HW#2 I.3

Let's put the vessel with helium (V, N_{He}) into a much larger vessel, V_2, containing N_2 moles of He and N moles of air at the same pressure and temperature (p, T). Then, the entropy in the initial state:

(number of moles of He)

$$S_1 = R N_{He} \ln \frac{V}{N_{He}} + R N_2 \ln \frac{V_2}{N_2} + R N \ln \frac{V_2}{N}$$

(R — univ. gas constant)

In the final state; when all helium diffused outside:

$$S_2 = R(N_{He}+N_2) \ln \frac{V+V_2}{N_{He}+N_2} + RN \ln \frac{V+V_2}{N}$$

$\Delta S = S_2 - S_1$ must be calculated in the limit of $N, N_2, V_2 \to \infty$, while $\frac{V_2}{N}$ and $\frac{V_2}{N_2} \to$ const.

$$\Delta S \approx R N_{He} \ln \frac{N_{He} V_2}{N_2 V} = \frac{pV}{T} \ln \frac{n_1}{n_2} \approx 110 \frac{J}{K}$$

where n_1 and n_2 - molar concentrations of He in the vessel and in the environment

Min isothermic work to collect such an amount is (comp. I.2):

$$|A_{min}| = T \Delta S = pV \ln \frac{n_1}{n_2} \approx 32 \text{ kJ}$$