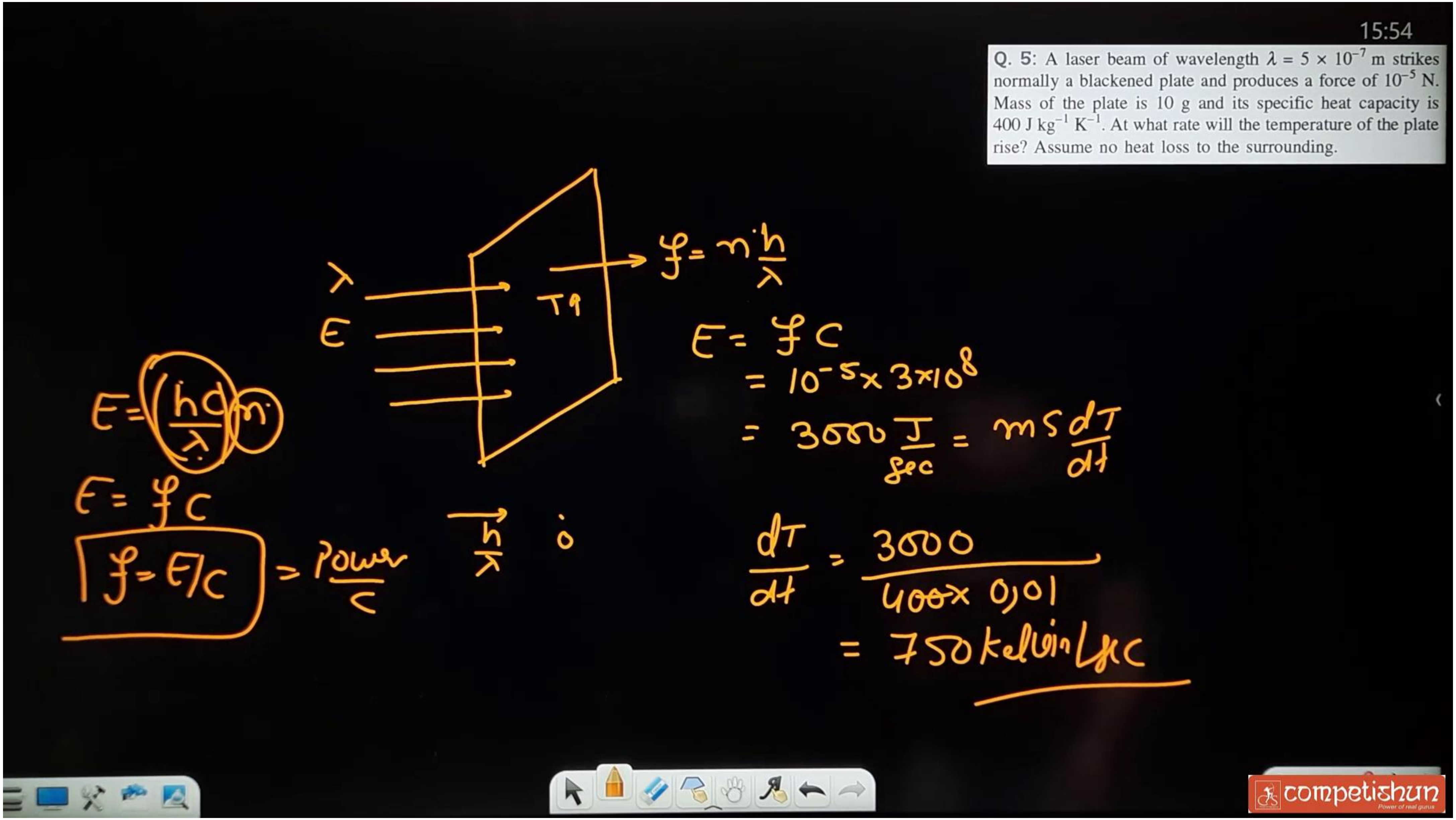
15:54
Q. 5: A laser beam of wavelength λ = 5 × 10^-7 m strikes normally a blackened plate and produces a force of 10^-5 N. Mass of the plate is 10 g and its specific heat capacity is 400 J kg^-1 K^-1. At what rate will the temperature of the plate rise? Assume no heat loss to the surrounding.
λ
E
T↑
F = n h/λ
E = hc/λ n
E = F c
F = E/c = Power/c
E = F C
= 10^-5 × 3×10^8
= 3000 J/sec = m s dT/dt
dT/dt = 3000 / (400 × 0.01)
= 750 kelvin/sec
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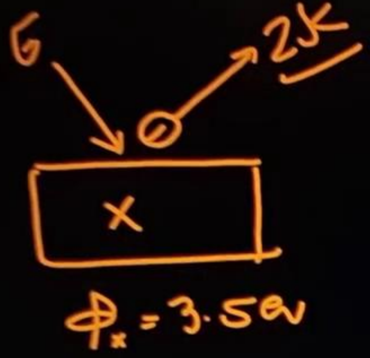
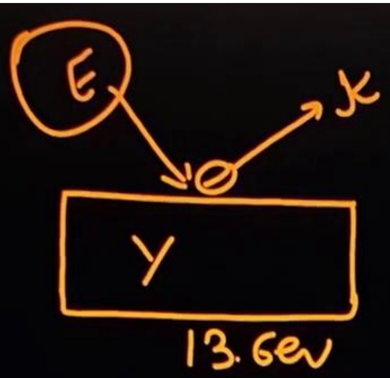
**Q. 7:** Work function of metal $X$ is equal to 3.5 eV and work function of material $Y$ is equal to ionization energy of $He^+$ ion in its first excited state. Light of same wavelength is incident on both $X$ and $Y$. The maximum kinetic energy of photoelectrons emitted from $X$ is twice that of photoelectrons emitted from $Y$. Find the wavelength of incident light. $hc = 12400$ eV Å.




