10th January 2024

E4 If the LED ~~light~~ bulb emits red light with frequency 650 nm in E2 then as per Planck's proposal, how many light quanta pass through the ~~bulb~~ ~~bulb~~ square per second.

Soln: $\lambda = 650\text{nm}$ / $A = (10\text{cm})^2$

$W = 5W$, $\boxed{S = nh\nu}$

$$nA = \frac{SA}{n\nu} = \frac{SA\lambda}{nc}$$

$$\Rightarrow nA = \frac{(SA)\lambda}{nc} \Rightarrow nA = \frac{W\lambda}{nc}$$

$$\Rightarrow nA = \frac{(5)(650\times10^{-9})}{(6.626\times10^{-34})(3\times10^{8})}$$

$$= \frac{(5)(650)}{(6.626)(3)} \times 10^{17}$$

$$= 1.6\times10^{19}\ s^{-1}$$

(*) E5 (Q3/A2) Estimate the peak electric field caused by a single light-quanta in the E2

We will see that Maxwell equations predict correctly in it's own domain. But Planck's hypothesis expands it.

(2) Photoelectric effect:

If a light beam falls on a material then electrons are emitted from the material.

(*) Lennard (1902 AD): Observed that the kinetic energy of the emitted electrons increases if the frequency of incident light beam is increased.

→ This is in conflict with Maxwell equations, as it states that energy of EM wave depends only on the intensity. (not on frequency)

⊛ Albert Einstein: (1905)

→ Using Planck's idea of light quanta, the maximum kinetic energy of an emitted electrons ~~should be~~ are given.

$$KE_{max} = h\nu - W$$

- KE_{max} → Max KE of electron
- $h\nu$ → Energy of light quanta
- W → Binding energy of the electron (work function)

→ This matched with experiment.

E6 In a photo-electric expt. the max K.E of an emitted electron found to be 0.86 eV and 0.37 eV when corresponding incident lights were violet (400nm) and blue (475nm). Determine the value of the Planck's constant. Does the material show any photoelectric effect if one uses red light beam (620nm)

Soln:

$$0.86 = h(400\times10^{-9}) - W$$

$$0.37 = h(475\times10^{-9}) - W$$

$$\Rightarrow W = h(475\times10^{-9}) - 0.37$$

~~$\Rightarrow 0.86 = h(400\times10^{-9}) - h(475$~~

$$\Rightarrow 0.37 - 0.86 = h(75\times10^{-9})$$

$$\Rightarrow h = \frac{(0.37-0.86)(1.6\times10^{-19})}{(75\times10^{-9})}$$

$$\Rightarrow \boxed{h = 4.14\times10^{-15}\ eV\cdot s}$$

$$\therefore W = (4.14)(10^{-15})(475\times10^{-9}) - 0.37$$

$$\Rightarrow \boxed{W = 2.24\ eV}$$

The energy of light quanta of red color = 2.0 eV
which is lower than the work function.

(3) Spectral lines in photo-emission →

→ Observations
↳ one see only certain lines (wavelengths) that are present in any photo emission spectrum.

(*) classically, it should have all ~~dis~~ lines.