

# Heat Transfer Quiz

## Solutions

1) Conduction, Convection, and Radiation

2) Conduction:  $q = kA \frac{dT}{dx}$

Convection:  $dq = h dA (\Delta T)$

Radiation:  $q_{12} = \sigma A_1 F_{12} (T_1^4 - T_2^4)$

3)  $R = R_1 + R_2 = \frac{L_1}{k_1 A} + \frac{L_2}{k_2 A} = \frac{1}{A} \left( \frac{L_1}{k_1} + \frac{L_2}{k_2} \right) = \frac{1}{120 \text{ m}^2} \left( \frac{0.3 \text{ m}}{200 \text{ W/m}\cdot\text{K}} + \frac{0.5 \text{ m}}{50 \text{ W/m}\cdot\text{K}} \right)$

$$R = 9.58 \times 10^{-5} \text{ K/W}$$

4.)  $R_{\text{conduction}} = \frac{L}{k}$   
 $R_{\text{convection}} = \frac{1}{h}$

$$R_{\text{total}} = R_{\text{conduction}} + R_{\text{convection}} = \sum \frac{L_i}{k_i} + \sum \frac{1}{h_i}$$

$$R_{\text{total}} = \frac{1}{30 \text{ W/m}\cdot\text{K}} + \frac{0.3 \text{ m}}{0.065 \text{ W/m}\cdot\text{K}} + \frac{1}{12 \text{ W/m}\cdot\text{K}} + \frac{1.5 \text{ m}}{0.05 \text{ W/m}\cdot\text{K}} = 30.16 \text{ m}^2\cdot\text{K/W}$$

$$\text{Now } \frac{q}{A} = \frac{T_2 - T_1}{R_{\text{total}}} = \frac{298 \text{ K} - (-268 \text{ K})}{30.16 \text{ m}^2\cdot\text{K/W}} = 0.995 \text{ W/m}^2$$

5.)  $R_{\text{total}} = \frac{1}{h_{\text{polymer}}} + \frac{L_{\text{polymer}}}{k_{\text{polymer}}} + \frac{1}{h_{\text{Al}}} + \frac{L_{\text{Al}}}{k_{\text{Al}}} = \frac{1}{5 \text{ W/m}\cdot\text{K}} + \frac{30 \times 10^{-6} \text{ m}}{0.3 \text{ W/m}\cdot\text{K}} + \frac{1}{30 \text{ W/m}\cdot\text{K}} + \frac{50 \times 10^{-6} \text{ m}}{177 \text{ W/m}\cdot\text{K}}$   
 $= 0.233 \text{ m}^2\cdot\text{K/W}$

$$\frac{q}{A} = \frac{T_{\text{hot}} - T_{\text{cold}}}{R_{\text{total}}} = \frac{363 \text{ K} - 298 \text{ K}}{0.233 \text{ m}^2\cdot\text{K/W}} = 278 \text{ W/m}^2$$

$$R_{\text{Al side}} = \frac{1}{h_{\text{Al}}} + \frac{L_{\text{Al}}}{k_{\text{Al}}} = \frac{1}{30 \text{ W/m}\cdot\text{K}} + \frac{50 \times 10^{-6} \text{ m}}{177 \text{ W/m}\cdot\text{K}} = 3.33 \times 10^{-2} \text{ m}^2\cdot\text{K/W}$$

$$\frac{q}{A} = \frac{T_{\text{hot}} - T_{\text{interface}}}{R_{\text{Al}}} \Rightarrow T_{\text{interface}} = T_{\text{hot}} - R_{\text{Al}} \left( \frac{q}{A} \right) = 363 \text{ K} - (3.33 \times 10^{-2} \text{ m}^2\cdot\text{K/W}) (278 \text{ W/m}^2)$$

$$T_{\text{interface}} = 354 \text{ K} = 81^\circ\text{C}$$