpoons Ba^{2+}(aq) + 2\ NO_3^{-}(aq)$

- Concentrations at equilibrium:

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

$[NO_3^{-}] = 2s$

- Ksp expression:

$K_{sp} = [Ba^{2+}][NO_3^{-}]^2 = s \times (2s)^2 = 4s^3$

- Solving for s:

$s = (K_{sp} / 4)^{(1/3)}$

For Ca(OH)2:

- Let s be the molar solubility (mol/L) of Ca(OH)2.

- Dissociation:

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

- Concentrations:

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

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

- Ksp expression:

$Ksp = [Ca^{2+}][OH^{-}]^2 = s \times (2s)^2 = 4s^3$

- Solving for s:

s = (Ksp / 4)^(1/3)

Step 2: Calculate the Solubility Values

Given:

- For Ba(NO3)2: $Ksp = 4.64 \times 10^{-3}$

- For Ca(OH)2: $Ksp \approx 4.7 \times 10^{-6}$

Calculations:

- Ba(NO3)2:

s_Ba = $(4.64 \times 10^{-3} / 4)$^(1/3) = (1.16×10^{-3})^(1/3)

s_Ba ≈ 0.097 mol/L

- Ca(OH)2:

s_Ca = $(4.7 \times 10^{-6} / 4)$^(1/3) = (1.175×10^{-6})^(1/3)

s_Ca ≈ 0.0104 mol/L

Ranking the Solubility of Ba(NO3)2 and Ca(OH)2

Based on the calculated molar solubilities:

1. Ba(NO3)2 with approximately 0.097 mol/L
2. Ca(OH)2 with approximately 0.0104 mol/L

Thus, Ba(NO3)2 is significantly more soluble in water than Ca(OH)2.

Final Ranking:

1. Most soluble: Ba(NO3)2
2. Less soluble: Ca(OH)2

Factors Influencing Solubility Beyond Ksp

Although Ksp provides a quantitative measure of solubility, other factors can influence how well a compound dissolves:

- Temperature: As temperature increases, solubility generally increases for most salts, but exceptions exist.
- Ionic lattice energy: Higher lattice energy reduces solubility.
- Hydration energy: Stronger interactions between ions and water molecules promote solubility.
- Common ion effect: Presence of similar ions in solution can suppress solubility.

In the case of Ba(NO3)2 and Ca(OH)2, their differing chemical natures and ionic interactions account for the variation in solubility.

Practical Applications of Solubility Rankings

Understanding the solubility hierarchy of compounds like Ba(NO3)2 and Ca(OH)2 has practical implications:

- Industrial processes: Selecting the appropriate salt based on solubility for applications like water treatment or manufacturing.
- Environmental science: Predicting pollutant behavior and mobility in water systems.
- Pharmaceuticals: Formulating solutions with desired dissolution properties.
- Chemical synthesis: Controlling precipitation reactions and crystal formation.

Conclusion

In summary, by analyzing the Ksp values and applying the principles of chemical equilibria, we have established that Barium nitrate (Ba(NO3)2) is more soluble in water than Calcium hydroxide (Ca(OH)2). The calculated molar solubilities reinforce this ranking, with Ba(NO3)2 exhibiting roughly ten times greater solubility at room temperature. This understanding allows chemists and engineers to predict and manipulate solution behaviors effectively, optimizing processes across various scientific and industrial domains.

References

- Atkins, P., & de Paula, J. (2010). Physical Chemistry (9th ed.). Oxford University Press.
- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Lide, D. R. (Ed.). (2004). CRC Handbook of Chemistry and Physics (85th ed.). CRC Press.
- NIST Chemistry WebBook. (2023). Solubility Data. National Institute of Standards and Technology.

Frequently Asked Questions

Which compound is more soluble in water: $Ba(NO_3)_2$ or $Ca(OH)_2$?

$Ba(NO_3)_2$ is more soluble in water than $Ca(OH)_2$ because it has a higher solubility product constant (Ksp).

Given Ksp values, how do you rank $Ba(NO_3)_2$ and $Ca(OH)_2$ from most to least soluble in water?

Since only $Ba(NO_3)_2$'s Ksp is provided (4.64×10^{-3}) and $Ca(OH)_2$'s Ksp is missing, the compound with the higher Ksp value is more soluble; therefore, if $Ca(OH)_2$'s Ksp is less than 4.64×10^{-3}, $Ba(NO_3)_2$ is more soluble, otherwise, the order depends on the actual Ksp of $Ca(OH)_2$.

