Question 4: Thermodynamics

(a) Thermal Conduction and Entropy

(i) Thermal Conductivity

The rate of heat flow P is:

$$P = \frac{dm}{dt} L_f = \left(\frac{0.1683}{60} \right) (3.36 \times 10^4) = 94.248\,\text{W}$$

From the heat conduction equation, $P = kA\frac{\Delta T}{L}$:

$$k = \frac{PL}{A\Delta T} = \frac{(94.248)(0.2)}{(\pi(0.01)^2)(150)} \approx 400\,\text{W m}^{-1}\text{K}^{-1}$$

(ii) Rate of Entropy Change

$$\frac{dS_{\text{total}}}{dt} = \frac{-P}{T_H} + \frac{P}{T_C} = 94.248 \left(\frac{1}{273.15} - \frac{1}{423.15} \right) \approx 0.1223 \, \text{J K}^{-1}\text{s}^{-1}$$