Previous Year JEE Problems with Explanations

If p is the momentum of the fastest electron ejected from a metal surface after the irradiation of light having wavelength λ, then for 1.5 p momentum of the photoelectron, the wavelength of the light should be

(Assume kinetic energy of ejected photoelectron to be very high in comparison to work function) **(2019 Main, 8 April II)**

(a) $\frac{4}{9}\lambda$ (b) $\frac{3}{4}\lambda$

(c) $\frac{2}{3}\lambda$ (d) $\frac{1}{2}\lambda$

The expression of kinetic energy of photo electrons,

$$KE = \frac{1}{2}mv^2 = E - E_0$$

When, $KE >> E_0$, the equation becomes,

$$KE = \frac{1}{2}mv^2 = E$$

$$\Rightarrow \quad \frac{1}{2}mv^2 = \frac{hc}{\lambda} \Rightarrow \frac{p^2}{2m^2} = \frac{hc}{\lambda}$$

$$\Rightarrow \lambda = hc \times 2m^2 \times \frac{1}{p^2} \Rightarrow \lambda \propto \frac{1}{p^2}$$

$E = \frac{hc}{\lambda}$ = energy of incident light.

E_0 = threshold energy or work functions,

$$\frac{1}{2}mv^2 = \frac{1}{2} \times \frac{(mv)^2}{m^2} = \frac{1}{2} \times \frac{p^2}{m^2}$$

$\because p$ = momentum = mv

As per the given condition,

$$\frac{\lambda_2}{\lambda_1} = \left(\frac{p_1}{p_2}\right)^2$$

$$\Rightarrow \qquad \frac{\lambda_2}{\lambda} = \left(\frac{p}{1.5 \times p}\right)^2 = \left(\frac{2}{3}\right)^2 = \frac{4}{9}$$

$$\Rightarrow \qquad \lambda_2 = \frac{4}{9}\lambda \qquad \left[\because \begin{matrix} \lambda_1 = \lambda \\ p_1 = p \end{matrix}\right]$$