What is the significance of the Ksp value in ranking the solubility of these compounds?

The Ksp value indicates the solubility of a compound in water; a higher Ksp means greater solubility, allowing us to rank compounds accordingly.

If the Ksp of $Ca(OH)_2$ is 5.5×10^{-6}, how does it compare to $Ba(NO_3)_2$?

$Ba(NO_3)_2$ with $K_{sp} = 4.64\times10^{-3}$ is significantly more soluble than $Ca(OH)_2$ with $K_{sp} = 5.5\times10^{-6}$.

What factors influence the solubility of $Ba(NO_3)_2$ and $Ca(OH)_2$ in water?

Factors include the compound's lattice energy, ion interactions, temperature, and the Ksp value, which directly relates to solubility.

How does temperature affect the solubility of $Ba(NO_3)_2$ and $Ca(OH)_2$?

Typically, increasing temperature increases solubility for most salts; specific effects depend on their enthalpy of dissolution.

Can you determine the solubility of $Ba(NO_3)_2$ from its Ksp value?

Yes, using the Ksp value and the stoichiometry of the dissociation, you can calculate the molar solubility of $Ba(NO_3)_2$.

Why is it important to compare Ksp values when analyzing solubility?

Comparing Ksp values allows us to quantitatively assess which compound is more soluble in water under the same conditions.

What is the typical solubility order of these compounds based on their Ksp values?

Assuming $Ca(OH)_2$ has a lower Ksp than $Ba(NO_3)_2$, the order from most to least soluble would be $Ba(NO_3)_2 > Ca(OH)_2$.

How would you experimentally determine the solubility of Ca(OH)2 if its Ksp is unknown?

You could dissolve an excess amount of Ca(OH)2 in water, measure the concentration of calcium and hydroxide ions at equilibrium, and calculate the solubility from the ion concentrations.

Additional Resources

Rank The Species From Most To Least Soluble In Water is a fundamental question in chemistry that invites us to explore the solubility behaviors of different ionic compounds. When comparing substances like barium nitrate ($Ba(NO_3)_2$) and calcium hydroxide ($Ca(OH)_2$), understanding their solubility involves delving into their solubility product constants (Ksp) and the nature of their ionic bonds. This guide aims to provide a comprehensive analysis, helping you rank these species from most soluble to least soluble in water, supported by relevant calculations, theoretical insights, and practical implications.

Understanding Solubility and Ksp

Before diving into the specific compounds, it's essential to grasp the fundamentals of solubility and the role of 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 given temperature to form a saturated solution. It's usually expressed in grams per liter (g/L), molarity (mol/L), or molar solubility (the number of moles of solute per liter of solution).

What Is Ksp?

The solubility product constant (Ksp) quantifies the equilibrium between a solid ionic compound and its ions in solution:

\[\text{AB}_n (s) \leftrightarrow nA^{m+} (aq) + mB^{n-} (aq) \]

For salts, Ksp provides a measure of how much the compound dissolves. A higher Ksp indicates greater solubility, while a lower Ksp suggests limited solubility.

The Compounds Under Comparison

In this analysis, we focus on:

- Barium Nitrate ($Ba(NO_3)_2$):
- Ksp = 4.64×10^{-3}
- An ionic compound with barium cations and nitrate anions.

- Calcium Hydroxide ($Ca(OH)_2$):
- Ksp value not provided here, but typically around 5.5×10^{-6} at 25°C.
- An ionic compound with calcium cations and hydroxide anions.

Step-by-Step Analysis of Solubility

1. Analyzing Barium Nitrate ($Ba(NO_3)_2$)

Dissolution Equation:

$$
\text{Ba(NO}_3)_2 (s) \leftrightarrow \text{Ba}^{2+} (aq) + 2 \text{NO}_3^- (aq)
$$

Expression for Ksp:

$$
K_{sp} = [\text{Ba}^{2+}][\text{NO}_3^-]^2
$$

If we let the molar solubility of $Ba(NO_3)_2$ be s (mol/L), then:

$$
[\text{Ba}^{2+}] = s
$$

and

$$
[\text{NO}_3^-] = 2s
$$

Calculating Solubility in Molarity:

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

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

$$
s^3 = \frac{4.64 \times 10^{-3}}{4} = 1.16 \times 10^{-3}
$$

$$
s = \sqrt[3]{1.16 \times 10^{-3}} \approx 0.105\, \text{mol/L}
$$

Interpretation:

- Molar solubility of $Ba(NO_3)_2$ ≈ 0.105 mol/L.

