

## Chapter 34 Problem 41 <sup>†</sup>

### Given

$$\lambda_{max} = 660 \text{ nm}$$

### Solution

a) What is the temperature of the blackbody?

Using Wein's law

$$\lambda_{peak}T = 2.898 \times 10^{-3} \text{ m} \cdot \text{K}$$

$$T = \frac{2.898 \times 10^{-3} \text{ m} \cdot \text{K}}{\lambda_{peak}} = \frac{2.898 \times 10^{-3} \text{ m} \cdot \text{K}}{660 \times 10^{-9}} = 4390 \text{ K}$$

b) What is the ratio of radiance at 400 nm compared to 700 nm?

The radiance formula for a blackbody radiator is

$$R(\lambda, T) = \frac{2\pi hc^2}{\lambda^5 (e^{hc/\lambda kT} - 1)}$$

The radiance at 400 nm is

$$R(400 \text{ nm}, 4390 \text{ K}) = \frac{2\pi(6.63 \times 10^{-34} \text{ J} \cdot \text{s})(3.0 \times 10^8 \text{ m/s})^2}{(400 \times 10^{-9} \text{ m})^5 (e^{(6.63 \times 10^{-34} \text{ J} \cdot \text{s})(3.0 \times 10^8 \text{ m/s}) / ((400 \times 10^{-9} \text{ m})(1.38 \times 10^{-23} \text{ J/K})(4390 \text{ K}))} - 1)}$$

$$R(400 \text{ nm}, 4390 \text{ K}) = 9.98 \times 10^{12}$$

The radiance at 700 nm is

$$R(700 \text{ nm}, 4390 \text{ K}) = \frac{2\pi(6.63 \times 10^{-34} \text{ J} \cdot \text{s})(3.0 \times 10^8 \text{ m/s})^2}{(700 \times 10^{-9} \text{ m})^5 (e^{(6.63 \times 10^{-34} \text{ J} \cdot \text{s})(3.0 \times 10^8 \text{ m/s}) / ((700 \times 10^{-9} \text{ m})(1.38 \times 10^{-23} \text{ J/K})(4390 \text{ K}))} - 1)}$$

$$R(700 \text{ nm}, 4390 \text{ K}) = 2.05 \times 10^{13}$$

The ratio of the two radiance is then

$$\frac{R(400 \text{ nm}, 4390 \text{ K})}{R(700 \text{ nm}, 4390 \text{ K})} = \frac{9.98 \times 10^{12}}{2.05 \times 10^{13}} = 0.487$$

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<sup>†</sup>Problem from Essential University Physics, Wolfson