

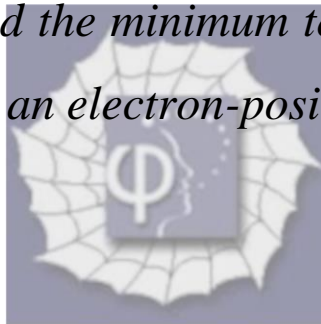
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Problem 56.27 (RHK)

The wavelengths of the photons at which a radiation field of temperature T radiates most intensely is given by $\lambda_{\max} = (2898 \mu\text{m}\cdot\text{K})/T$. We have to show (a) that the energy E in MeV of such a photon can be computed from

$$E = (4.28 \times 10^{-10} \text{ MeV/K})T.$$

(b) *We have to find the minimum temperature at which a photon can create an electron-positron pair.*



Solution:

(a)

The wavelengths of the photons at which a radiation field of temperature T radiates most intensely is given by

$\lambda_{\max} = (2898 \mu\text{m}\cdot\text{K})/T$. The energy E of a photon of wavelength $\lambda_{\max} = (2898 \mu\text{m}\cdot\text{K})/T$ will be

$$\begin{aligned}
 E &= \frac{hc}{\lambda_{\max}} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8 \text{ J s m s}^{-1}}{2898 \times 10^{-6} \text{ m.K}/T} \\
 &= \frac{6.63 \times 10^{-34} \times 3 \times 10^8 \times \text{MeV}}{2898 \times 10^{-6} \times 1.6 \times 10^{-13} \text{ K}/T} \\
 &= (4.28 \times 10^{-10} \text{ MeV/K})T.
 \end{aligned}$$

(b)

The rest mass energy of an electron (positron) is 0.51 MeV. Therefore, the minimum energy photon that can create an electron-positron pair will be 1.02 MeV.

The blackbody temperature that will radiate most intensely at wavelength corresponding to energy of 1.02 MeV will be

$$T = \frac{1.01 \text{ MeV}}{4.28 \times 10^{-10} \text{ MeV/K}} = 2.36 \times 10^9 \text{ K}.$$