- Mass solubility:
Molar mass of $Ba(NO_3)_2$ ≈ 137.33 (Ba) + 2×62.00 (NO_3) ≈ 261.33 g/mol.

$$
\text{Mass solubility} = 0.105\, \text{mol/L} \times 261.33\, \text{g/mol} \approx 27.45\, \text{g/L}
$$

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2. Analyzing Calcium Hydroxide ($Ca(OH)_2$)

Dissolution Equation:

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

Expression for Ksp:

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

Let the molar solubility be s (mol/L). Then:

$$
[\text{Ca}^{2+}] = s
$$
$$
[\text{OH}^-] = 2s
$$

Calculating Solubility:

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

Assuming K_{sp} for $Ca(OH)_2$ is approximately 5.5×10^{-6}:

$$
s^3 = \frac{K_{sp}}{4} = \frac{5.5 \times 10^{-6}}{4} = 1.375 \times 10^{-6}
$$

$$
s = \sqrt[3]{1.375 \times 10^{-6}} \approx 0.0118\, \text{mol/L}
$$

Mass solubility:

- Molar mass of $Ca(OH)_2$ ≈ 40.08 (Ca) + 2×16.00 (OH) ≈ 72.08 g/mol.

$$
\text{Mass solubility} = 0.0118\, \text{mol/L} \times 72.08\, \text{g/mol} \approx 0.85\, \text{g/L}
$$

Comparing Solubilities: From Most to Least

Based on the molar and mass solubility calculations:

Species	Molar Solubility (mol/L)	Mass Solubility (g/L)	Relative Solubility
$Ba(NO_3)_2$	0.105	27.45 g/L	Most soluble
$Ca(OH)_2$	0.0118	0.85 g/L	Least soluble

Therefore, the ranking from most to least soluble in water is:

1. Barium nitrate ($Ba(NO_3)_2$)
2. Calcium hydroxide ($Ca(OH)_2$)

Key Factors Influencing Solubility

1. Nature of Ionic Bonds and Lattice Energy

- Barium nitrate, with its relatively high Ksp, indicates weaker lattice energy, allowing it to dissolve more readily.
- Calcium hydroxide has a lower Ksp, implying a stronger lattice energy or less favorable dissolution under standard conditions.

2. Ion-Dipole Interactions

- The nitrate ion (NO_3^-) is highly soluble and stabilizes the dissociated ions.
- Hydroxide ions (OH^-) tend to form strong hydrogen bonds, which can limit solubility.

3. Temperature Dependence

- Both Ksp values are temperature-dependent; typically, increasing temperature increases solubility for endothermic dissolution processes.

Practical Implications

Understanding the solubility ranking is crucial in various applications:

- Industrial processes: Barium nitrate is used in pyrotechnics and manufacturing, where high solubility facilitates its handling.
- Environmental considerations: Calcium hydroxide is used in water treatment; its low solubility limits its dissolution rate but provides effective pH adjustment.

Summary and Final Thoughts

By analyzing the Ksp values and performing molar solubility calculations, we can confidently rank barium nitrate ($Ba(NO_3)_2$) as more soluble than calcium hydroxide ($Ca(OH)_2$) in water at room temperature. Although both are ionic compounds, their differing lattice energies and ion interactions significantly influence their solubility behaviors.

Final ranking:

Most soluble: $Ba(NO_3)_2$
Less soluble: $Ca(OH)_2$

Understanding these differences helps chemists predict how substances behave in aqueous environments, design chemical processes, and interpret experimental data effectively.

Additional Resources

- Tables of Ksp values for common salts.
- Solubility rules for ionic compounds.
- Laboratory techniques for measuring solubility.

This comprehensive guide illustrates how to evaluate and compare the solubility of ionic compounds using theoretical principles and practical calculations, empowering you to analyze similar systems with confidence.

Rank The Species From Most To Least Soluble In Water I Ba No3 2 Ksp 4 64x10 3 Ii Ca Oh 2 Ksp

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