BRAGG'S LAW - ORDER OF DIFFRACTION

❖ **Introduction:**

❖ Bragg's Law was proposed in 1913 by W.H. Bragg and his son W.L. Bragg.

❖ For their contributions to crystallography, particularly the development of Bragg's Law, the father and son pair were awarded the Nobel Prize in Physics in 1915.

❖ It describes the condition under which X-rays are constructively diffracted by atomic planes in a crystal

❖ When the path difference between the reflected rays is equal to an integral multiple of the wavelength, constructive interference occurs, producing intense spots of maximum intensity.

❖ **Statement:**

❖ Bragg's Law states that "For constructive interference in X-ray diffraction, the path difference between the scattered rays must be an integral multiple of the wavelength (nλ)."

❖ Mathematical Form:

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

❖ **Where:** n → order of diffraction(a positive integer).

λ → the wavelength of the X-rays.

d → the interplanar distance in the crystal lattice.

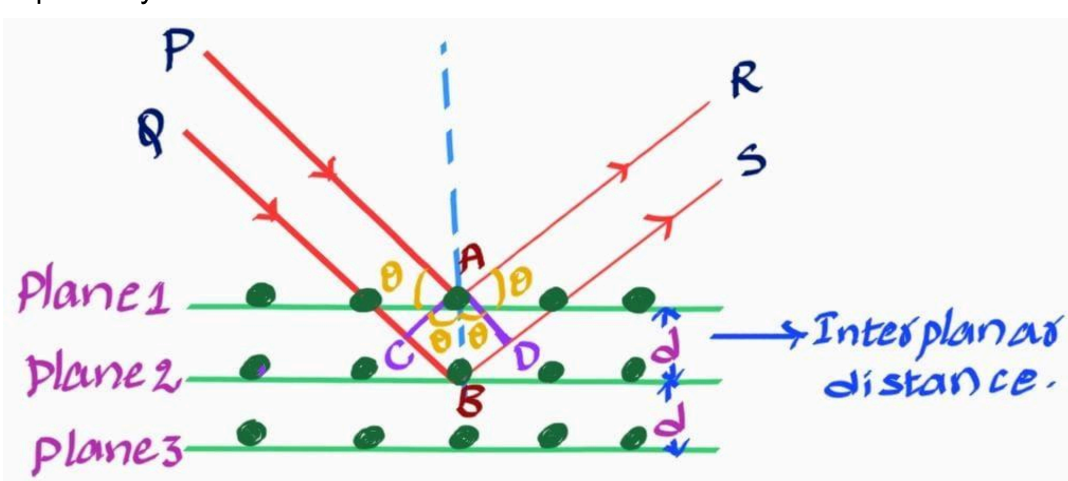
θ → Bragg's angle or Glancing angle or Angle of incidence.

❖ Derivation of Bragg's Equation:

❖ Let us consider a set of parallel planes in a crystal having an interplanar distance(spacing) of d.

❖ A narrow beam of X-rays with a wavelength of **λ** is incident on the planes at points A and B, and is reflected as rays AR and BS, respectively.

❖ Now draw perpendiculars AC and AD on the incident and reflected rays QB and BS respectively.



- The path difference between the two reflected rays is given by $\Delta = CB + BD$ …….(1)
- The angle between the incident rays and the planes is called the glancing angle or Bragg's angle (θ).
- **From ◺ACB:** $\sin\theta = CB/AB = CB/d$

  $CB = d\sin\theta$ ……………… (2)
- **From ◺ABD:** $\sin\theta = BD/AB = BD/d$

  $BD = d\sin\theta$ ……………… (3)
- **From (1), (2) & (3):** $\Delta = d\sin\theta + d\sin\theta$

  $\mathbf{\Delta = 2d\sin\theta}$…………..(4)
- According to Bragg's condition, if the path difference (Δ) is an integral multiple of the wavelength ($n\lambda$), the reflected beams interfere constructively to produce maximum intensity.

  $\mathbf{\Delta = n\lambda}$ ……………….(5)
- **From (4) and (5): $2d\sin\theta = n\lambda$** ……………..(6)
- This equation(6) is known as Bragg's Equation.

ORDER OF DIFFRACTION

- The Bragg's angle $\boldsymbol{\theta}$ is different for different order of diffractions.
- From equation (5): $\mathbf{2d\sin\theta_n = n\lambda}$ **or** $\mathbf{\sin\theta_n = n\lambda/2d}$

  (i) First order maxima (n = 1): $\mathbf{\sin\theta = 1\lambda/2d}$

  (ii) Second order maxima (n = 2): $\mathbf{\sin\theta = 2\lambda/2d}$

  (iii) Third order maxima (n = 3): $\mathbf{\sin\theta = 3\lambda/2d}$
- Thus, $\mathbf{\sin\theta_1 : \sin\theta_2 : \sin\theta_3 = 1 : 2 : 3}$
- **Note:** 1.The intensity decreases as the order of the spectrum increases.

  2.When a beam of X-rays falls on a crystal, each atom acts as a source of scattered radiation.