

### Examples

1. Determine the energy possessed by X-rays whose frequency is  $4 \times 10^{17}$  Hz.

Solution

$$E = hf \Rightarrow 6.63 \times 10^{-34} \times 4 \times 10^{17} = 2.652 \times 10^{-16} \text{ J.}$$

2. An x-ray tube operates at 60 kV and the current through it is 4.0 mA. Calculate the,
- Number of electrons striking the target per second.
  - Speed of the electrons when they hit the target.

Solution

- a) Current through the tube is given by  $I = ne$ , where  $n$ - number of electrons striking target per second and  $e$ - electronic charge ( $e = 1.6 \times 10^{-19}$  coulombs)

$$\text{So, } n = I/e = (4.0 \times 10^{-3}) / 1.6 \times 10^{-19} = 2.5 \times 10^{16} \text{ electrons.}$$

- b) Kinetic energy = electrical energy

$$\frac{1}{2} m_e v^2 = eV, \text{ then } v = \sqrt{\frac{2eV}{m_e}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 60 \times 10^3}{9.0 \times 10^{-31}}} = 2.13 \times 10^8 \text{ m/s.}$$

3. An 18 kV accelerating voltage is applied across an X-ray tube. Calculate:

- The velocity of the fastest electron striking the target
- The minimum wavelength in the continuous spectrum of X-rays produced. (mass of electron- $9 \times 10^{-31}$  kg, charge on an electron- $1.6 \times 10^{-19}$  C,  $h$ -  $6.6 \times 10^{-34}$  J/s,  $c$ -  $3 \times 10^8$  m/s)

Solution

a)  $V = 18 \times 10^3$  V

$$m_e = 9 \times 10^{-31} \text{ kg}$$

$$e = 1.6 \times 10^{-19} \text{ C}$$

$$h = 6.6 \times 10^{-34} \text{ J/s}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$\frac{1}{2} m_e v^2 = eV; \text{ therefore } v = \sqrt{\frac{2eV}{m_e}} = \sqrt{\frac{2 \times 1.6 \times 10^{-19} \times 18 \times 10^3}{9 \times 10^{-31}}} = 8 \times 10^7 \text{ m/s}$$

- b)  $(hc) / \lambda_{\text{min}} = eV; \lambda_{\text{min}} = hc / eV$

$$\lambda_{\text{min}} = (6.6 \times 10^{-34} \times 3 \times 10^8) / (1.6 \times 10^{-19} \times 18 \times 10^3) = 6.9 \times 10^{-11} \text{ m.}$$

# Physics Form 4 Notes

**J Rink**



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