ILLUSTRATIONS OF OBJECTIVE QUESTIONS

1. The maximum kinetic energy of photoelectrons ejected from a metal, when it is irradiated with radiation of frequency $2 \times 10^{14}\ s^{-1}$ is 6.63×10^{-20} J. The threshold frequency of the metal is:

(a) $2 \times 10^{14}\ s^{-1}$ (b) $3 \times 10^{14}\ s^{-1}$

(c) $2 \times 10^{-14}\ s^{-1}$ (d) $1 \times 10^{-14}\ s^{-1}$

(e) $1 \times 10^{14}\ s^{-1}$

[**Ans.** (e)]

[**Hint :** Absorbed energy = Threshold energy + Kinetic energy of photoelectrons

$$h\nu = h\nu_0 + KE$$
$$h\nu_0 = h\nu - KE$$
$$6.626 \times 10^{-34} \times \nu_0 = 6.626 \times 10^{-34} \times 2 \times 10^{14} - 6.63 \times 10^{-20}$$
$$\nu_0 = \frac{1.3252 \times 10^{-19} - 6.63 \times 10^{-20}}{6.626 \times 10^{-34}}$$
$$\nu_0 = 9.99 \times 10^{13} = 10^{14}\ s^{-1}]$$

2. If λ_0 and λ be the threshold wavelength and the wavelength of incident light, the velocity of photoelectrons ejected will be:

(a) $\sqrt{\frac{2h}{m}(\lambda_0 - \lambda)}$ (b) $\sqrt{\frac{2hc}{m}(\lambda_0 - \lambda)}$

(c) $\sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$ (d) $\sqrt{\frac{2h}{m}\left(\frac{1}{\lambda_0} - \frac{1}{\lambda}\right)}$

[**Ans.** (c)]

[**Hint :** Absorbed energy = Threshold energy + Kinetic energy of photoelectrons

$$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + \frac{1}{2}mv^2$$
$$v = \sqrt{\frac{2hc}{m}\frac{(\lambda_0 - \lambda)}{\lambda\lambda_0}}\ ]$$

3. A radiation of wavelength λ illuminates a metal and ejects photoelectrons of maximum kinetic energy of 1eV. Another radiation of wavelength $\frac{\lambda}{3}$, ejects photoelectrons of maximum kinetic energy of 4 eV. What will be the work function of metal?

(a) 1 eV (b) 2 eV (c) 0.5 eV (d) 3 eV

[**Ans.** (c)]

[**Hint :** Absorbed energy = Threshold energy + Kinetic energy of photoelectrons

$$h\frac{c}{\lambda} = E_0 + 1\ \text{eV} \quad ...(i)$$
$$3h\frac{c}{\lambda} = E_0 + 4\text{eV} \quad ...(ii)$$
$$3(E_0 + 1\ \text{eV}) = E_0 + 4\text{eV}$$
$$E_0 = 0.5\ \text{eV}]$$

4. The ratio of slopes of maximum kinetic energy *versus* frequency and stopping potential (V_0) *versus* frequency, in photoelectric effect gives:

(a) charge of electron (b) planck's constant

(c) work function (d) threshold frequency

[**Ans.** (a)]

[**Hint :**
$$h\nu = h\nu_0 + eV_0$$
$$eV_0 = h\nu - h\nu_0$$
$$V_0 = \frac{h}{e}\nu - \frac{h}{e}\nu_0 \quad ...(i)$$
$$(\text{Slope})_1 = h/e$$
$$(\text{KE})_{max} = h\nu - h\nu_0 \quad ...(ii)$$
$$(\text{Slope})_2 = h$$
$$(\text{Slope})_2 / (\text{Slope})_1 = \frac{h}{h/e} = e]$$

5. Ground state energy of H-atom is ($-E_1$), the velocity of photoelectrons emitted when photon of energy E_2 strikes stationary Li^{2+} ion in ground state will be:

(a) $v = \sqrt{\frac{2(E_2 - E_1)}{m}}$ (b) $v = \sqrt{\frac{2(E_2 + 9E_1)}{m}}$

(c) $v = \sqrt{\frac{2(E_2 - 9E_1)}{m}}$ (d) $v = \sqrt{\frac{2(E_2 - 3E_1)}{m}}$

[**Ans.** (c)]

[**Hint:** Threshold energy of $Li^{2+} = 9E_1$

Absorbed energy = Threshold energy + Kinetic energy of photoelectrons

$$E_2 = 9E_1 + \frac{1}{2}mv^2$$
$$mv^2 = 2(E_2 - 9E_1)$$
$$v = \sqrt{\frac{2(E_2 - 9E_1)}{m}}\ ]$$