$He^+$ $n = 2$

$$E = \frac{13.6\text{ eV}}{(2)^2}(2)^2 = 13.6\text{ eV}$$

$$K = E - 13.6$$
$$2K = E - 3.5$$

$$2E - 27.2 = E - 3.5$$
$$E = 27.2 - 3.5$$
$$= 23.7\text{ eV} = \frac{hc}{\lambda} = \frac{12400\text{ eV-Å}}{\lambda}$$

$$\lambda = \frac{12400}{23.7}\text{ Å} = 523\text{ Å}$$

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**Q. 19:** The circumference of circular orbit of electron in a $He^+$ ion is five times the de-Broglie wavelength associated with the electron. Find the radius of the orbit.


$$\lambda = \frac{h}{mv}$$

$$2\pi r = 5\frac{h}{mv}$$

$$mvr = 5\frac{h}{2\pi} \qquad n = 5$$

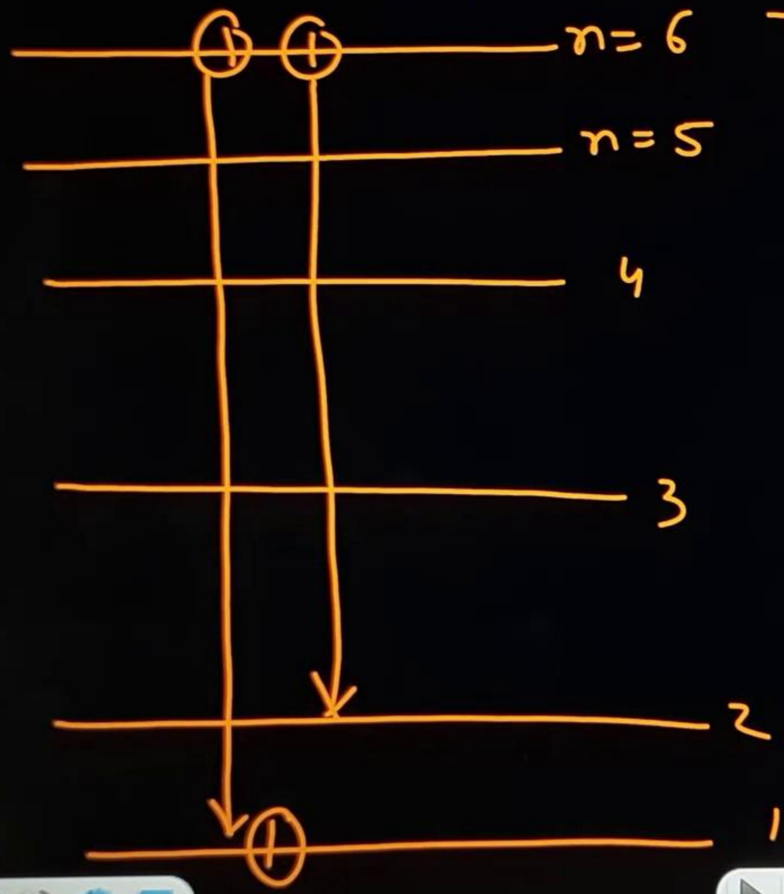
$$r = 0.529 \times \frac{5^2}{2}$$

$$= 0.529 \times \frac{25}{2} \, Å$$

Q. 22: Hydrogen like atoms (atomic number = Z) in a sample are in excited state with principal quantum number $n$. The emission spectrum of the sample has 15 different lines. The second most energetic photon emitted by the sample has energy of 27.2 eV. Find Z.

