920.

Problem 56.27 (RHK)

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

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

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

$$E = \frac{hc}{\lambda_{\max}} = \frac{6.63\times10^{-34}\times3\times10^{8}\ \text{J s m s}^{-1}}{2898\times10^{-6}\ \text{m.K}/T}$$

$$= \frac{6.63\times10^{-34}\times3\times10^{8}\times\ \text{MeV}}{2898\times10^{-6}\times1.6\times10^{-13}\ \text{K}/T}$$

$$= \left(4.28\times10^{-10}\ \text{MeV/K}\right)T.$$

(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

$$T = \frac{1.01\ \text{MeV}}{4.28\times10^{-10}\ \text{MeV/K}} = 2.36\times10^{9}\ \text{K}.$$