## Solutions

Each answer shows the steps, then the **result**.

**2.1**

- $\lambda_{\max} T = \text{constant}$ (or $\lambda_{\max} \propto 1/T$)

**2.2**

- $T = b/\lambda_{\max}$

$$T = \frac{2.90 \times 10^{-3}\ \text{m K}}{500 \times 10^{-9}\ \text{m}} = \mathbf{5800}\ \text{K}$$

**2.3**

- $L = 4\pi\sigma r^2 T^4$

**2.4**

- it is **shorter** ($\lambda_{\max} \propto 1/T$)

**3.1 B**

- a hotter star has its peak at a **shorter wavelength**

**3.2**

- $T = b/\lambda_{\max}$

$$T = \frac{2.90 \times 10^{-3}\ \text{m K}}{290 \times 10^{-9}\ \text{m}} = \mathbf{1.0 \times 10^{4}}\ \text{K}$$

**3.3**

(a) $L = 4\pi r^2 \sigma T^4$

$$L = 4\pi(7.0 \times 10^{8}\ \text{m})^2(5.67 \times 10^{-8}\ \text{W m}^{-2}\,\text{K}^{-4})(5800\ \text{K})^4 = \mathbf{4.0 \times 10^{26}}\ \text{W}$$

(b) $L \propto r^2$ at fixed temperature

- so tripling the radius makes the luminosity $3^2 = 9$ times larger: $\mathbf{3.6 \times 10^{27}}$ W

**3.4**

- find $T$ from $\lambda_{\max}$ (Wien's law) and measure $L$
- then use the Stefan–Boltzmann law $L = 4\pi\sigma r^2 T^4$ to solve for $r$

**3.5**

(a) the wavelength at which the emitted intensity is a **maximum** is **inversely proportional** to the thermodynamic temperature of the body

- $\lambda_{\max} T = \text{constant}$

(b) $T = b/\lambda_{\max}$

$$T = \frac{2.90 \times 10^{-3}\ \text{m K}}{580 \times 10^{-9}\ \text{m}} = \mathbf{5.0 \times 10^{3}}\ \text{K}$$



(c) $L = 4\pi d^2 F$

$$L = 4\pi(8.4 \times 10^{17}\ \text{m})^2(3.6 \times 10^{-10}\ \text{W m}^{-2}) = \mathbf{3.2 \times 10^{27}}\ \text{W}$$

(d) $r = \sqrt{L/(4\pi\sigma T^4)}$

$$r = \sqrt{\frac{3.19 \times 10^{27}\ \text{W}}{4\pi(5.67 \times 10^{-8}\ \text{W m}^{-2}\,\text{K}^{-4})(5000\ \text{K})^4}} = \mathbf{2.7 \times 10^{9}}\ \text{m}$$

- a few solar radii, so a star of ordinary main-sequence size

(e) at fixed luminosity $r^2 T^4$ is constant, so $r \propto 1/T^2$

- doubling $T$ gives a radius 1/4 as large, i.e. a ratio of 0.25
- a star of the same luminosity packed into a quarter of the radius and much hotter suggests a **white dwarf** rather than a main-sequence star