775.

Problem 52.13 (RHK)

A 20.0-keV *electron is brought to rest by undergoing two successive bremsstrahlung events, thus transferring its kinetic energy into energy of two photons. The wavelength of the second photon is 130 pm greater than the wavelength of the first photon to be emitted.* (a) *We have to find the energy of the electron after its first deceleration.* (b) *We have to calculate the wavelengths and energies of the two photons.*

Solution:

(b)

Let the wavelength of the first photon that is emitted when the electron of energy 20 keV goes through *bremsstrahlung* be λ pm. It is given that the electron emits a second photon by undergoing *bremsstrahlung* before losing all its energy and that the wavelength of the second photon is 130 pm greater than the wavelength of the first photon. That is the wavelength of the second photon is $(\lambda + 130)$ pm. We assume that the entire kinetic energy of the electron is transferred as the energy of the two photons.

We have the relation

$$hc\left(\frac{1}{\lambda\ \text{pm}}+\frac{1}{(\lambda+130)\ \text{pm}}\right)=20\times10^{3}\times1.6\times10^{-19}\ \text{J},$$

or

$$\frac{(2\lambda+130)}{\lambda(\lambda+130)}\times10^{12}\ \text{m}=\frac{20\times10^{3}\times1.6\times10^{-19}\ \text{J}}{6.63\times10^{-34}\ \text{J s}\times3\times10^{8}\ \text{m s}^{-1}},$$

or

$$\frac{(2\lambda+130)}{\lambda(\lambda+130)}=1.608\times10^{-2},$$

or

$$0.016\lambda^{2}+0.09\lambda-130=0,$$

or

$$\lambda^{2}+5.625\lambda-8125\lambda=0.$$

The physical root of this equation is

$$\lambda=87.36\ \text{pm}.$$

The wavelength of the second photon emitted by the *bremsstrahlung* of the 20 keV electron will be

$$(130+87.36)\ \text{pm}=217.36\ \text{pm}$$

The energy of the first photon will be

$$\frac{hc}{\lambda} = \frac{6.63\times10^{-34}\times3\times10^{8}}{87.36\times10^{-12}}\times6.242\times10^{18}\ \text{eV}$$
$$= 14.21\ \text{keV.}$$

(a)

Therefore, the energy of the electron after its first deceleration and the energy of the second photon will be $(20-14.21)\ \text{keV} = 5.79\ \text{keV}$.