$$15 = {}^{n}C_2 = \frac{n(n-1)}{2}$$

$$n = 6$$




$$-13.6 \times \frac{Z^2}{6^2}$$

$$-13.6 \times \frac{Z^2}{2^2}$$

$$13.6 \times Z^2 \left\{ \frac{1}{2^2} - \frac{1}{6^2} \right\} = 27.2$$

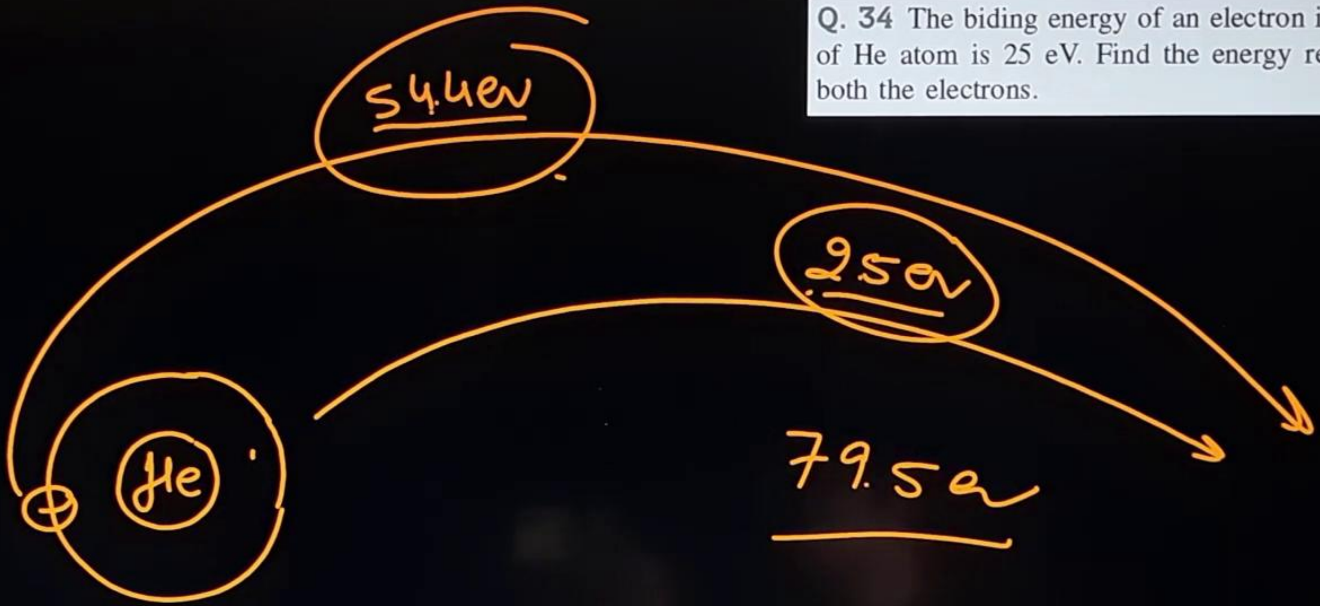
$$\frac{1}{4} - \frac{1}{36}$$

$$13.6 \times \frac{8 \times Z^2}{36} = 27.2 \quad 2$$

$$Z^2 = \frac{36 \times 4}{8}$$

$$Z = 3$$

**Q. 34** The biding energy of an electron in the ground state of He atom is 25 eV. Find the energy required to remove both the electrons.




$$He^{+} \quad E = -\frac{13.6 \times 2^2}{1^2} = -54.4\,\text{ev}$$

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Q. 38: An $X$ ray tube with Copper target is found to emit characteristic $X$ rays other than only due to Copper. The $k_\alpha$ lie of Copper has a wavelength of 1.5405 Å. The other $K_\alpha$ line observed is having a wavelength of 1.6578 Å. Identify the impurity.

$$\sqrt{f} = a(Z-b)$$

$$\sqrt{\frac{c}{\lambda}} = a(Z-1)$$

$$\sqrt{\frac{c}{1.5405\,Å}} = a(29-1)$$

$$\sqrt{\frac{c}{1.6578}} = a(Z-1)$$

