Exercise 6-9

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$n = 1\ mol$

$V_i = 5\ L = 5\ dm^3 = 0.005\ m^3$

$V_f = 10\ L = 10\ dm^3 = 0.010\ m^3$

$T = 20^\circ C$

ideal gas: $Pv = RT$

$PV = nRT$

~~$ds = \frac{dq}{T} =$~~

isothermal: $dT = 0$

fundamental relation

$du = Tds - Pdv$

ideal gas and $dT = 0 \Longrightarrow du = 0$

$\Rightarrow Tds = Pdv$ ($P = \frac{RT}{v}$)

$ds = \frac{R}{v} dv$

$\Delta S = R \ln\left(\frac{v_f}{v_i}\right) = 8.314\ J\ mol^{-1} K^{-1} \cdot \ln(2)$

$= 5.763\ J\ mol^{-1} K^{-1}$

$\Delta S = n \Delta s = 1\ mol \times 5.763\ J\ mol^{-1} K^{-1}$

$= 5.763 \times 10^{3}\ J K^{-1}$

reversible process $\Longrightarrow \Delta S_{universe} = 0$

b) ideal gas: $\eta = 0 \Rightarrow dT = 0$ for a free expansion, thus $\Delta S_{system} = 5.763 \cdot 10^{3}\ J K^{-1}$

$\Delta S_{surroundings} = 0$, as $du = 0$ and $dq = 0$

Thus $\Delta S_{universe} = \Delta S_{system} + \Delta S_{surroundings} = 5.763 \cdot 10^{3}\ J K^{-1}$