

Problem 13-07 Freezing point depression – non-electrolyte solutions

At which temperature will freeze 0.3 dm³ of water ($M = 18.016 \text{ g mol}^{-1}$, density 0.9992 g cm^{-3}), to which 33 g of sucrose ($M(\text{C}_{12}\text{H}_{22}\text{O}_{11}) = 342.3 \text{ g mol}^{-1}$) was added? Enthalpy of fusion of has the value of 6009 J mol^{-1} .

$$[t_{\text{fusion}} = -0.6^{\circ}\text{C}, (K_K = 1.86, \underline{m}_2 = 0.3216 \text{ mol kg}^{-1})]$$

Solution:

$$K_K = \frac{RT_1^2 \cdot M_1}{\Delta_{\text{fusion}} H_1} \quad (\text{index 1 ... water})$$

$$M_1 = 18.016 \text{ g mol}^{-1}$$

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

$$T_1 = 273.15 \text{ K}$$

$$K_K = \frac{8.314 \cdot 273.15^2 \cdot 18.016 \cdot 10^{-3}}{6009} = 1.86 \text{ K kg mol}^{-1}$$

$$m_2 = 33 \text{ g}$$

$$V_1 = 0.3 \text{ dm}^3, \quad \rho_1 = 0.9992 \text{ g cm}^{-3} = 0.9992 \text{ kg dm}^{-3} \Rightarrow m_1 = V_1 \cdot \rho_1 = 0.3 \cdot 0.9992 = 0.29976 \text{ kg}$$

$$M_2 = 342.3 \text{ g mol}^{-1}$$

$$\underline{m}_2 = \frac{m_2}{M_2 \cdot m_1} = \frac{33}{342.3 \cdot 0.29976} = 0.3216 \text{ mol kg}^{-1}$$

$$-\Delta T_f = K_K \cdot \underline{m}_2 = 1.86 \cdot 0.3411 = 0.598 \text{ K}$$

$$t_{\text{fusion}} = -0.6 \text{ K}$$