DPP 04

SOLUTION

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1. $\lambda_1 = 500 \text{ nm}, KE_1 = K, \lambda_2 = 200 \text{ nm}, KE_2 = 3K$

Work function of the metal is W. From Einstein's photoelectric equation, $K_E = \frac{hc}{\lambda} - W$

First case, $K = \frac{hc}{500} - W$ ...(i)

After the wavelength is decreased, $3K = \frac{hc}{200} - W$ ...(ii)

From(ii) and (i)

$$3 = \frac{\frac{hc}{200} - W}{\frac{hc}{500} - W}$$

$$\frac{3 \times 1237.5}{500} - 3W = \frac{1237.5}{200} - W \ [\because hc = 1237.5 eV]$$

Hence, $W = 0.61 eV$

2. $\lambda_1 = 1 \text{ nm}, \lambda_2 = 500 \text{ nm}, P = 200 \text{ W}$ Power $= n \cdot \frac{hc}{\lambda}$

Number of photons/secs $= n$

So, power is same, $n \propto \lambda$

$$\frac{n_1}{n_2} = \frac{\lambda_1}{\lambda_2} = \frac{1}{500}$$

3. $K_{max} = eV_0 = hv - \phi$

$= 6.62 \times 10^{-34} \times 6 \times 10^{14} - 2 \times 1.6 \times 10^{-19} = 7.72 \times 10^{-20} \text{ J}$

$$\therefore V_0 = \frac{7.72 \times 10^{-20}}{1.6 \times 10^{-19}} = 0.48 \text{ V}$$

4. Einstein's equation of photoelectric effect

$hv = \phi + eV_0$

$$V_0 = \frac{hv}{e} - \frac{\phi}{e}$$

V_0 -stopping potential

From the graph $V_0 = 0$ at $v = 4 \times 10^4$ Hz

$$0 = \frac{h \times 4 \times 10^{14}}{1.6 \times 10^{-19}} - \frac{\phi}{e}$$

$\phi = 4 \times 10^{14} \times 6.6 \times 10^{-34} \text{ J}$

$$= \frac{4 \times 10^{14} \times 6.6 \times 10^{-34}}{1.6 \times 10^{-19}} eV = 1.66 eV$$

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5. $E_1 = \frac{1240}{350}$ eV; $E_2 = \frac{1240}{540}$ eV

Also, $v_1 = 2v_2$

Einstein photoelectric equation,

$$E - \phi = \frac{1}{2}mv^2 \Rightarrow \frac{E_1 - \phi}{E_2 - \phi} = \frac{v_1^2}{v_2^2} = 4 \Rightarrow E_1 - \phi = 4E_2 - 40$$

$$\phi = \frac{4E_2 - E_1}{3} = \frac{1240}{3}\left(\frac{4}{540} - \frac{1}{350}\right) \approx 1.88\text{eV}$$

6. $\phi = 4.7$eV

Frequency of light used for maximum energy

$$v = \frac{(6.28 \times 10^7)c}{2 \times 3.14} = 10^7 \times 3 \times 10^8 = 3 \times 10^{15}\text{ Hz}$$

$$E = hv = 6.6 \times 10^{-34} \times 3 \times 10^{15}\text{ J}$$

$$= \frac{6.6 \times 3 \times 10^{-19}}{1.6 \times 10^{-19}}\text{eV} = 12.375\text{eV}$$

Einstein photoelectric equation,

$$K_{max} = E - \phi = 12.375 - 4.7 = 7.675\text{ eV} \approx 7.72\text{ eV}$$

7. Threshold wavelength for sphere be λ_0.

Einstein's photoelectric equation

$$eV_s = \frac{hc}{\lambda} - \frac{hc}{\lambda_0} \therefore eV = \frac{hc}{\lambda_1} - \frac{hc}{\lambda_0}$$

$$3eV = \frac{hc}{\lambda_2} - \frac{hc}{\lambda_0}$$

$$eV' = \frac{hc}{\lambda_3} - \frac{hc}{\lambda_0}$$

8.

9. Einstein's photoelectric equation $K_{max} = hv - \phi_0$

v = frequency of incident light

ϕ_0 = work function of the metal

Since $K_{max} = eV_0$

$V_0 = \frac{hv}{e} - \frac{\phi_0}{e}$ As $v_{\text{X-rays}} > v_{\text{Ultraviolet}}$

So, both K_{max} and V_0 increase when ultraviolet light is replaced by X-rays.

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10. Power of a source, $P = 4\text{ kW} = 4 \times 10^3\text{ W}$

Number of photons emitted per second, $N = 10^{20}$

Energy of photon, $E = h\nu = \frac{hc}{\lambda}$

$\because\ E = \frac{P}{N}\ \therefore \frac{hc}{\lambda} = \frac{P}{N}$

or $\lambda = \frac{Nhc}{P} = \frac{10^{20} \times 6.63 \times 10^{-34} \times 3 \times 10^8}{4 \times 10^3}$

$= 4.972 \times 10^{-9}\text{ m} = 49.72\text{Å}$