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Understanding the solubility product constant (Ksp) is fundamental in chemistry, especially when analyzing the solubility of ionic compounds such as zinc sulfide (ZnS). The molar solubility of ZnS in pure water is given as 1.6 × 10-12 M. Based on this information, we can accurately calculate the solubility product constant (Ksp) for ZnS. This article will guide you through the step-by-step process of understanding, deriving, and calculating the Ksp for ZnS, including important concepts, formulas, and relevant details to deepen your grasp of solubility equilibria.

Understanding the Basics of Solubility and Ksp

What is Molar Solubility?

Molar solubility refers to the maximum amount of a substance (in molarity, mol/L) that can dissolve in a solvent at a specific temperature to form a saturated solution. For ZnS, a molar solubility of 1.6 × 10-12 M indicates an extremely low solubility, characteristic of sparingly soluble salts.

What is the Solubility Product Constant (Ksp)?

Ksp is an equilibrium constant that expresses the extent to which a salt dissolves in water. It applies to the dissolution equilibrium:

$$ \text{ZnS (s)} \leftrightarrow \text{Zn}^{2+} (aq) + \text{S}^{2-} (aq) $$

The Ksp expression is:

$$ K_{sp} = [\text{Zn}^{2+}] \times [\text{S}^{2-}] $$

where the brackets denote molar concentrations at equilibrium.

Deriving the Ksp for ZnS from Molar Solubility

Step 1: Write the Dissolution Equation

The dissolution reaction of zinc sulfide is:

$$ \text{ZnS (s)} \leftrightarrow \text{Zn}^{2+} (aq) + \text{S}^{2-} (aq) $$

Since the solid phase (ZnS) is not included in the Ksp expression, the solubility (s) directly relates to the ions produced:

- $[Zn^{2+}] = s$
- $[S^{2-}] = s$

Step 2: Express the Ionic Concentrations

Given the molar solubility $s = 1.6 \times 10^{-12}$ M, then:

- $[\text{Zn}^{2+}] = 1.6 \times 10^{-12}$ M
- $[\text{S}^{2-}] = 1.6 \times 10^{-12}$ M

Step 3: Write the Ksp Expression

Substituting the concentrations into the Ksp formula:

$$ K_{sp} = [\text{Zn}^{2+}] \times [\text{S}^{2-}] $$

$$ K_{sp} = (1.6 \times 10^{-12}) \times (1.6 \times 10^{-12}) $$

Step 4: Calculate Ksp

Perform the multiplication:

$$ K_{sp} = (1.6)^2 \times 10^{-12} \times 10^{-12} $$

$$ K_{sp} = 2.56 \times 10^{-24} $$

Thus, the calculated Ksp for ZnS is:

$$ \boxed{K_{sp} = 2.56 \times 10^{-24}} $$

Interpreting the Results and Comparing Options

The options provided in the problem are:

- 8.0 × 10-13
- 6.8 × 10-51
- 1.6

Given our calculation of 2.56×10^{-24}, none of these options perfectly match. However, some options are significantly off, indicating that perhaps the question wants you to recognize the order of magnitude or that there might be a typo or misprint.

Key Takeaways:
- The calculated Ksp for ZnS with molar solubility 1.6×10^{-12} M is approximately 2.56×10^{-24}.
- The options listed (8.0 × 10-13, 6.8 × 10-51, 1.6) are either orders of magnitude different or not relevant based on the calculation.

Factors Affecting the Solubility of ZnS

While the calculation above provides the theoretical Ksp value at a specific temperature, real-world solubility can be influenced by various factors:

Temperature

Most salts have temperature-dependent solubility. Generally, increasing temperature increases solubility, but some salts are exceptions.

pH of the Solution

In some cases, pH can influence the solubility of sulfides due to complex formation or precipitation.

Common Ion Effect

The presence of common ions in the solution can suppress or enhance solubility, impacting the apparent solubility and Ksp.

Applications and Significance of Ksp of ZnS

Understanding the Ksp of ZnS is crucial in various scientific and industrial contexts, including:

- Predicting the solubility of ZnS in natural waters, which affects environmental assessments.
- Designing processes for mineral extraction and purification involving zinc sulfide ores.
- Controlling precipitation reactions in chemical manufacturing.
- Studying the behavior of ZnS in semiconductor applications.

Conclusion: Summary of Calculations and Insights

In summary, the molar solubility of ZnS in pure water being 1.6 × 10-12 M allows us to calculate the solubility product constant (Ksp) as approximately 2.56 × 10-24. This value indicates an extremely low solubility, consistent with the properties of sparingly soluble salts like ZnS.

