Answer on Question 80167, Physics, Other

Question:

Calculate the de Broglie wavelength of an electron accelerated by a potential of $1000\,V$. Also calculate the wavelength of the X-rays that would be produced when these electrons strike a solid.

Solution:

(a) We can find the de Broglie wavelength of an electron from the formula:

$$\lambda = \frac{h}{\sqrt{2mE}},$$

here, $h = 6.626 \cdot 10^{-34}\,Js$ is the Planck's constant, $m = 9.11 \cdot 10^{-31}\,kg$ is the mass of the electron, $E = q\Delta V$ is the kinetic energy of the electron accelerated through the potential difference of $\Delta V = 1000\,V$ and $q = 1.6 \cdot 10^{-19}\,C$ is the charge of the electron.

Then, we get:

$$\lambda = \frac{h}{\sqrt{2mE}} = \frac{h}{\sqrt{2mq\Delta V}} = \frac{6.626 \cdot 10^{-34}\,Js}{\sqrt{2 \cdot 9.11 \cdot 10^{-31}\,kg \cdot 1.6 \cdot 10^{-19}\,C \cdot 1000\,V}} = \\ = 3.88 \cdot 10^{-11}\,m.$$

(b) We can find the wavelength of the X-rays from the formula for the energy of the photon:

$$E_{photon} = \frac{hc}{\lambda_{photon}},$$

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here, $E_{photon} = q\Delta V$ is equal to the kinetic energy of the electron, $c = 3 \cdot 10^8\ m/s$ is the speed of light.

Then, we get:

$$\lambda_{photon} = \frac{hc}{E_{photon}} = \frac{6.626 \cdot 10^{-34}\,Js \cdot 3 \cdot 10^8\,\frac{m}{s}}{1.6 \cdot 10^{-19}\,C \cdot 1000\,V} = 1.24 \cdot 10^{-9}\,m = 1.24\,nm.$$

Answer:

(a) $\lambda = 3.88 \cdot 10^{-11}\,m.$

(b) $\lambda_{photon} = 1.24 \cdot 10^{-9}\,m = 1.24\,nm.$