Problem 13-10 Freezing point depression of electrolyte solutions

What is the temperature of freezing of the solution obtained by dissolving of 7.40 g of magnesium chloride in 111.6 cm^3 of water? Assume that magnesium chloride completely dissociates in aqueous solution. The density of water at the temperature in question is 0.986 g cm^{-3} and enthalpy of fusion at normal freezing point has the value of 6.009 kJ mol^{-1}. (M_{MgCl2} = 95.21 g mol^{-1}, M_{H2O} = 18.016 g mol^{-1})

[t_f = –3.77 °C]

Solution:

Calculation of the cryoscopic constant:

$$K_K = \frac{\boldsymbol{R} T_1^2 \cdot M_1}{\Delta_{fusion} H_1}$$

M_1 = 18.016 g mol^{-1}

$\Delta_{fusion}H_m$ = 6009 J mol^{-1}

T_1 = 273.15 K

$$K_K = \frac{8.314 \cdot 273.15^2 \cdot 18.016 \cdot 10^{-3}}{6009} = 1.8598 \text{ K kg mol}^{-1}$$

$MgCl_2 = Mg^{2+} + 2\ Cl^-$

i = 3

m_2 = 7.4 g , M_2 = 95.21 g mol^{-1}

V_1 = 111.6 cm^3 , ρ_1 = 0.986 g cm^{-3}, $m_1 = V_1 \cdot \rho_1 = 111.6 \cdot 0.986$

$$\underline{m_2} = \frac{m_2}{M_2 \cdot m_1} = \frac{7.4}{95.21 \cdot 116.6 \cdot 0.986 \cdot 10^{-3}} = 0.676 \text{ mol kg}^{-1}$$

$-\Delta T_f = i \cdot K_K \cdot \underline{m_2} = 3 \cdot 1.86 \cdot 0.676 = 3.772$ K