Understanding the relationship between molar solubility and Ksp is essential for predicting solubility behavior, designing chemical processes, and managing environmental impacts. When analyzing solubility data, it’s important to pay attention to the magnitude of Ksp and the conditions affecting solubility to make accurate predictions and informed decisions.

References:

- Zumdahl, S. S., & Zumdahl, S. A. (2014). Chemistry: An Atoms First Approach. Cengage Learning.
- Atkins, P., & de Paula, J. (2010). Physical Chemistry. Oxford University Press.
- Lide, D. R. (2004). CRC Handbook of Chemistry and Physics. CRC Press.

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Frequently Asked Questions

What is the molar solubility of ZnS in pure water?

The molar solubility of ZnS in pure water is 1.6×10^{-12} M.

How do you calculate the solubility product constant (Ksp) from molar solubility?

Ksp is calculated by expressing the solubility equilibrium and substituting the molar solubility values into the expression. For ZnS, Ksp = $[Zn^{2+}][S^{2-}]$, where each ion’s concentration equals the molar solubility.

What is the Ksp of ZnS given its molar solubility?

Given molar solubility of 1.6×10^{-12} M, Ksp = $(1.6 \times 10^{-12}) \times (1.6 \times 10^{-12}) = 2.56 \times 10^{-24}$.

Why is the molar solubility of ZnS so low in water?

ZnS has a very low molar solubility due to its low Ksp value, indicating it is poorly soluble in water because the ionic bonds are strong and the lattice energy is high.

How does the Ksp value relate to the solubility of ZnS?

A smaller Ksp value indicates lower solubility. For ZnS, the very low Ksp reflects its minimal solubility in water.

If the molar solubility of ZnS were to increase, what would happen to its Ksp?

The Ksp would increase proportionally since Ksp is based on the product of ion concentrations at equilibrium.

What is the significance of knowing the Ksp of ZnS?

Knowing the Ksp helps predict whether ZnS will precipitate or dissolve under certain conditions, which is important in fields like mineralogy, environmental science, and materials engineering.

Are the provided options 8.0×10^{-13}, 6.8×10^{-51}, or 1.6 the correct Ksp for ZnS?

The correct Ksp for ZnS, based on the molar solubility of 1.6×10^{-12} M, is approximately 2.56×10^{-24}, which is not listed among the options. Therefore, none of the options precisely match the calculated value.

Additional Resources

Understanding the Molar Solubility of Zinc Sulfide (ZnS) and Calculating Its Solubility Product (Ksp)

Introduction to Solubility and Its Significance in Chemistry

Solubility is a fundamental concept in chemistry, describing how much of a substance (solute) can dissolve in a solvent (usually water) to form a saturated solution at a specific temperature. It plays a crucial role in various fields, including environmental science, pharmaceuticals, metallurgy, and analytical chemistry. Among the key parameters to quantify solubility is the solubility product constant, denoted as Ksp, which provides a measure of the equilibrium between the solid and dissolved ions in a saturated solution.

Understanding the molar solubility of salts like zinc sulfide (ZnS) is vital because it informs us about their stability, potential for precipitation, and behavior in aqueous environments. In this context, we will analyze the given data: the molar solubility of ZnS in pure water, and use it to determine the Ksp, a critical parameter reflecting the salt's solubility equilibrium.

Fundamentals of Zinc Sulfide (ZnS) Dissolution

Chemical Dissociation Equation

When zinc sulfide dissolves in water, it dissociates into zinc and sulfide ions:

$$\mathrm{ZnS (s)} \leftrightarrow \mathrm{Zn^{2+} (aq)} + \mathrm{S^{2-} (aq)}$$

The extent of this dissociation depends on the ionic interactions, lattice energy, and solvation effects. The equilibrium constant for this process, Ksp, quantifies the level of ionization at saturation:

$$ K_{sp} = [\mathrm{Zn^{2+}}][\mathrm{S^{2-}}] $$

Given Data and Its Interpretation

The problem provides the molar solubility (S) of ZnS as:

- $S = 1.6 \times 10^{-12} \, \mathrm{M}$

This molar solubility indicates the molar concentration of ZnS that dissolves in pure water to achieve a saturated solution at the specified conditions.

Additionally, the multiple-choice options for the Ksp calculation are:

- 8.0×10^{-13}
- 6.8×10^{-15}
- 1.6

Our goal is to compute the Ksp based on the given molar solubility.

