Problem 13-20 Osmotic pressure of protein solution

A solution prepared by dissolving of 0.75 g of ribonuclease in 0.15 dm^3 of NaCl solution of concentration 0.22 mol dm^{-3} exhibited osmotic pressure of 967.2 Pa, when measured against NaCl solution of the same concentration. The membrane used to measure the osmotic pressure is permeable for low molecular ions, but it is impermeable for ribonuclease molecules. Determine the molar mass of ribonuclease.

[M_R = 12.6 kg mol^{-1}]

Solution:

T = 293.15 K
π = 967.2 Pa
V_A = 0.15 dm^3
m_R = 0.75 g
$(c_{NaCl})_A = (c_{NaCl})_B$ = 0.22 mol dm^{-3}

A	B
ribonuclease (R): $c_R = \frac{m_R}{M_R \cdot V_A}$ NaCl: $(c_{NaCl})_A$=0.22 mol /dm^3	NaCl: $(c_{NaCl})_B$ = 0.22 mol dm^{-3}

Compartment A contains NaCl and ribonuclease, $c_R = \frac{m_R}{M_R \cdot V_A} = \frac{0,75}{M_R \cdot 0,15 \cdot 10^{-3}} = \frac{5000}{M_R}$ mol m^{-3}

$$\left[\frac{\text{g}}{(\text{g mol}^{-1}) \cdot \text{m}^3} = \text{mol m}^{-3}\right]$$

$\pi = (\Sigma c_A - \Sigma c_B) \cdot \boldsymbol{R}T = (c_R + (c_{NaCl})_A - (c_{NaCl})_B) \cdot \boldsymbol{R}T$

$$c_R = \frac{5000}{M_R} = \frac{\pi}{\boldsymbol{R}T}$$

$$M_R = \frac{5000}{\pi} \cdot \boldsymbol{R}T = \frac{5000}{967.2} \cdot 8.314 \cdot 293.15 = 12599.5 \text{ g mol}^{-1} \approx 12.6 \text{ kg mol}^{-1}$$