26th Session: Modern Physics – II (X-Rays)

- Sunday test
- Recap
- Characteristic X-Rays
- Moseley's Law

2). The electron in the hydrogen atom jumps from excited state (n=3) to its ground state (n=1) and the photons thus emitted irradiate a photosensitive material. If the work function of the material is 5.1 eV, the stopping potential is estimated to be: (The energy of the electron in n^{th} state $E_n = -\frac{13.6}{n^2}$ eV).

(1) 12.1 V

(2) 17.2 V

✓(3) 7 V

(4) 5.1 V

$h\nu = 12.09\,eV$

$\phi = 5.1\,eV$

$K_{max} = h\nu - \phi$

$= 12.09 - 5.1$

$= 6.99$

$\sim 7\,eV_s$

3). An electron of mass m and a photon have the same energy E. The ratio of de-Broglie wavelength associated with them is.

(1) $\frac{1}{c}\left(\frac{E}{2m}\right)^{\frac{1}{2}}$ ✓

(2) $\left(\frac{E}{2m}\right)^{\frac{1}{2}}$

(3) $c(2mE)^{\frac{1}{2}}$

(4) $\frac{1}{xc}\left(\frac{2m}{E}\right)^{\frac{1}{2}}$

$$\lambda_e = \frac{h}{\sqrt{2mE}}$$

$$\lambda_p = \frac{hc}{E}$$

$$\frac{\lambda_e}{\lambda_p} = \frac{h}{\sqrt{2m.E}} \times \frac{E}{hc}$$

$$= \sqrt{\frac{E}{2m}} \times \frac{1}{c}$$

4). The wavelength of the first line of Lyman series for hydrogen atom is equal to that of the second line of Balmer series for a hydrogen like ion. The atomic number Z of hydrogen like ion is.

(1) 3 (2) 4

(3) 1 (4) 2 ✓

$\frac{1}{\lambda_1} = R \times 1^2 \left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$\lambda_1 = \frac{4}{3R}$

$\frac{1}{\lambda_2} = R Z^2 \left(\frac{1}{2^2} - \frac{1}{4^2}\right)$

$\lambda_2 = \frac{16}{3RZ^2}$

$\frac{4}{3R} = \frac{16}{3RZ^2}$

$Z = 2$

ABLES KOTA

5). Consider 3rd orbit of He^+ (Helium), using non-relativistic approach, the speed of electron in this orbit will be [given K = 9×10^9 constant, Z = 2 and h (Planck's Constant) = 6.6×10^{-34} J s].

(1) 1.46×10^6 m/s (2) 0.73×10^6 m/s

(3) 3.0×10^8 m/s (4) 2.92×10^6 m/s

$V_n = (2.18\times10^6)\frac{Z}{n}$

$= 2.18\times10^6 \times \frac{2}{3}$

$= 1.46\times10^6$

6). In the spectrum of hydrogen, the ratio of the longest wavelength in the Lyman series to the longest wavelength in the Balmer series is.

✓ (1) $\frac{5}{27}$

(2) $\frac{4}{9}$

(4) $\frac{27}{5}$

(3) $\frac{9}{4}$

$\frac{1}{\lambda_1} = R \cdot 1 \cdot \left(\frac{1}{1^2} - \frac{1}{2^2}\right)$

$\frac{1}{\lambda_2} = R \cdot 1 \left(\frac{1}{2^2} - \frac{1}{3^2}\right)$

7). The transition from the state n = 3 to n = 1 in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition from.

(1) 4 → 2

(2) 4 → 2

(3) 2 → 1

(4) 3 → 2

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$$

$$\lambda = \frac{n_1^2 n_2^2}{(n_2^2 - n_1^2)} \times \frac{1}{RZ^2}$$

8). Out of the following which one is not a possible energy for a photon to be emitted by hydrogen atom according to Bohr's atomic model.

(1) 0.65 eV (2) 1.9 eV

(3) 11.1 eV (4) 13.6 eV

9). The total energy of an electron in an atom in an orbit is −3.4 eV. Its kinetic and potential energies are, respectively.

(1) –3.4 eV, –3.4 eV (2) –3.4 eV, –6.8 eV

(3) 3.4 eV, –6.8 eV (3) 3.4 eV, 3.4 eV

10). Given the value of Rydberg constant is 10^7 m^{-1}, the wave number of the last line of the Balmer series in hydrogen spectrum will be.

