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

- (a)

By the photoelectric 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 maximal fractional power is

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

3.26

- (a)

Using the photoelectric equation,we can find threshold freq and wavelength, f_t, λ_t as follows,

$$\Phi = hf_t = \frac{hc}{\lambda_t} \quad \Rightarrow f_t = \frac{\Phi}{h}, \quad \lambda_t = \frac{hc}{\Phi} \tag{13}$$

- (b,c,d) The stopping potential can be found as follows,

$$eV_0 = \frac{hc}{\lambda} - \Phi \quad \Rightarrow V_0 = \frac{hc}{\lambda e} - \frac{\Phi}{e}. \tag{14}$$

For $\lambda = 300$nm:

$$V_0 = \frac{hc}{e * 300e\text{-}9m} - \frac{1.9 \text{ eV}}{e} = \tag{15}$$

3.28

3.31

3.32

3.42