Problem 9-03 Heterogeneous ionic equilibria – solubility of sparingly soluble salts

The solubility product of lanthanum oxalate (standard state of infinite dilution, c^{st} = 1 mol dm^{-3}) at 25 °C is $2 \cdot 10^{-28}$. Lanthanum oxalate precipitate was four times decanted always with 50 cm^3 of distilled water (it is supposed that each time the equilibrium between the solid phase and the solution was established). Calculate total weight loss of the precipitate. Assume that the mean activity coefficient is equal to one. $M_{La_2(C_2O_4)_3}$ = 541.9 g mol^{-1}.

[$\Delta m = 1.226 \cdot 10^{-4}$ g]

Solution:

$La_2(C_2O_4)_3$ (s) = 2 La^{3+} + 3 $C_2O_4^{3-}$; solubility of $La_2(C_2O_4)_3$ = $c_{La_2(C_2O_4)_3}$

$c_{La^{3+}} = 2\, c_{La_2(C_2O_4)_3}$

$c_{C_2O_4^{2-}} = 3\, c_{La_2(C_2O_4)_3}$

$$K_S(La_2(C_2O_4)_3) = a^2_{La^{2+}} \cdot a^3_{C_2O_4^{2-}} = \left(\gamma_+ \cdot \frac{c_{La^{3+}}}{c^{st}}\right)^2 \cdot \left(\gamma_- \cdot \frac{c_{C_2O_4^{2-}}}{c^{st}}\right)^3 =$$

$$= \gamma_\pm^5 \cdot \left(\frac{2\, c_{La_2(C_2O_4)_3}}{c^{st}}\right)^2 \cdot \left(\frac{3\, c_{La_2(C_2O_4)_3}}{c^{st}}\right)^3 = \gamma_\pm^5 \cdot 108 \cdot \left(\frac{c_{La_2(C_2O_4)_3}}{c^{st}}\right)^5$$

$\gamma_+^3 \cdot \gamma_-^2 = \gamma_\pm^5 = 1$, c^{st} = 1 mol dm^{-3}

$$c_{La_2(C_2O_4)_3} = \left(\frac{K_S}{108}\right)^{1/5} = \left(\frac{2 \cdot 10^{-28}}{108}\right)^{1/5} = 1.131 \cdot 10^{-6} \text{ mol dm}^{-3}$$

V = 200 cm^3

$\Delta m = c_{La_2(C_2O_4)_3} \cdot V \cdot M_{La_2(C_2O_4)_3} = 1.131 \cdot 10^{-6} \cdot 200 \cdot 10^{-3} \cdot 541.9 = 1.226 \cdot 10^{-4}$ g