(1) 0.025×10^4 m^{-1}

(2) 0.5×10^7 m^{-1}

✓(3) 0.25×10^7 m^{-1}

(4) 2.5×10^7 m^{-1}

$$\frac{1}{\lambda} = RZ^2\left(\frac{1}{2^2} - \frac{1}{\infty}\right)$$

$\lambda \rightarrow$

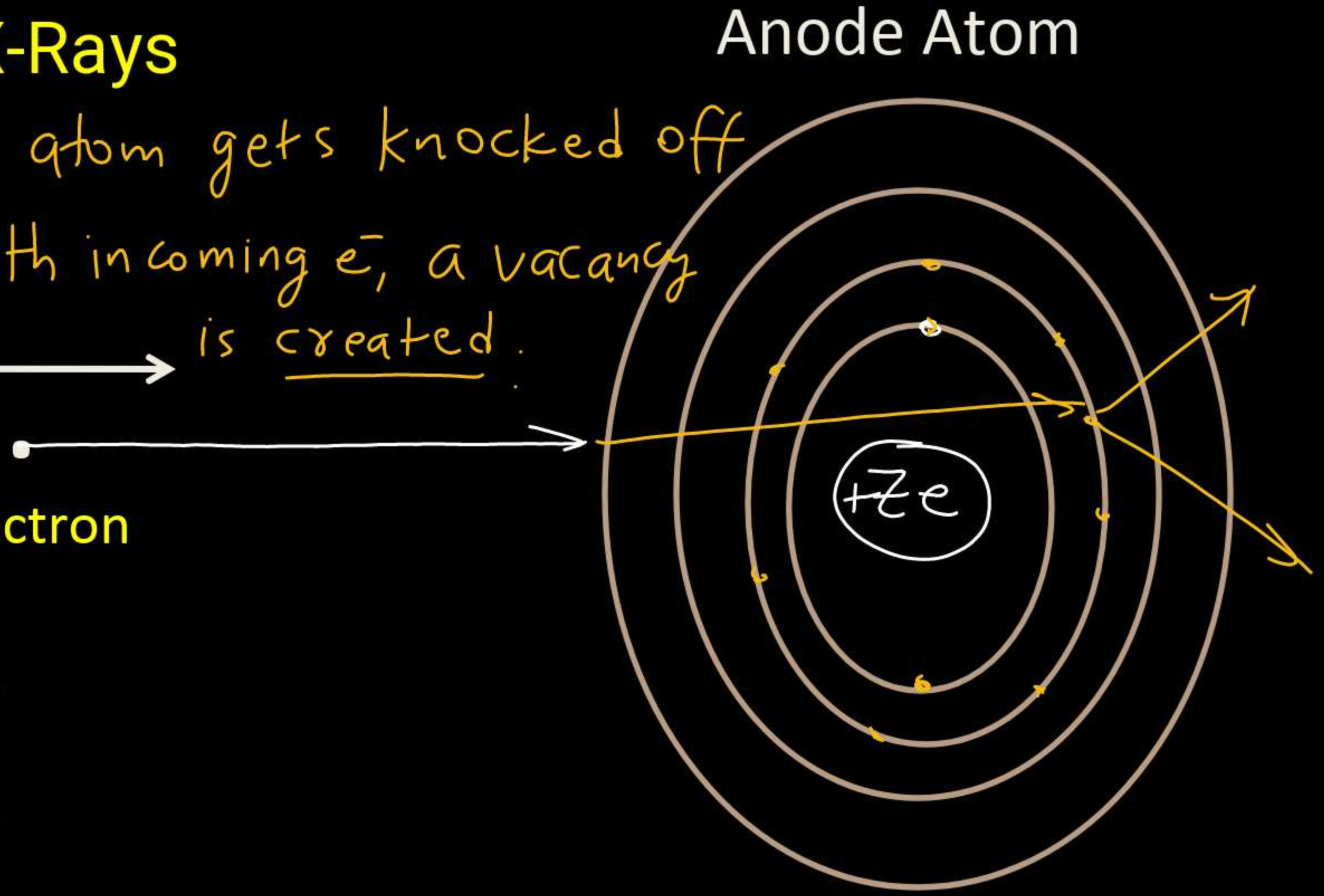
Q 1). Consider a photon of continuous X-ray coming from a Coolidge tube. Its energy comes from

a). KE of the striking electron
b). KE of the free electrons of the target
c). KE of the ions of the target
d). An atomic transition in the target

Characteristic X-Rays

If an e^- of anode atom gets knocked off due to collision with incoming e^-, a vacancy is created.

