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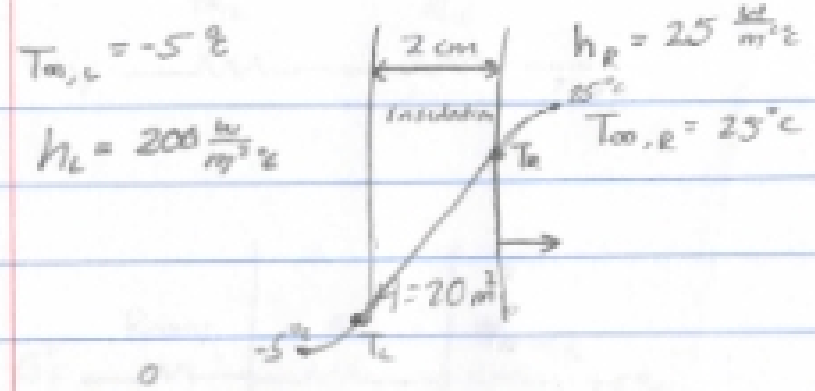
Chapter 3 - One dimensional, steady-state conduction



Find q, T_R, T_L

$k = 0.027 \frac{W}{m°C}$ → table A.3 (p. 908)

steady state: $\dot{E}_{st} = \dot{E}_{in} - \dot{E}_{out} + \dot{E}_{gen}$ → $\dot{E}_{in} = \dot{E}_{out}$

conv R: $q_R = h_R A \Delta T \rightarrow q_R = 25 \frac{W}{m^2 °C} (20 m^2)(25°C - T_R) \rightarrow q_R = 500 \frac{W}{°C} (25°C - T_R)$

conv L: $q_L = h_L A \Delta T \rightarrow q_L = 200 \frac{W}{m^2 °C} (20 m^2)(T_L + 5°C) \rightarrow q_L = 4000 \frac{W}{°C} (T_L + 5°C)$

combine: $q_L = q_R \rightarrow 500 \frac{W}{°C} (25°C - T_R) = 4000 \frac{W}{°C} (T_L + 5°C)$ (1)

cond ins: $q_{ins} = kA \frac{\Delta T}{L} \rightarrow kA \frac{(T_R - T_L)}{0.02m} \rightarrow (0.027 \frac{W}{m°C})(20 m^2) \frac{T_R - T_L}{0.02 m} \rightarrow q_{ins} = 27 \frac{W}{°C} (T_R - T_L)$

$q_{insul} = q_L = q_R$

$4000 \frac{W}{°C} (T_L + 5°C) = 27 \frac{W}{°C} (T_R - T_L)$ (2)

eqn 1) $4000\ T_L + 500\ T_R = +7,500°C$

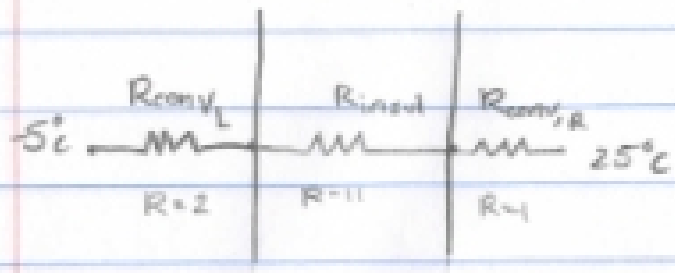
eqn 2) $4027\ T_L + (-27)\ T_R = -20{,}000°C$

↳ solve equations

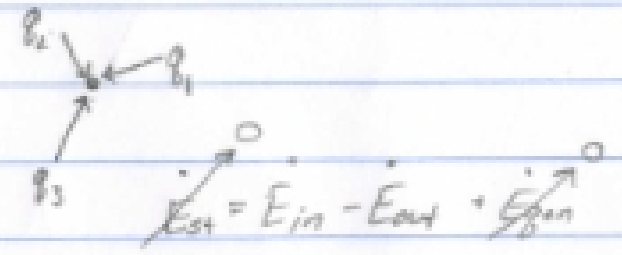
$T_L = -4.809°C$

$T_R = 23.473°C$

$q_{cond} = kA \frac{\Delta T}{L} \rightarrow (0.027 \frac{W}{m°C})(20 m^2) \left(\frac{23.472 + 4.809}{.02 m}\right) = 763.5\ °C$



$$I = \frac{\Delta V}{R_{Elec}} \Rightarrow q = \frac{\Delta T}{R_{Heat\ Transfer}}$$



$$\dot{E}_{st} = \dot{E}_{in} - \dot{E}_{out} + \dot{E}_{gen}$$

R_{conv}

$$q_{conv} = hA\Delta T \rightarrow q_{conv} = \frac{\Delta T}{R_{conv}} \rightarrow hA\Delta T = \frac{\Delta T}{R_{conv}}$$

$$\hookrightarrow R_{conv} = \frac{1}{hA}$$

R_{cond}

$$q_{cond} = kA\frac{\Delta T}{L} = \frac{\Delta T}{R_{cond}} \rightarrow R_{cond} = \frac{L}{kA}$$

$$R_{cond} = \frac{.02m}{.027 \frac{W}{m \cdot °C}(20m^2)} = 0.037037 \frac{°C}{W}$$

$$R_{conv_L} = \frac{1}{(200 \frac{W}{m^2 °C})(20m^2)} = .0025$$

$$R_{conv_R} = \frac{1}{(25 \frac{W}{m^2 °C})(20m^2)} = .002$$

$$R_{eq} = .03929 \frac{°C}{W}$$

$$q = \frac{30°C}{.03929 \frac{°C}{W}} = 763.6 \text{ Watts}$$