10-20 A double-pane window consists of two layers of glass separated by a stagnant air space. For specified indoors and outdoors temperatures, the rate of heat loss through the window and the inner surface temperature of the window are to be determined.

Assumptions **1** Heat transfer through the window is steady since the indoor and outdoor temperatures remain constant at the specified values. **2** Heat transfer is one-dimensional since any significant temperature gradients will exist in the direction from the indoors to the outdoors. **3** Thermal conductivities of the glass and air are constant. **4** Heat transfer by radiation is negligible.

Properties The thermal conductivity of the glass and air are given to be $k_{glass} = 0.78$ W/m·°C and $k_{air} = 0.026$ W/m·°C.

Analysis The area of the window and the individual resistances are

$$A = (1.2 \text{ m}) \times (2 \text{ m}) = 2.4 \text{ m}^2$$

$$R_i = R_{conv,1} = \frac{1}{h_1 A} = \frac{1}{(10 \text{ W/m}^2 \cdot °\text{C})(2.4 \text{ m}^2)} = 0.0417 \, °\text{C/W}$$

$$R_1 = R_3 = R_{glass} = \frac{L_1}{k_1 A} = \frac{0.003 \text{ m}}{(0.78 \text{ W/m} \cdot °\text{C})(2.4 \text{ m}^2)} = 0.0016 \, °\text{C/W}$$

$$R_2 = R_{air} = \frac{L_2}{k_2 A} = \frac{0.012 \text{ m}}{(0.026 \text{ W/m} \cdot °\text{C})(2.4 \text{ m}^2)} = 0.1923 \, °\text{C/W}$$

$$R_o = R_{conv,2} = \frac{1}{h_2 A} = \frac{1}{(25 \text{ W/m}^2 \cdot °\text{C})(2.4 \text{ m}^2)} = 0.0167 \, °\text{C/W}$$

$$R_{total} = R_{conv,1} + 2R_1 + R_2 + R_{conv,2} = 0.0417 + 2(0.0016) + 0.1923 + 0.0167$$
$$= 0.2539 \, °\text{C/W}$$

The steady rate of heat transfer through window glass then becomes

$$\dot{Q} = \frac{T_{\infty 1} - T_{\infty 2}}{R_{total}} = \frac{[24 - (-5)]°\text{C}}{0.2539 °\text{C/W}} = \mathbf{114 \text{ W}}$$

The inner surface temperature of the window glass can be determined from

$$\dot{Q} = \frac{T_{\infty 1} - T_1}{R_{conv,1}} \longrightarrow T_1 = T_{\infty 1} - \dot{Q}R_{conv,1} = 24°\text{C} - (114 \text{ W})(0.0417°\text{C/W}) = \mathbf{19.2°C}$$