$eV = \frac{1}{2} mv^2$ →



$$\text{If } eV > \Delta E_{KShell}$$

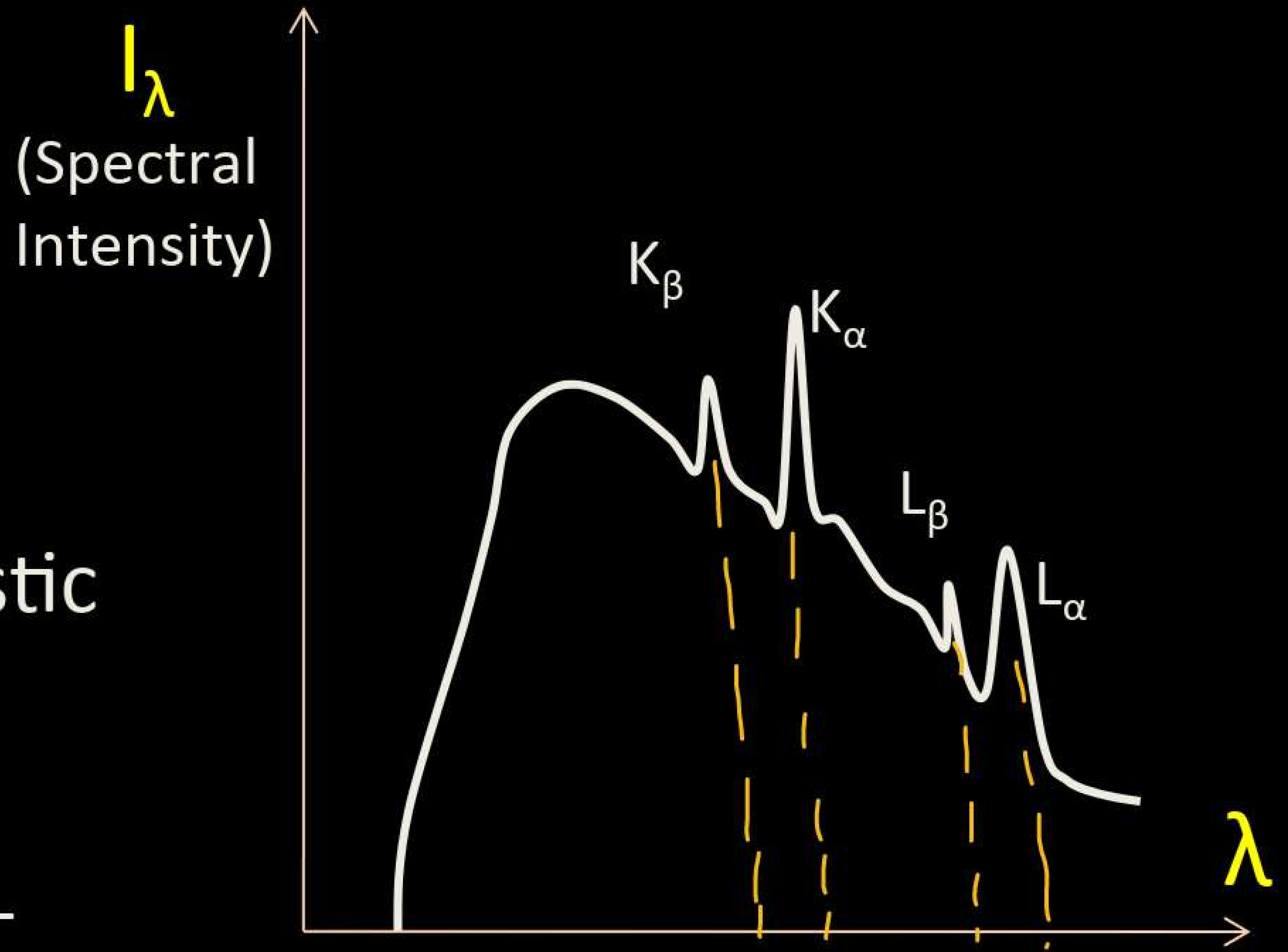
Spectrum of Characteristic X-Rays

- Eligibility of **e⁻**

$eV > E_{k\,shell}$

- Collision between **two e⁻**
- Anode material's characteristic

- Spectrum of characteristic X-Rays: K series, L series, M series



Q 2). Consider a photon of continuous X-ray & a photon of characteristic X-ray of the same wavelength, coming from a Coolidge tube. Which is different between the two

a). Frequency
b). Energy
c). Penetration power
d). Method of creation

Q 3). For a given material, the energy and wavelength of characteristic X-rays satisfy