Calculating the Ksp of ZnS

Step 1: Understanding the Dissociation Equilibrium

Since ZnS dissolves according to:

$$ \mathrm{ZnS (s)} \leftrightarrow \mathrm{Zn^{2+} (aq)} + \mathrm{S^{2-} (aq)} $$

and assuming complete dissociation of the solid to produce ions in solution, the molar concentrations of the ions at equilibrium are equal to the molar solubility:

$$ [\mathrm{Zn^{2+}}] = S $$
$$ [\mathrm{S^{2-}}] = S $$

This is because for every mole of ZnS that dissolves, one mole of Zn^{2+} and one mole of S^{2-} are produced.

Step 2: Applying the Ksp Expression

The solubility product constant is given by:

$$ K_{sp} = [\mathrm{Zn^{2+}}][\mathrm{S^{2-}}] $$

Substituting the molar solubility:

$$ K_{sp} = S \times S = S^2 $$

Step 3: Plugging in the Values

Calculate K_{sp}:

$$ K_{sp} = (1.6 \times 10^{-12})^2 $$
$$ K_{sp} = (1.6)^2 \times (10^{-12})^2 $$
$$ K_{sp} = 2.56 \times 10^{-24} $$

This is a very small value, indicating that ZnS is extremely insoluble in water.

Comparison with Multiple-Choice Options and Final Result

The options provided are:

- 8.0×10^{-13}
- 6.8×10^{-15}
- 1.6

Our calculated value, 2.56×10^{-24}, does not match any of these options directly. This discrepancy suggests that perhaps the molar solubility value given might be a typo or requires reevaluation. Alternatively, the options might be based on different assumptions or approximations.

Possible explanations:

- The molar solubility might have been intended as 1.6×10^{-6} M, which would yield a different Ksp.
- Or, perhaps, the options are approximate or rounded values derived from different interpretations.

Let’s verify with an alternative molar solubility:

Suppose the molar solubility is:

$$ S = 8.0 \times 10^{-13} \, \mathrm{M} $$

then,

$$ K_{sp} = (8.0 \times 10^{-13})^2 = 64 \times 10^{-26} = 6.4 \times 10^{-25} $$

which is still much lower.

Alternatively, with $ S = 6.8 \times 10^{-15} $:

$$ K_{sp} = (6.8 \times 10^{-15})^2 = 46.24 \times 10^{-30} \approx 4.6 \times 10^{-29} $$

Again, not matching the options.

Deep Dive: Factors Affecting Solubility and Ksp

While the calculations above are straightforward, understanding the broader context enriches our comprehension.

1. Ionic Lattice Energy and Solvation

- The lattice energy of ZnS is high because of the strong electrostatic attraction between Zn^{2+} and S^{2-} ions.
- High lattice energy correlates with low solubility.
- Water molecules hydrate ions, stabilizing them in solution, but this stabilization isn't sufficient to overcome the lattice energy significantly, resulting in very low molar solubility.

2. Temperature Dependence

- The solubility of salts like ZnS is temperature-dependent.
- Typically, for most salts, solubility increases with temperature, but specific data for ZnS at various temperatures would refine Ksp calculations.

3. Effect of Ionic Strength

- The presence of other ions can influence the solubility via common ion effects.
- Pure water minimizes such effects, making the molar solubility measurement more straightforward for Ksp calculation.

4. Practical Implications of Low Solubility

- ZnS's extremely low solubility makes it useful in applications like phosphors, semiconductors, and as a pigment.
- Its insolubility ensures stability in various environments but also complicates certain processing steps requiring dissolution.

Alternative Approaches to Determine Ksp

If the molar solubility data seems inconsistent or possibly misprinted, alternative methods include:

- Experimental Measurement: Directly measuring ion concentrations in saturated solutions.
- Literature Data: Consulting standard reference tables for ZnS solubility and Ksp at specific temperatures.
- Theoretical Estimation: Using lattice energy and hydration energy calculations (Born-Haber cycle) to estimate Ksp.

Summary and Key Takeaways

- The molar solubility of ZnS in pure water is given as 1.6×10^{-12} M.
- The solubility product, K_{sp}, can be calculated straightforwardly as S^2, resulting in approximately 2.56×10^{-24}.
- This extremely low Ksp value confirms the poor solubility of ZnS, aligning with its practical uses and chemical behavior.
- Discrepancies between the calculated Ksp and multiple-choice options highlight the importance of accurate data and the potential for typographical errors in problem statements.

Final Remarks

Understanding the molar solubility and Ksp of compounds like ZnS is fundamental in inorganic chemistry, impacting material science, environmental chemistry, and industrial processes. Accurate calculations demand attention to detail, proper interpretation of data, and awareness of the factors influencing solubility. This exercise exemplifies how theoretical principles translate into practical parameters, enhancing our comprehension of solubility equilibria and their applications.

Note: Always verify data and assumptions when performing such calculations, especially when the results do not align with provided options.

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