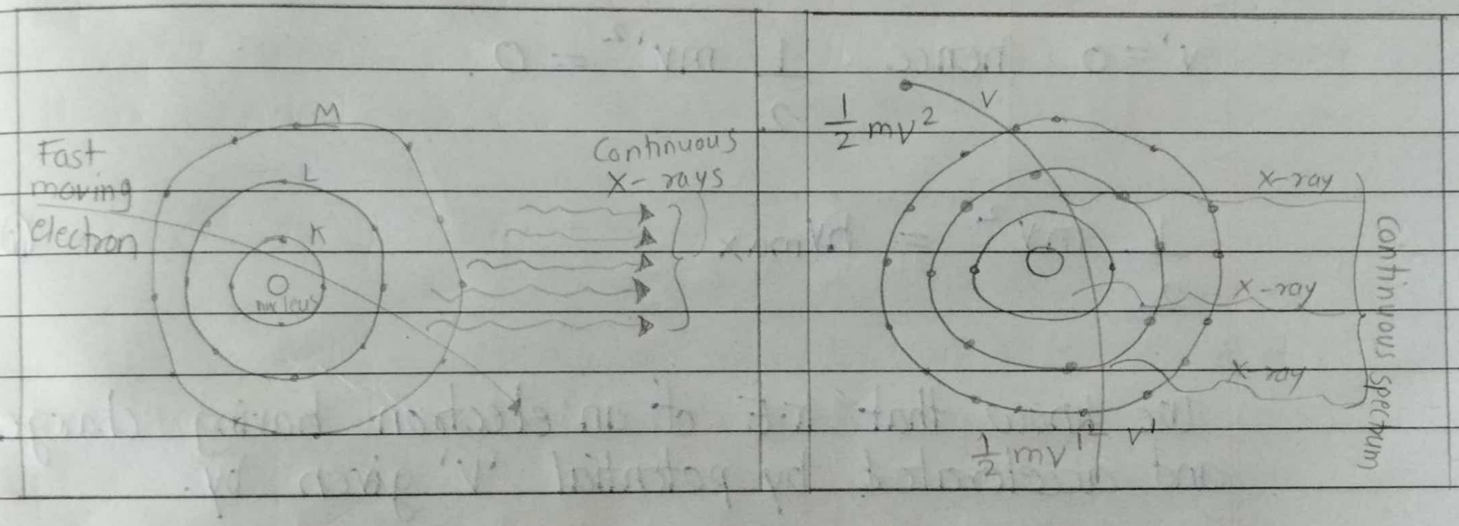
Assignment No.: 1B

1. What is X-ray? How we get the continuous spectrum in X-ray? Explain.

→ i) X rays are invisible electromagnetic radiations of very high penetration power.
ii) Under suitable conditions, X-rays are reflected and refracted ~~by~~ like Ordinary light.
iii) X-rays are electromagnetic waves of very short wavelength. They travel in straight lines with the velocity of light.
iv) The have wavelength between 0.01 to 10 nm.



① A few fast moving electrons penetrate deep into the interior of atoms of the target material & are attracted by the attractive forces of their nuclei.
② Due to these forces, the electrons get deflected by from their original paths.
③ In this way, the e^- are deaccelerated i.e. Their velocity is reduced & this gives rise to loss of energy during retardation is given off in form of electromagnetic radiations. The X-rays consists of continuous range of frequencies upto maximum frequency or minimum λ. This is called Continuous Spectrum.

Page No.
Date

④ Let the velocity of an e^- change from $v - v'$ due to deflection. If m is mass of e^- then the energy of emitted photon due to reduction in velocity of electron is

$$\frac{1}{2}mv^2 - \frac{1}{2}mv'^2 = h\nu \quad - (i)$$

⑤ When the e^- moves very close to nucleus, then it loses a greater amount of energy and consequently releases a photon of high frequency.

