Lecture 3. /B

Calculation of X-ray wavelengths & frequency

If electrons are accelerated to a velocity **v** by a potential difference **V** and then allowed to collide with a metal target, the maximum frequency of the X-rays emitted is given by the equation:

$$\frac{1}{2} mv^2 = eV = hf$$

Therefore:

X ray frequency (f) = eV/h

↥↥

This mathematical formula shows that the maximum frequency is directly proportional to the accelerating voltage.

Example problem

Q/Calculate the minimum wavelength of X-rays emitted when electrons accelerated through 30 kV strike a target.

Answer is:-

f = $[1.6 \times 10^{-19} \times 3 \times 10^{4}] / 6.63 \times 10^{-34} = 7.2 \times 10^{18}$ Hz

Therefore the wavelength

λ (= c/f) is 0.41×10^{-10} m = 0.04 1 nm (compared with some 600 nm for yellow light)

(Quizzes examination No. 1) Q1/ Calculate the: - 1-maximum energy &

2- minimum wavelength for an x-ray beam generated at 100 kVp.

Answer /

The maximum energy (keV) numerically equals the maximum tube voltage (kVp).
Because the maximum tube voltage is 100 kVp, the maximum energy of the photons is 100 keV:

λ_{min}= {1.24}/{100 kVp}

$\lambda min=0.0124\ nm$

Q2/

Find the

(a) maximum frequency

(b) Minimum wavelength of X-rays produced by 30 kV electrons.

The Solutions

(a).

Potential of the electrons, $V=30kV=3\times10^{4}V$

Hence, energy of the electrons, $E=3\times10^{4}$ eV

Where,

e = Charge on an electron = $1.6\times10^{-19}C$

Maximum frequency produced by the X-rays is ν

The energy of the electrons is given by the relation is $E=h\nu$

Where,

h = Planck's constant = 6.626×10^{-34}Js

$\nu=E/h=7.24\times10^{18}$Hz

(**b**).

Energy of a electron, $E=30\times10^{3}$eV

Let Maximum frequency produced by the X-rays be ν

$\nu=E/h=1.6\times10^{-19}\times3\times10^{4}/6.626\times10^{-34}=7.24\times10^{18}$Hz where h is the planck's constant.

The minimum wavelength produced by the X-rays is given as-

$\lambda=c/\nu=0.0414$nm