3-16. $\lambda_m T = 2.898 \times 10^{-3} m \cdot K$

(a) $T = \dfrac{2.898 \times 10^{-3} m \cdot K}{700 \times 10^{-9} m} = 4140K$

(b) $T = \dfrac{2.898 \times 10^{-3} m \cdot K}{3 \times 10^{-2} m} = 9.66 \times 10^{-2} K$

(c) $T = \dfrac{2.898 \times 10^{-3} m \cdot K}{3m} = 9.66 \times 10^{-4} K$

3-17. Equation 3-4: $R_1 = \sigma T_1^4$ $\quad R_2 = \sigma T_2^4 = \sigma(2T_1)^4 = 16\sigma T_1^4 = 16R_1$

3-18. (a) Equation 3-17: $\bar{E} = \dfrac{hc/\lambda}{e^{hc/\lambda kT} - 1} = \dfrac{hc/(10hc/kT)}{e^{(hc/kT)/(10hc/kT)} - 1} = \dfrac{0.1kT}{e^{0.1} - 1} = 0.951kT$

(b) $\bar{E} = \dfrac{hc/\lambda}{e^{hc/\lambda kT} - 1} = \dfrac{hc/(0.1hc/kT)}{e^{(hc/kT)/(0.1hc/kT)} - 1} = \dfrac{10kT}{e^{10} - 1} = 4.59\times10^{-4}kT$

Equipartition theorem predicts $\bar{E} = kT$. The long wavelength value is very close to *kT*, but the short wavelength value is much smaller than the classical prediction.

3-19. (a) $\lambda_m T = 2.898\times10^{-3}\, m\cdot K \quad \therefore \quad T_1 = \dfrac{2.898\times10^{-3}\, m\cdot K}{27.0\times10^{-6}\, m} = 107K$

$R_1 = \sigma T_1^4$ and $R_2 = \sigma T_2^4 = 2R_1 = 2\sigma T_1^4$

$\therefore \quad T_2^4 = 2T_1^4$ or $T_2 = 2^{1/4}T_1 = (2^{1/4})(107K) = 128K$

(b) $\lambda_m = \dfrac{2.898\times10^{-3}\, m\cdot K}{128K} = 23\times10^{-6}\, m$

3-20. (a) $\lambda_m T = 2.898\times10^{-3}\, m\cdot K$ (Equation 3-5)

$$\lambda_m = \frac{2.898\times10^{-3}\, m\cdot K}{2\times10^{4}\, K} = 1.45\times10^{-7}\, m = 145nm$$

(b) λ_m is in the ultraviolet region of the electromagnetic spectrum.

3-21. Equation 3-4: $R = \sigma T^4$

$P_{abs} = \left(1.36\times10^3 W/m^2\right)\left(\pi R_E^2 m^2\right)$ where R_E = radius of Earth

$P_{emit} = \left(RW/m^2\right)\left(4\pi R_E^2\right) = \left(1.36\times10^3 W/m^2\right)\left(\pi R_E^2 m^2\right)$

$$R = \left(1.36\times10^3 W/m^2\right)\left(\frac{\pi R_E^2}{4\pi R_E^2}\right) = \frac{1.36\times10^3}{4}\frac{W}{m^2} = \sigma T^4$$

$$T^4 = \frac{1.36\times10^3 W/m^2}{4\left(5.67\times10^{-8} W/m^2\cdot K^4\right)} \quad \therefore \quad T = 278.3K = 5.3°C$$

3-22. (a) $\lambda_m T = 2.898\times10^{-3} m\cdot K \quad \therefore \quad \lambda_m = \dfrac{2.898\times10^{-3} m\cdot K}{3300K} = 8.78\times10^{-7} m = 878nm$

$$f_m = c/\lambda_m = \frac{3.00\times10^8 m/s}{8.78\times10^{-7} m} = 3.42\times10^{14} Hz$$

(b) Each photon has average energy $E = hf$ and $NE = 40J/s$.

$$N = \frac{40J/s}{hf_m} = \frac{40J/s}{\left(6.63\times10^{-34} J\cdot s\right)\left(3.42\times10^{14} Hz\right)} = 1.77\times10^{20}\ photons/s$$

(c) At 5m from the lamp N photons are distributed uniformly over an area $A = 4\pi r^2 = 100\pi m^2$. The density of photons on that sphere is $\left(N/A\right)/s\cdot m^2$.

The area of the pupil of the eye is $\pi\left(2.5\times10^{-3} m\right)^2$, so the number of photons entering the eye per second is:

$$n = \left(N/A\right)\left(\pi\right)\left(2.5\times10^{-3} m\right)^2 = \frac{\left(1.77\times10^{20}/s\right)\left(\pi\right)\left(2.5\times10^{-3} m\right)^2}{100\pi m^2}$$
$$= \left(1.77\times10^{20}/s\right)\left(\pi\right)\left(2.5\times10^{-3} m\right)^2 = 1.10\times10^{13}\ photons/s$$