$$\frac{Z-1}{28} = \sqrt{\frac{1.5405}{1.6578}} \Rightarrow Z-1 = \sqrt{\frac{1.5405}{1.6578}} \times 28 = 27$$

$$\boxed{Z \simeq 28} \text{ (Nickel)}$$

**Q. 40:** When the voltage applied to an $X$-ray tube increase[s] from 10 to 20 kV the wavelength difference between the $K$[α] line and the short wave cut-off of continuous $X$-ray spectru[m] increases by a factor of 3.0. Identify the target element.

Take $\frac{4}{3R} \simeq 1200$ Å where $R$ is Rydberg's contant an[d] $hc = 12.4$ keV Å

$K_\alpha$

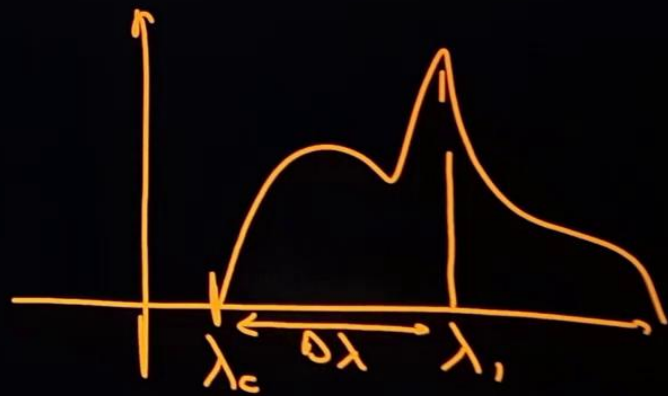
n=2

1=n

$$\frac{1}{\lambda} = R(Z-1)^2\left\{\frac{1}{1^2} - \frac{1}{2^2}\right\}$$

$$\frac{1}{\lambda} = R(Z-1)^2 \times \frac{3}{4}$$

$$\boxed{\lambda_1 = \frac{4}{3R(Z-1)^2}}$$




$$\lambda_c = \frac{12400}{V_a}$$

$$\Delta\lambda = \frac{4}{3R(Z-1)^2} - \frac{12400}{10,000} = \frac{1200}{(Z-1)^2} - 1.24$$

$$3\Delta\lambda = \frac{4}{3R(Z-1)^2} - \frac{12400}{20000} = \frac{1200}{(Z-1)^2} - 0.62 = 3\left\{\frac{1200}{(Z-1)^2} - 1.24\right\}$$

$$\underline{Z = 28.8 \simeq 29}$$ (4)