a). $E(K_{\alpha}) > E(K_{\beta}) > E(K_{\square})$

b). $E(M_{\alpha}) > E(L_{\alpha}) > E(K_{\alpha})$

c). $\lambda(K_{\alpha}) > \lambda(K_{\beta}) > \lambda(K_{\square})$

d). $\lambda(M_{\alpha}) > \lambda(L_{\alpha}) > \lambda(K_{\alpha})$

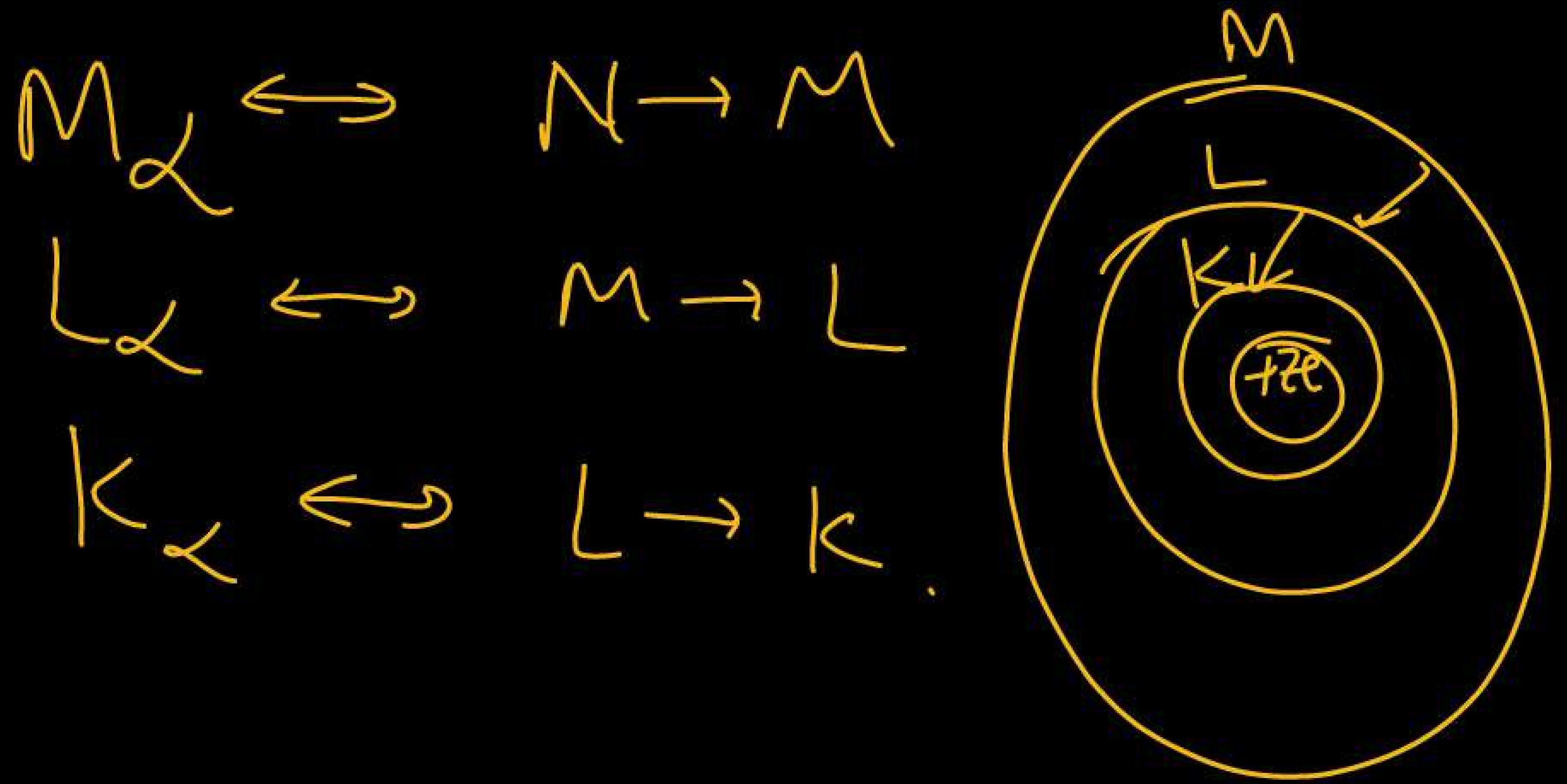
$E(K_{\alpha}) \rightarrow L \rightarrow K$

$E(K_{\beta}) \rightarrow M \rightarrow K$

$E(K_{\gamma}) \rightarrow N \rightarrow K$.

Q 3). For a given material, the energy and wavelength of characteristic X-rays satisfy

a). $E(K_{\alpha}) > E(K_{\beta}) > E(K_{?})$
b). $E(M_{\alpha}) > E(L_{\alpha}) > E(K_{\alpha})$
c). $\lambda(K_{\alpha}) > \lambda(K_{\beta}) > \lambda(K_{?})$
d). $\lambda(M_{\alpha}) > \lambda(L_{\alpha}) > \lambda(K_{\alpha})$



Characteristic X-ray series

K-series → when the incoming e^- knocks off an e^- from K shell

→ K_α, K_β, K_γ . . .
(L→K), (M→K), (N→K)

L-series → L_α, L_β . . . — " — L shell
(M→L), (N→L)

M-series → — " — M shell

$2n^2$.

K shell ($2\times1^2=2e^-$)	L shell ($8e^-$)	M shell ($18e^-$)