# Definition of X-ray

- It is a type of electromagnetic radiation characterized by wavelengths between approximately 1 *A* and $10^{-4}$ *A*.

- They are invisible, penetrative especially at higher photon energies, and travel with the same speed as visible light.

- They are usually produced by bombarding a target of high atomic number with fast electrons in a high vacuum

- Production of X ray:

X-rays are produced by the two methods

- a. When fast moving electron having sufficient energy strikes the metal surface of high atomic number, it knock out the some electron from the inner orbit of the target metal due to vacancies are created so, to fill the vacant space electron from the higher energy level jump into these spaces emitting the radiation whose energy is equal to the difference in the energy of two orbits .Thus obtained radiations by the heavy metals are X –rays.
- b. When the fast moving electron strike the target they are heavily retarded by the coulomb repulsive force due to the charges of the electron of the atom .As a result retarding energy emits the radiation called X-rays.
- Production of X ray by Coolidge Tube:

The apparatus consists of a highly evacuated discharge tube at low pressure($10^{-5}$ mm of Hg) With a tungsten filament connected with a low Tension battery as a cathode and a high atomic Wt. solid as a target(Pt, T, Mo) as anode, connected to Copper tube to circulate cold water to prevent melting

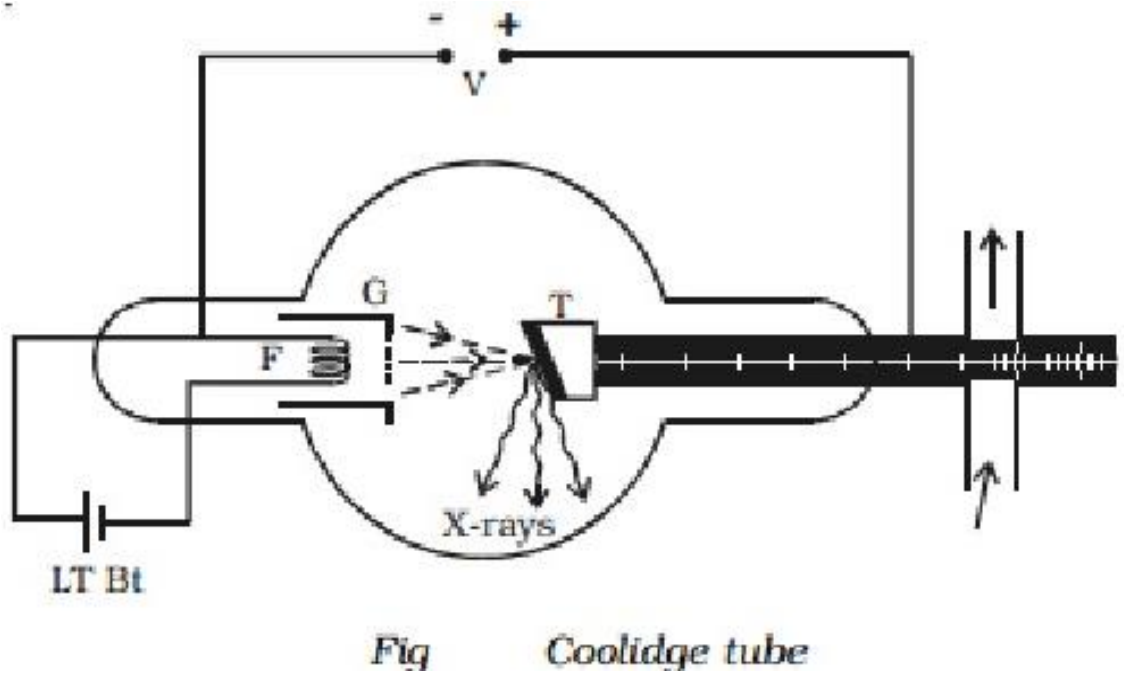



*Fig Coolidge tube*

of the target due to continuous collision of electrons. A high tension battery is connected in between its two electrodes as shown in figure.

working

When the filament is heated using low tension battery, negative electrons are produced from filament cathode due to thermionic emission which are accelerated highly toward anode using high tension battery and focus at its single point using metal cup G. Thus, most of the KE of electrons (95%) converts into heat and rest of it into a very energetic radiation of short wavelength(1-100) $A^0$, called X-rays.

In such case,

energy supplied by H.T. battery of Potential V = max. KE of electrons = max energy of X ray.

Or, eV = $\frac{1}{2}mv_{max}^2$ = hf ,where, m = mass of electrons, f =frequency of X ray.

Or, eV = $\frac{1}{2}mv_{max}^2 = \frac{hc}{\lambda_{min}}$

These equations are used to determine frequency and wavelength of X ray.

## Advantage of Coolidge tube method:

- It can be used for the commercial production of X ray.
- The intensity and quality of x ray can be controlled.
- The tube works in wide range of working voltage (100 to $10^6$) volt.

