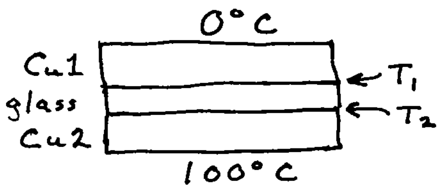
Problem 14-18



For steady-state (equilibrium), heat flow rate through each layer is the same.

heat flow rate through Cu 1 = heat flow rate through Cu2

$$\therefore \quad \frac{k_{Cu} A (\Delta T)_1}{\Delta x_{Cu}} = \frac{k_{Cu} A (\Delta T)_2}{\Delta x_{Cu}}$$

$$\therefore (\Delta T)_1 = (\Delta T)_2$$

$$\therefore T_1 - 0 = 100 - T_2 \quad [1]$$

heat flow rate through Cu1 = heat flow rate through glass

$$\therefore \frac{k_{Cu} A (\Delta T)_1}{\Delta x_{Cu}} = \frac{k_g A (\Delta T)_g}{\Delta x_g}$$

$$\therefore \frac{(384\, W \cdot m^{-1} \cdot K^{-1})(T_1 - 0)}{0.50\text{ cm}} = \frac{(1.05\, W \cdot m^{-1} \cdot K^{-1})(T_2 - T_1)}{0.010\text{ cm}}$$

$$\therefore 768\, T_1 = 105\, T_2 - 105\, T_1$$

$$\therefore 873\, T_1 = 105\, T_2$$

$$\therefore T_2 = \frac{873}{105} T_1 = 8.31\, T_1 \text{. Subst. in [1].}$$

$$\therefore [1] \rightarrow \quad T_1 = 100 - 8.31\, T_1$$

$$\therefore 9.31\, T_1 = 100 \quad \therefore T_1 = 10.7\,°C$$

$$\therefore T_2 = 8.31\, T_1 = (8.31)(10.7\,°C) = 89.3\,°C$$

heat flow rate through Cu1 is:

$$P = \frac{k_{Cu} A (\Delta T)_1}{\Delta x_{Cu}}$$

$$= \frac{(384\, W \cdot m^{-1} \cdot K^{-1})(0.10\, m)^2 (10.7\,°C - 0\,°C)}{0.50 \times 10^{-2}\, m}$$

$$= 8.2 \times 10^3\, W$$

$$\therefore T_1 = 11\,°C, \quad T_2 = 89\,°C, \quad P = 8.2 \times 10^3\, W$$