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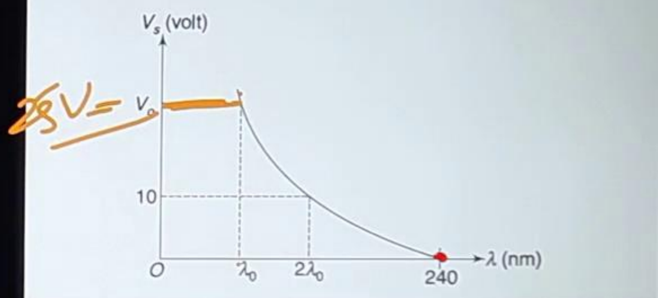
**Q. 47:** In a photoelectric experiment light of different wavelengths are used on a metal surface. For each wavelength the stopping potential difference is recorded. The given graph shows the variation of stopping potential difference ($V_s$) versus the wavelength ($\lambda$) of light used. Find the value of $V_0$ shown in the graph. Given $h = 4 \times 10^{-15}$ eVs and $c = 3 \times 10^8$ ms$^{-1}$.




$\lambda_0 = 240$ nm

$$\phi = \frac{hc}{\lambda} = \frac{4\times10^{-15}\ \text{eV-s} \times 3\times10^{8}\ \text{m/s}}{240\times10^{-9}\ \text{m}}$$

$\phi = 5$ eV

$2\lambda_0 \rightarrow 10$ eV, $\phi = 5$ eV

$E = 10\ \text{eV} + 5\ \text{eV} = 15\ \text{eV}$

$\lambda_0 \rightarrow K_{max}$, 5 eV

$K_{max} = 30\ \text{eV} - 5\ \text{eV} = 25\ \text{eV} = eV_s$

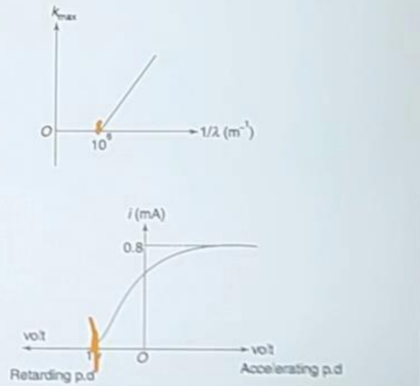
$K_{max} = eV_s$

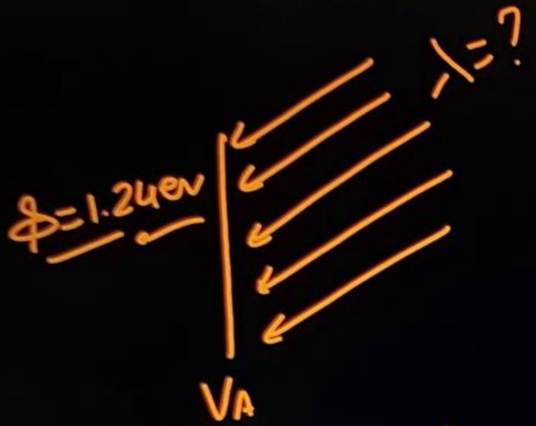
$25\ V = V_0$

**Q. 51:** In photoelectric experiment set up, the maxin kinetic energy ($k_{max}$) of emitted photoelectrons was meas for different wavelength ($\lambda$) of light used. The graph of vs $\frac{1}{\lambda}$ was obtained as shown in first figure. In the s setup, keeping the wavelength of incident light fixed at $\lambda$ applied potential difference was varied and the photoele current was recorded. The result has been shown in gr in second figure.

