Problem 13-18 Boiling point elevation and freezing point elevation of non-electrolyte solutions

The cooler of your car contains 4.45 dm^3 of water (M = 18 g mol^{-1}) and 1 kg of ethylene glycol ($C_2H_6O_2$, M = 62 g mol^{-1}). At what temperature the contents of your cooler (a) starts to freeze, (b) starts to boil? For the density of water take the value of 0.9986 g cm^{-3}. Cryoscopic constant is K_f = 1.86 K kg mol^{-1}, ebullioscopic constant is K_f = 0.513 K kg mol^{-1}.

[(a) $t_{freezing}$ = –6.75°C; (b) $t_{boiling}$ = 101.86°C]

Solution:

$M_2 = 62\ g\ mol^{-1}$

$m_2 = 1000\ g$

$V_1 = 4.45\ dm^3$, $\rho_1 = 0.9986\ g\ cm^{-3} = 0.9986\ kg\ dm^{-3}$, $m_1 = V_1 \cdot \rho_1 = 4.45 \cdot 0.9986$

$$\underline{m_2} = \frac{m_2}{M_2 \cdot m_1} = \frac{1000}{62 \cdot 4,45 \cdot 0,9986} = 3.6296\ mol\ kg^{-1} \qquad \left[\frac{g}{(g\ mol^{-1}) \cdot kg} = mol\ kg^{-1}\right]$$

(a) $\Delta T_f = -K_K \cdot \underline{m_2} = -1.86 \cdot 3.6296 = -6.751\ K$

$t_{freezing} = -6.75°C$

(b $\Delta T_b = K_E \cdot \underline{m_2} = 0.513 \cdot 3.6296 = 1.862\ K$

$t_{boiling} = 101.86°C$