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Solubility Product Constant (Ksp) of BiI_3

Step 1: Write the Dissociation Equation

$$ \text{BiI}_3 \rightarrow \text{Bi}^{3+} + 3\text{I}^- $$

Bismuth iodide (BiI_3) dissociates in water to produce one bismuth ion (Bi^{3+}) and three iodide ions (I^-).

Step 2: Convert Solubility to Moles per Liter (Molarity)

$$ \text{Molar Mass of BiI}_3 = 209.0 \text{ g/mol (Bi)} + 3 \times 126.9 \text{ g/mol (I)} = 589.7 \text{ g/mol} $$
$$ \text{Solubility in mol/L} = \frac{7.7 \times 10^{-3} \text{ g/L}}{589.7 \text{ g/mol}} = 1.31 \times 10^{-5} \text{ mol/L} $$

First, find the molar mass of BiI_3 and then use it to convert the given solubility from grams per liter to moles per liter.

Step 3: Determine Ion Concentrations

$$ [\text{Bi}^{3+}] = 1.31 \times 10^{-5} \text{ M} $$
$$ [\text{I}^-] = 3 \times 1.31 \times 10^{-5} = 3.93 \times 10^{-5} \text{ M} $$

Using the stoichiometry from the dissociation equation, determine the concentrations of ions produced from the dissociation of BiI_3.

Step 4: Write the Expression for Ksp

$$ K_{sp} = [\text{Bi}^{3+}][\text{I}^-]^3 $$

The solubility product expression for BiI_3 involves the concentrations of Bi^{3+} and I^- ions, raised to the power of their stoichiometric coefficients.

Step 5: Substitute Ion Concentrations into Ksp Expression

$$ K_{sp} = (1.31 \times 10^{-5}) (3.93 \times 10^{-5})^3 $$
$$ K_{sp} = 1.31 \times 10^{-5} \times (6.08 \times 10^{-14}) $$
$$ K_{sp} = 7.96 \times 10^{-19} $$

By substituting the ion concentrations into the Ksp expression, the solubility product constant for BiI_3 is calculated.

Final Answer

$$ K_{sp} = 7.96 \times 10^{-19} $$

The calculated Ksp value indicates the very low solubility of BiI_3 in water, consistent with the given solubility data.

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