ECE235 HW1, Harry Luo

3.17

By Stefan-Boltzmann Law, set total power $P = \kappa R$ and initial tempreture T_0 , we have

$$R = \sigma T^4 \Rightarrow P = \kappa \sigma T^4$$
$$\frac{P'}{P} = \frac{T'^4}{T^4} = \frac{(2T_0)^4}{T_0^4} = 16) \tag{1}$$

$\boxed{\text{Power increases by a factor of 16.}}$

3.19

- (a)

Let initial tempreture be T_0 and the new tempreture be T'. By Wien's Law, we have

$$\lambda T_0 = 2.898e^{-3}\ m \cdot K \quad \Rightarrow T_0 = \frac{2.898e\text{-}3}{27e\text{-}6})K = 107.33K. \tag{2}$$

Using Stefan-Boltzmann Law to find the new tempreture.

$$\frac{P'}{P} = \frac{(T')^4}{T_0^4} = 2 \quad \Rightarrow T' = \sqrt[4]{2T_0^4} = \sqrt[4]{2 * 107.33^4} = \boxed{127.63K} \tag{3}$$

- (b) By Wien's law,

$$\lambda = \frac{2.898e\text{-}3}{T'} = \frac{2.898e\text{-}3}{127.63} m = \boxed{22.7\mu m} \tag{4}$$

3.24

- (a)

Energy quantization shows:

$$E = hf = \frac{hc}{\lambda}. \tag{5}$$

Given $\lambda \in (380, 750)$nm,

$$\frac{hc}{750\text{nm}} < E < \frac{hc}{380\text{nm}} \quad \Rightarrow \boxed{E \in (1.653, 3.542)\text{eV}} \tag{6}$$

- (b)

$$E = hf = 4.136 \times 10^{-15} * 100 * 10^6\ \text{eV} = \boxed{4.136 \times 10^-7\ \text{eV}} \tag{7}$$

3.25

The orbiting space shuttle moves around Earth well above 99 percent of the atmosphere, yet it still accumulates an electric charge on its skin due, in part, to the loss of electrons caused by the photoelectric effect with sunlight. Suppose the skin of the shuttle is coated with Ni, which has a relatively large work function $\Phi = 4.87$ eV at the temperatures encountered in orbit. (a) What is the maximum wavelength in the solar spectrum that can result in the emission of photoelectrons from the shuttle's skin? (b) What is the maximum fraction of the total power falling on the shuttle that could potentially produce photoelectrons?

- (a)

By the potoelectric effect equation, at therashold wavelength, we have

$$\Phi = hf_t = h\frac{c}{\lambda_t} \quad \Rightarrow \lambda_t = \frac{hc}{\Phi} = \frac{1.24e\text{-}6}{4.87}m = \boxed{2.546e\text{-}7m} \tag{8}$$

- (b)

As suggested on Piazza, we assume constant energy density of sunlight from 0nm to 254.6nm to be the intensity of $254.6/2 = 127.3$ nm:

$$u(127.3\text{nm})(254.6\text{ nm}) = \frac{8\pi hc(127.3e\text{-}9m)^{-5}}{e^{hc/(k*5800K*127.3e\text{-}9m)} - 1} * (254.6e\text{-}9m) \approx 1.23e\text{-}4 \quad J/m^3 \tag{9}$$

Integration of the energy density is thus approximately

$$R' = \frac{1}{c}(1.23e\text{-}4) \quad W/m^3 \tag{10}$$

Total energy is given by

$$R = \sigma T^4 = \sigma * 5800K^4 \approx 6.42e7 \quad W/m^2 \tag{11}$$

Thus the fractional power is

$$\frac{R'}{R} \approx 1.4e\text{-}4 \tag{12}$$

3.26

3.28

3.31

3.32

3.42