

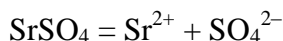
Problem 10-08 Conductivity, molar conductivity of sparingly soluble salts

The resistance of the conductivity cell filled with KCl solution (molality 0.02 mol kg^{-1}) at 25°C is 197Ω . This solution has the conductivity of 0.2765 S m^{-1} . The resistance of the same cell filled with saturated solution of strontium sulphate was 3663Ω . The conductivity of water used to these measurements was $1.8 \cdot 10^{-4} \text{ S m}^{-1}$. Use these data to determination the solubility product of strontium sulphate (standard state infinite dilution, $c^{\text{st}} = 1 \text{ mol dm}^{-3}$) under the assumption that the activities can be replaced by relative concentrations. Limiting molar conductivities of ions are:

$$\lambda_{\text{Sr}^{2+}}^{\infty} = 0.0119 \text{ S m}^2 \text{ mol}^{-1}; \quad \lambda_{\text{SO}_4^{2-}}^{\infty} = 0.01596 \text{ S m}^2 \text{ mol}^{-1}$$

$$[K_s = 2.78 \cdot 10^{-7}]$$

Solution:



$$c_{\text{SrSO}_4} = c_{\text{SO}_4^{2-}} = c_{\text{Sr}^{2+}}$$

$$K_s = a_{\text{Sr}^{2+}} \cdot a_{\text{SO}_4^{2-}} = \gamma_+ \cdot \frac{c_{\text{Sr}^{2+}}}{c^{\text{st}}} \cdot (\gamma_- \cdot \frac{c_{\text{SO}_4^{2-}}}{c^{\text{st}}}) = \gamma_{\pm}^2 \cdot c_{\text{SrSO}_4}^2 \quad ; \quad \gamma_{\pm} = 1$$

Calculation of the concentration of saturated SrSO_4 solution from the conductivity:

$$R_{\text{KCl}} = 197 \Omega \quad , \quad \kappa_{\text{KCl}} = 0.2765 \text{ S m}^{-1}$$

$$R = 3663 \Omega$$

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

$$\kappa_{\text{solution}} \cdot R = \kappa_{\text{KCl}} \cdot R_{\text{KCl}}$$

$$\kappa_{\text{solution}} = \frac{197 \cdot 0.2765}{3663} = 0.0148705 \text{ S m}^{-1}$$

$$\kappa_{\text{SrSO}_4} = \kappa_{\text{solution}} - \kappa_{\text{water}} = 0.0148705 - 0.00018 = 0.0146905 \text{ S m}^{-1}$$

$$\lambda_{\text{SrSO}_4} \doteq \lambda_{\text{SrSO}_4}^{\infty} = \frac{\kappa_{\text{SrSO}_4}}{c_{\text{SrSO}_4}} = \lambda_{\text{Sr}^{2+}}^{\infty} + \lambda_{\text{SO}_4^{2-}}^{\infty} = 0.0119 + 0.01596 = 0.02786 \text{ S m}^2 \text{ mol}^{-1}$$

$$c_{\text{SrSO}_4} = \frac{\kappa_{\text{SrSO}_4}}{\lambda_{\text{SrSO}_4}^{\infty}} = \frac{0.0146905}{0.02786} = 0.5273 \text{ mol m}^{-3} = 5.273 \cdot 10^{-4} \text{ mol dm}^{-3}$$

$$\left[\frac{\text{S m}^{-1}}{\text{S m}^2 \text{ mol}^{-1}} = \text{mol m}^{-3} \right]$$

Solubility product:

$$K_s = \gamma_{\pm}^2 \cdot c_{\text{SrSO}_4}^2 = 1 \cdot (5.273 \cdot 10^{-4})^2 = 2.78 \cdot 10^{-7}$$