$v' = 0$ hence $\frac{1}{2}mv'^2 = 0$.

$$\frac{1}{2}mv^2 = h\nu_{max} \quad - (ii)$$

We know that K.E of an electron having charge e and accelerated by potential 'V' given by.

$$eV = \frac{1}{2}mv^2 \quad - (iii)$$

by eq^n (ii) & (iii)

$$eV = h\nu_{max}$$

We know that, $c = \nu\lambda$ $\therefore$ $\nu = \frac{c}{\lambda}$

$$\therefore eV = \frac{hc}{\lambda_{min}}$$

$$\therefore \lambda_{min} = \frac{hc}{eV}$$

---

2. State and Derive Mosdey's law for Characteristics X-ray spectrum.

→ Moseley's Law tells us that the atomic number is fundamental property of elements. The law basically connects the frequency of an emitted X-ray and the atomic number of an element.

- The frequency of a spectral line in the characteristics X-ray spectrum varies directly as the square of the atomic no. of the element emitting it.
- The accurate mathematical eq^n between frequency and atomic number or the eq^n of Moseley's law:

$\sqrt{v} = a(z-b)$

i) $\nu \propto (z-a)^2$

$\nu = b(z-a)^2$

where,

ν = frequency of characteristic radiation.

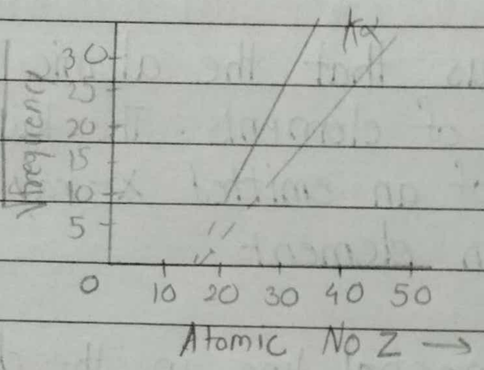
b = constant, which is different for different series.

a = constant, known as screening constant

Z = Atomic number of the target material.

ii) The frequency of a spectral line in characteristic X-ray spectrum varies directly as the square of the atomi number of the element emitting it.

iii) Moseley's diagram for K_α & K_β lines, obtained by plotting $\sqrt{\nu}$ versus Z of different elements is show in following fig.



iv) For K_α line, it was found that $b = \frac{3}{4} R$, where R is Rydberg constant and $a \approx 1$.

Hence for K_α line,

$$\nu_{K_\alpha} = \frac{3}{4} R (Z-1)^2$$

3. State and Derive Bragg's Law

→

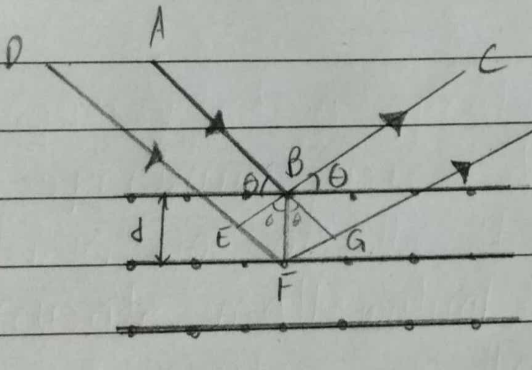
i) Consider a crystal consisting of a set of parallel planes separated by a distance 'd'.

ii) Let a narrow monochromatic beam of X-rays of wavelength λ be incident on this plane at a glancing angle θ.

iii) Consider two parallel rays ABC & DFH which are reflected by two atoms B & F in adjacent layers

iv) The path difference between them is 'EF + FG'.

v) When the path difference is equal to $n\lambda$, the reflected rays will reinforce each other to produce an intense beam.



Path difference = ~~QR + RS~~ EF + FG — (i)

$$\sin\theta = \frac{opp}{hyp} = \frac{EF}{BF} = \frac{EF}{d}$$

$$\therefore d\sin\theta = EF \qquad \text{— (ii)}$$

$$\sin\theta = \frac{FG}{BF} = \frac{FG}{d}$$

$$\therefore d\sin\theta = FG \qquad \text{— (iii)}$$

put eq^n (ii) & (iii) in (i)
we get,

Path difference $= d\sin\theta + d\sin\theta$
$= 2d\sin\theta$

$\therefore \quad n\lambda = 2d\sin\theta$

This relation is known as Bragg's Law