How could Intensity and Quality of x rays can be controlled?

## Intensity Controlled

The intensity of X rays depends on number of electrons striking the target metal which are dependent on current passing through filament using low tension battery. Thus by controlling low tension battery , intensity of X ray can be controlled.

## Quality Controlled

The quality means frequency of X rays which is directly proportional to KE of electrons emitted from filament. The KE of electrons and frequency of X ray depend on energy supplied by High tension battery. By controlling high tension battery, the quality of X-ray whether hard or soft can be controlled.

The X-rays of high penetrating power due to electrons of high KE are hard X rays and the X-rays of low penetrating power due to electrons of low KE are soft X rays.

## Properties of X-ray:

- They are electromagnetic wave of short wavelength (1-100)$A^o$
- They are not deflected by electric and magnetic field being chargeless.
- They ionize the gas through which they pass.
- They produce fluorescent effect on some substances like Zns.
- They affect photographic plate.
- They have high penetrating power which can through soft opaque solids like skin, flesh etc but can not penetrate through hard solid like stone, bone, metal etc.
- On exposing multiple X ray, it is harmful for living cells.

## Uses of X- rays.

X- rays are widely used in various fields like,

- Diagnosis, Radio therapy, Detective departments, Engineering, Scientific research, Industry.

*H.W.Please study in details how X ray is useful in such many more fields.*

## X-ray diffraction and Laue,s Experiment

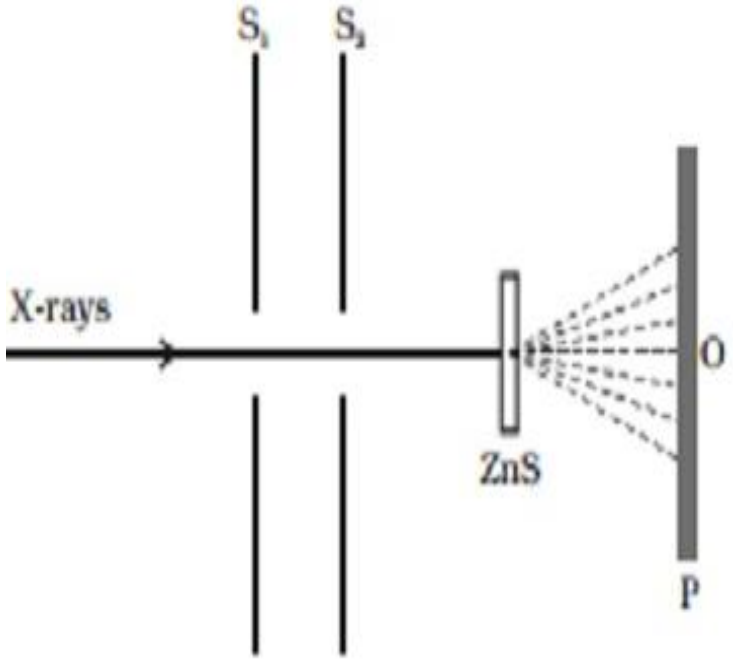
a phenomenon in which the atoms of a crystal, by virtue of their uniform spacing, cause an interference pattern of the waves present in an incident beam of **X rays**. The atomic planes of the crystal act on the **X rays** in exactly the same manner as does a uniformly ruled grating on a beam of light.

In the Laue,s experiment , the X- rays produced by a sources are collimated by using two slits S1 and S2 to pass through a thin crystal of Zinc sulphide which are allowed to fall on a photographic plate. When the photographic plate is sufficiently exposed to X-rays, the film is developed in the plate in which the central big spot is formed due to direct beam however there are many faint and regular spot around the central spot.

Conclusion:

1.X-rays are E.M. waves of very short wavelength.

2.The atoms in a crystal are arranged in a regular three dimensional lattice.




