Problem 13-24 Osmotic pressure of non-electrolyte solutions

Molar mass of a polymer was determined by osmometry. At the temperature of 37.6 °C the solution of the polymer in acetone climbed in the osmometric capillary up to 44 mm. The concentration of the solution was 0.616 kg m^{-3} and its density 854 kg m^{-3}. You can assume that for this case the van't Hoff equation can be used. Calculate

(a) molar mass of the studied substance,
(b) osmotic pressure exhibited by the acetone solution of this polymer of concentration 1.79 kg m^{-3} at 42.4 °C.
(c) Will be the length of 10 cm of the osmometric capillary enough for the determination of osmotic pressure of the solution of density 895 kg m^{-3}?

[(a) M = 4317.4 g mol^{-1}; (b) π = 1087.7 Pa; (c) h = 12.4 cm > $\ell_{capillary}$, capillary is too short]

Solution:

w_1 = 0.616 kg m^{-3}
T_1 = 37.6 + 273.15 =310.75 K
ρ_1 = 854 kg m^{-3}
h_1 = 44 mm
w_2 = 1.79 kg m^{-3}
T_2 = 42.4 + 273.15 =315.55 K

(a) $\pi_1 = h_1 \cdot \rho_1 \cdot g = \dfrac{\boldsymbol{R}T_1}{M} \cdot w_1 \quad \Rightarrow M = \dfrac{\boldsymbol{R}T_1}{h_1 \cdot \rho_1 \cdot g} \cdot w_1 = \dfrac{8.314 \cdot 310.75}{0.044 \cdot 854 \cdot 9.81} \cdot 0.616 = 4.3174$ kg mol^{-1}

(b) $\pi_2 = \dfrac{\boldsymbol{R}T_2}{M} \cdot w_2 = \dfrac{8.314 \cdot 315.55}{4.3174} \cdot 1.79 = 1087.7$ Pa

(c) $\pi_2 = h_2 \cdot \rho_2 \cdot g$

$h_2 = \dfrac{\pi_2}{\rho_2 \cdot g} = \dfrac{1087.7}{895 \cdot 9.81} = 0.12388$ m $\Rightarrow$ $\ell_{capillary}$ = 10 cm < h_2 the capillary is too short