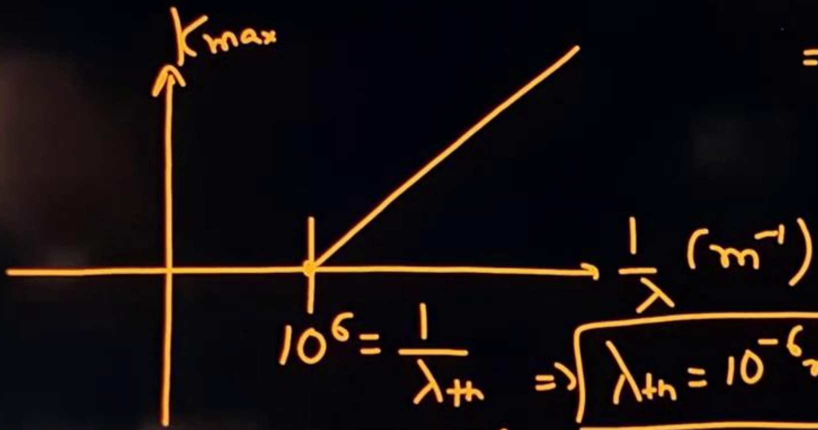
(a) Find $\lambda$ is Å

(b) Taking the photo efficiency to be 2% (i.e. percentage of incident photons which produce photoelectrons) find the power of light incident on the emitter plate in the experiment. [Take $hc = 12400$ eV Å]




$\phi = \frac{hc}{\lambda_{th}} = \frac{12400\text{ eV-Å}}{10000\text{ Å}} = 1.24\text{ eV}$




$10^6 = \frac{1}{\lambda_{th}} \Rightarrow \lambda_{th} = 10^{-6}\text{ m}$

$1V \Rightarrow K_{max} = 1\text{eV} = E - \phi$

$E = 1\text{eV} + 1.24\text{eV} = 2.24\text{eV}$

$2.24\text{eV} = \frac{12400\text{eV-Å}}{\lambda}$

$\lambda = \frac{12400}{2.24} = 5536\text{ Å}$

17:22

$i_s = 0.8\times10^{-3}\,A =$

$0.8\times10^{-3}\,C = n_e \times 1.6\times10^{-19}\,C$

$$n_e = \frac{0.8\times10^{-3}}{1.6\times10^{-19}} = \frac{0.8}{1.6}\times 10^{16} = 5\times10^{15}$$