ig (a) Laue experimental set up

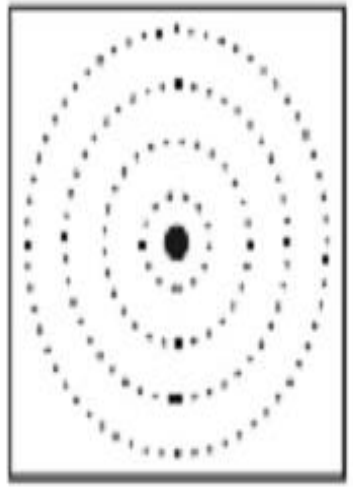
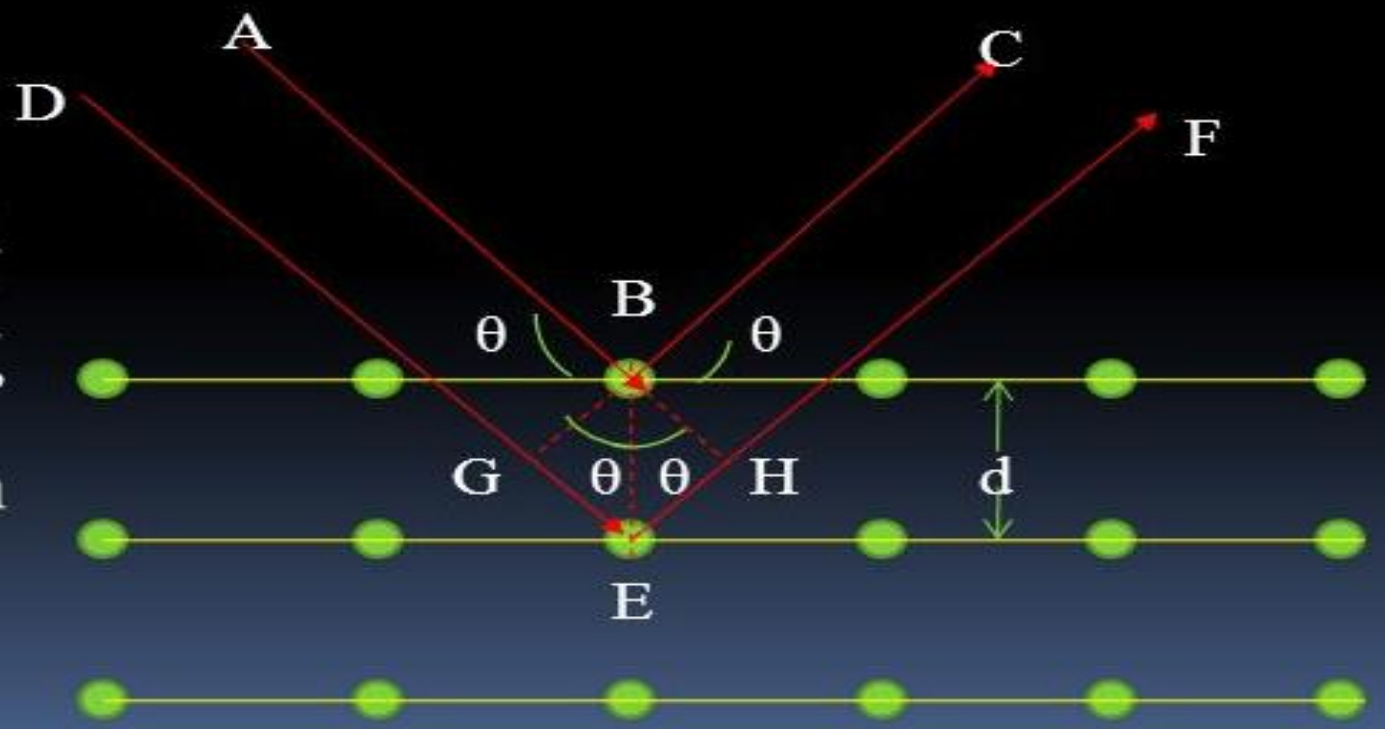


Fig (b) Laue spot

# Bragg's Law:

Bragg's law states the x-rays reflected from different parallel planes of a crystal interfere constructively when the path difference is integral multiple of the wavelength of x-rays.

Consider a set of parallel lattice planes of a crystal separated by spacing 'd' between each other as shown in figure.



When a narrow beam of monochromatic X –ray AB and DG incident on the atoms B and G on the parallel plane separated at 'd' with glancing $\theta$, they are reflected along BC and EF resp.

Now the path difference between DEF and ABC can be determined by drawing perpendiculars BG on DE and BH on EF.

Now, the path difference between them is , Path difference = GE +EH

From right angled triangle BGE and BHE, GE =d Sin$\theta$ = EH

the path difference GE+ EH = 2d sin$\theta$.....2

Thus, path difference = n$\lambda$ = 2d sin$\theta$

Which is Bragg's diffraction equation to determine atomic spacing d of a crystal and wavelength of X ray where n = number of order, 1,2,3,.....

Bragg's diffraction can occur in a crystal when $\lambda$=2d. The visible light can not be used in crystal diffraction because they have $\lambda > 2d$.

- *X –rays are not visible why?*
- *What is the difference between hard and soft X-rays?*
- *Can X-rays be produced from gases? Explain.*
- *Can aluminum be used as a target in X-ray tube?*
- *A patient is suggested to put off gold ornaments before entering into the X-rays room. Explain why?*
- *Production of X-rays is inverse process of photoelectric effect. Do you agree? Justify.*
- *Can X-ray diffraction experiment be performed by an ordinary grating? Why?*
- *X-rays can penetrate through the flesh but not through bone . Why?*
- *How could you control Quality and Intensity of X-rays?*
- *All the numerical from Question Bank.*