

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: $\mathbf{3.6 \times 10^{27} \text{ W}}$

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