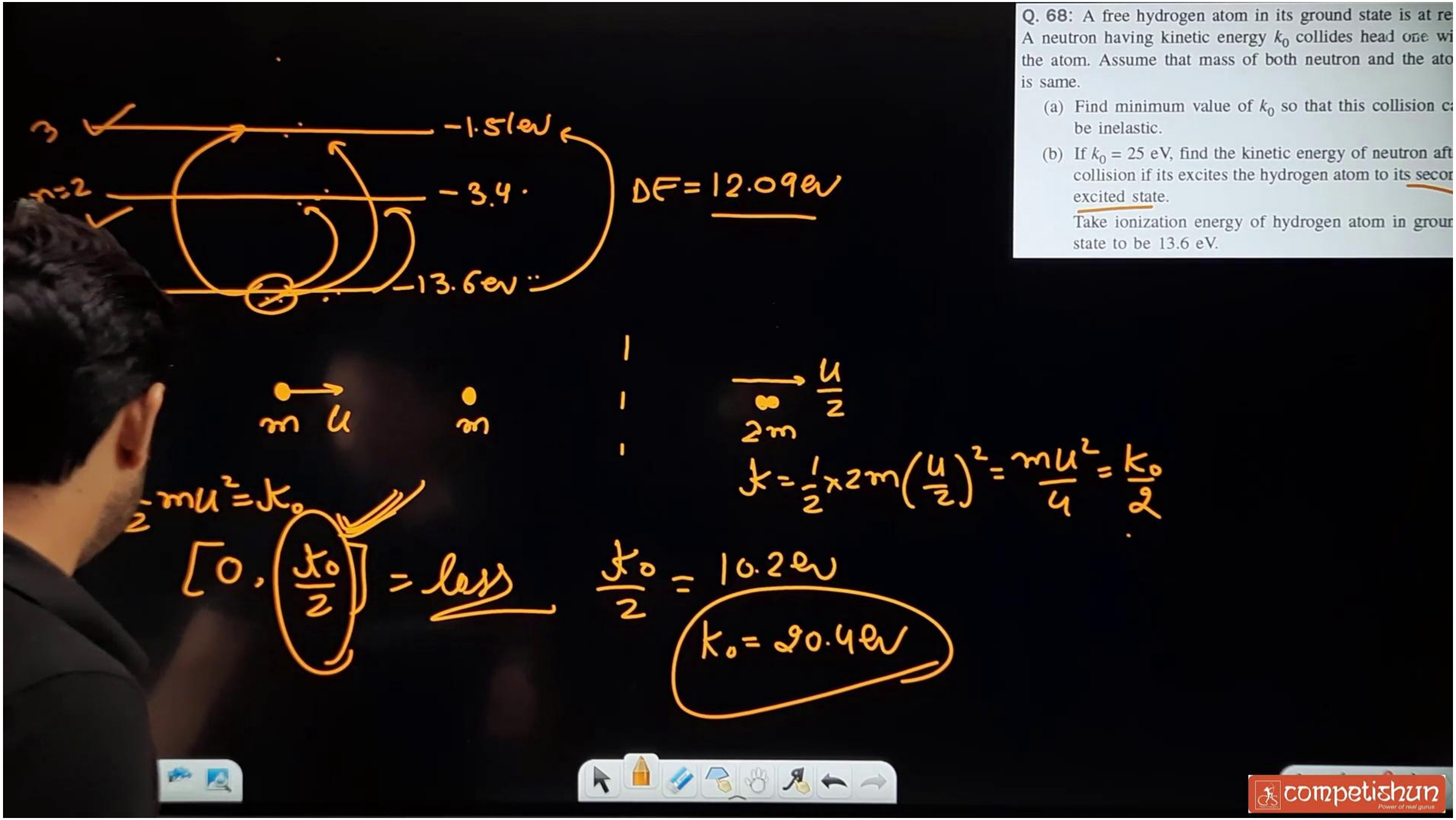
$2 \rightarrow 100$

$1 \rightarrow \frac{100}{2}$

$5\times10^{15} \rightarrow \frac{100}{2}\times 5\times10^{15} = n_p$

$n_p E = 50\times5\times10^{15}\times2.24\times1.6\times10^{-19}\,W$

$= 0.089\,\text{Watt}$


Q. 68: A free hydrogen atom in its ground state is at re
A neutron having kinetic energy $k_0$ collides head one wi
the atom. Assume that mass of both neutron and the ato
is same.
(a) Find minimum value of $k_0$ so that this collision ca
be inelastic.
(b) If $k_0$ = 25 eV, find the kinetic energy of neutron aft
collision if its excites the hydrogen atom to its secon
excited state.
Take ionization energy of hydrogen atom in groun
state to be 13.6 eV.
−1.51eV
−3.4
−13.6eV
n=2
ΔE = 12.09eV
m u
m
2m
u/2
$k = \frac{1}{2} \times 2m\left(\frac{u}{2}\right)^2 = \frac{mu^2}{4} = \frac{k_0}{2}$
$\frac{1}{2}mu^2 = k_0$
$[0, \frac{k_0}{2}]$ = loss
$\frac{k_0}{2} = 10.2eV$
$k_0 = 20.4eV$
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$$K_0 - (K_1 + K_2) = 12.09\ eV \quad \text{—} (1)$$

$$\sqrt{2mK_0} + 0 = \sqrt{2mK_1} + \sqrt{2mK_2}$$

$$K_0 = K_1 + K_2 + 2\sqrt{K_1 K_2}$$

$$K_0 - (K_1 + K_2) = 2\sqrt{K_1 K_2} = 12.09\ eV \quad \text{—} (2)$$

$$(K_1 - K_2)^2 = (K_1 + K_2)^2 - 4K_1K_2$$

$$= (12.91)^2 - (12.09)^2$$

$$= 166.66 - 146.16$$

$$= 20.49$$

$$K_1 - K_2 = \pm\sqrt{20.49}$$

8.72 eV

4.19 eV

$$K_1 + K_2 = 25\ eV - 12.09\ eV = 12.91\ eV$$

$$K_1 - K_2 = \pm(4.52)$$

$$2K_1 = 17.43$$

$$K_1 = \frac{17.43}{2}\ eV = 8.72$$

$$K_2 = 4.19$$