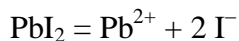


**Problem 10-07 Conductivity, molar conductivity of sparingly soluble salts**

The conductivity of saturated lead iodide solution at the temperature of 18 °C was found to be  $3.742 \cdot 10^{-2} \text{ S m}^{-1}$ , the conductivity of the water used for conductivity measurements was  $1.8 \cdot 10^{-4} \text{ S m}^{-1}$ . Calculate the solubility product of  $\text{PbI}_2$  for the standard state of infinite dilution,  $c^{\text{st}} = 1 \text{ mol dm}^{-3}$ . You can assume that activities can be replaced by relative concentrations. Limiting molar conductivities of ions are  $\lambda^\infty (\text{Pb}^{2+}) = 0.0139 \text{ S m}^2 \text{ mol}^{-1}$ ,  $\lambda^\infty (\text{I}^-) = 0.00769 \text{ S m}^2 \text{ mol}^{-1}$ .

$$[K_s (\text{PbI}_2) = 8.23 \cdot 10^{-9}]$$

Solution:



$$c_{\text{PbI}_2} = 2 c_{\text{I}^-} = c_{\text{Pb}^{2+}}$$

$$c^{\text{st}} = 1 \text{ mol dm}^{-3}; \quad \gamma_{\pm} = 1$$

$$K_s = a_{\text{Pb}^{2+}} \cdot a_{\text{I}^-}^2 = \gamma_+ \cdot \frac{c_{\text{Pb}^{2+}}}{c^{\text{st}}} \cdot \left( \gamma_- \cdot \frac{c_{\text{I}^-}}{c^{\text{st}}} \right)^2 = \gamma_{\pm}^3 \cdot 4 \cdot c_{\text{PbI}_2}^3$$

Calculation of the concentration of the saturated solution:

$$\kappa_{\text{solution}} = 4.32 \cdot 10^{-2} \text{ S m}^{-1},$$

$$\kappa_{\text{water}} = 1.8 \cdot 10^{-4} \text{ S m}^{-1}$$

$$\kappa_{\text{PbI}_2} = \kappa_{\text{solution}} - \kappa_{\text{water}} = 3.742 \cdot 10^{-2} - 1.8 \cdot 10^{-4} = 3.724 \cdot 10^{-2} \text{ S m}^{-1}$$

$$\lambda^\infty (\text{Pb}^{2+}) = 0.0139 \text{ S m}^2 \text{ mol}^{-1}$$

$$\lambda^\infty (\text{I}^-) = 0.00769 \text{ S m}^2 \text{ mol}^{-1}$$

$$\lambda_{\text{PbI}_2}^\infty = \lambda_{\text{Pb}^{2+}}^\infty + 2 \lambda_{\text{I}^-}^\infty = 0.0139 + 2 \cdot 0.00769 = 0.02928 \text{ S m}^2 \text{ mol}^{-1}$$

$$\lambda_{\text{PbI}_2} \doteq \lambda_{\text{PbI}_2}^\infty = \frac{\kappa_{\text{PbI}_2}}{c_{\text{PbI}_2}} \Rightarrow c_{\text{PbI}_2} = \frac{\kappa_{\text{PbI}_2}}{\lambda_{\text{PbI}_2}^\infty} = \frac{0.03724}{0.02928} = 1.27186 \text{ mol m}^{-3} \\ = 1.27186 \cdot 10^{-3} \text{ mol dm}^{-3}$$

Solubility product:

$$K_s = 4 \cdot (1.27186 \cdot 10^{-3})^3 = 8.23 \cdot 10^{-9}$$