Photoelectric effect ($h\nu = w_0 + \frac{1}{2}mv^2$)

work function

Examples

(2) $h\nu = h\nu_0 + \frac{1}{2}mv^2$

$\frac{hc}{\lambda} = \frac{hc}{\lambda_0} + \frac{1}{2}mv^2 \Rightarrow \frac{1}{2}mv^2 = \frac{hc}{\lambda} - \frac{hc}{\lambda_0}$

$= hc\left(\frac{1}{\lambda} - \frac{1}{\lambda_0}\right)$

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

$v = \sqrt{\frac{2hc}{m}\left(\frac{\lambda_0 - \lambda}{\lambda\lambda_0}\right)}$

(3) $\frac{hc}{\lambda} = w_0 + 1\,eV$ — (1) ✓

$\frac{hc}{\lambda/3} = w_0 + 4\,eV$ — (2)

$\frac{3hc}{\lambda} = w_0 + 4\,eV$

$\frac{hc}{\lambda} = \frac{w_0}{3} + \frac{4}{3}$ — (2)' ✓

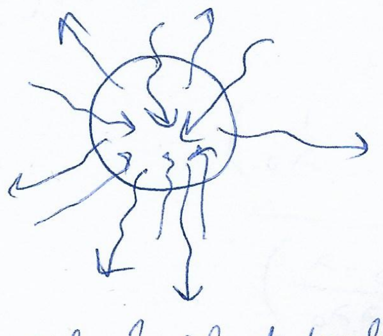
(1) − (2)' $\Rightarrow 0 = w_0 - \frac{w_0}{3} + 1 - \frac{4}{3}$

$\frac{4}{3} - 1 = \frac{2w_0}{3} = \frac{1}{3}$

$\underline{w_0 = \frac{1}{2} = 0.5\,eV}$

(2) Black body Radiation

→ Black body is a perfect absorber and emitter of radiation
does not reflect any radiatio



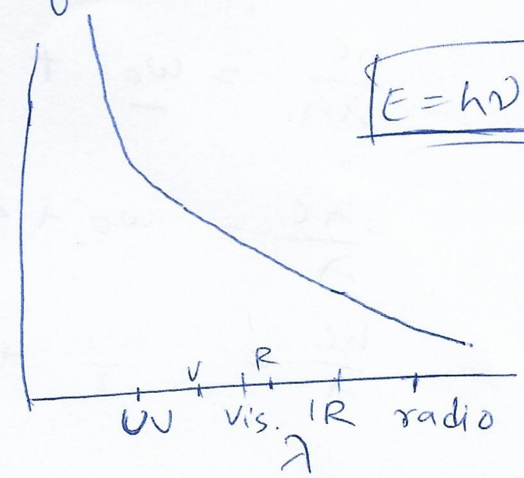
Ideal black body

→ can absorb radiation of all wavelengths and emits radiation of all wavelengths

heat → IR

$E = h\nu$

$= \frac{hc}{\lambda}$

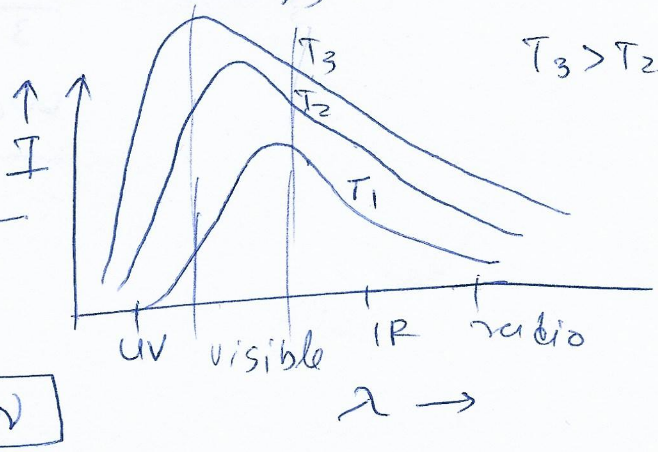


$\boxed{E = h\nu}$

Radiation emitted

I = Energy × no. of photons having that energy

$I \propto E$



$T_3 > T_2 > T_1$

Can be explained based on quantum theory of radiation $\boxed{E = nh\nu}$

Summary of Dual nature of radiation

(i) Phenomena based on wave nature of light for exemple interference, diffraction, polarisation

(ii) Phenomena based on particle nature of light for exemple photoelectric effect, Black body radiation

(iii) phenomena can be explained on any wave or particle nature for example rectilinear propagation, reflection