

15-27 A glass window transmits 90% of the radiation in a specified wavelength range and is opaque for radiation at other wavelengths. The rate of radiation transmitted through this window is to be determined for two cases.

Assumptions The sources behave as a black body.

Analysis The surface area of the glass window is

$$A_s = 4 \text{ m}^2$$

(a) For a blackbody source at 5800 K, the total blackbody radiation emission is

$$E_b(T) = \sigma T^4 A_s = (5.67 \times 10^{-8} \text{ kW/m}^2 \cdot \text{K}^4)(5800 \text{ K})^4 (4 \text{ m}^2) = 2.567 \times 10^5 \text{ kW}$$

The fraction of radiation in the range of 0.3 to 3.0 μm is

$$\lambda_1 T = (0.30 \mu\text{m})(5800 \text{ K}) = 1740 \mu\text{mK} \longrightarrow f_{\lambda_1} = 0.03345$$

$$\lambda_2 T = (3.0 \mu\text{m})(5800 \text{ K}) = 17,400 \mu\text{mK} \longrightarrow f_{\lambda_2} = 0.97875$$

$$\Delta f = f_{\lambda_2} - f_{\lambda_1} = 0.97875 - 0.03345 = 0.9453$$

Noting that 90% of the total radiation is transmitted through the window,

$$\begin{aligned} E_{\text{transmit}} &= 0.90 \Delta f E_b(T) \\ &= (0.90)(0.9453)(2.567 \times 10^5 \text{ kW}) = \mathbf{2.184 \times 10^5 \text{ kW}} \end{aligned}$$

(b) For a blackbody source at 1000 K, the total blackbody emissive power is

$$E_b(T) = \sigma T^4 A_s = (5.67 \times 10^{-8} \text{ W/m}^2 \cdot \text{K}^4)(1000 \text{ K})^4 (4 \text{ m}^2) = 226.8 \text{ kW}$$

The fraction of radiation in the visible range of 0.3 to 3.0 μm is

$$\lambda_1 T = (0.30 \mu\text{m})(1000 \text{ K}) = 300 \mu\text{mK} \longrightarrow f_{\lambda_1} = 0.0000$$

$$\lambda_2 T = (3.0 \mu\text{m})(1000 \text{ K}) = 3000 \mu\text{mK} \longrightarrow f_{\lambda_2} = 0.273232$$

$$\Delta f = f_{\lambda_2} - f_{\lambda_1} = 0.273232 - 0$$

and

$$E_{\text{transmit}} = 0.90 \Delta f E_b(T) = (0.90)(0.273232)(226.8 \text{ kW}) = \mathbf{55.8 \text{ kW}}$$

