

# ECE235 HW1, Harry Luo

## 3.17

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

$$\begin{aligned} R &= \sigma T^4 \Rightarrow P = \kappa \sigma T^4 \\ \frac{P'}{P} &= \frac{T'^4}{T^4} = \frac{(2T_0)^4}{T_0^4} = 16 \end{aligned} \quad (1)$$

Power increases by a factor of 16.

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## 3.19

- (a)

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

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

Using Stefan-Boltzmann Law to find the new temperture.

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

- (b) By Wien's law,

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

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## 3.24

- (a)

Energy quantization shows:

$$E = hf = \frac{hc}{\lambda}. \quad (5)$$

Given  $\lambda \in (380, 750)\text{nm}$ ,

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

- (b)

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

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## 3.25

- (a)

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

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

- (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:

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

Integration of the energy density is thus approximately

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

Total energy is given by

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

Thus the maximal fractional power is

$$\frac{R'}{R} \approx 1.4e-4 \quad (12)$$

## 3.26

- (a)

Using the photoelectric equation, we can find threshold freq and wavelength,  $f_t, \lambda_t$  as follows,

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

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

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

For  $\lambda = 300\text{nm}$ :

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

## 3.28

## 3.31

## 3.32

## 3.42