Related Problems

Question 4

Following results are observed when sodium metal is irradiated with different wavelengths. Calculate threshold wavelength.

λ (nm)	500	450	400
$\upsilon \times 10^{-5}$ (cm s^{-1})	2·55	4·35	5·35

Answer:

λ(m)	:	500×10^{-9}	450×10^{-9}	400×10^{-9}
υ(m s^{-1})	:	$2{\cdot}55 \times 10^{5}$	$4{\cdot}35 \times 10^{5}$	$5{\cdot}35 \times 10^{5}$

Let threshold wavelength $= \lambda_0$ nm $= \lambda_0 \times 10^{-9}$ m

According to photoelectric effect :

$$h(\upsilon - \upsilon_0) = \frac{1}{2} m\upsilon^2$$

$$hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right) = \frac{1}{2} m\upsilon^2$$

Substituting the results of three experiments in the above equation :

$$\frac{hc}{10^{-9}}\left(\frac{1}{500} - \frac{1}{\lambda_0}\right) = \frac{1}{2} m(2{\cdot}55 \times 10^5)^2 \quad \ldots(i)$$

$$\frac{hc}{10^{-9}}\left(\frac{1}{450} - \frac{1}{\lambda_0}\right) = \frac{1}{2} m(4{\cdot}35 \times 10^5)^2 \quad \ldots(ii)$$

$$\frac{hc}{10^{-9}}\left(\frac{1}{400} - \frac{1}{\lambda_0}\right) = \frac{1}{2} m(5{\cdot}35 \times 10^5)^2 \quad \ldots(iii)$$

Divide eqn. *(ii)* by eqn. *(i)*,

$$\frac{(\lambda_0 - 450)}{450 \times \lambda_0} \times \frac{500 \times \lambda_0}{(\lambda_0 - 500)} = \frac{(4{\cdot}35 \times 10^5)^2}{(2{\cdot}99 \times 10^5)^2}$$

or $$\frac{(\lambda_0 - 450)}{(\lambda_0 - 500)} = \frac{(4{\cdot}35)^2}{(2{\cdot}99)^2} \times \frac{450}{500} = 2{\cdot}619$$

or $$(\lambda_0 - 450) = 2{\cdot}619\,(\lambda_0 - 500) = 2{\cdot}619\,\lambda_0 - 1309{\cdot}5$$

or $$1{\cdot}619\,\lambda_0 = 859{\cdot}5 \therefore \lambda_0 = \frac{859{\cdot}5}{1{\cdot}619} = \mathbf{531\ nm}$$