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X-ray diffraction and applications

ANSWERS

Answer all

1- What do you know about?

1- Short wave length
2- Characteristic spectrum
3- absorption coefficient
4- Ionization device
5- polycrystalline materials
6- composite materials
7- the main conditions to verify Bragg's low (20 Degree)

ANS

1- Short wave length

shows the kind of curves obtained. The intensity is zero up to a certain wavelength, called the *short-wavelength limit* (λ_{SWL}), increases rapidly to a maximum and then decreases, with no sharp limit on the long wavelength

2- Characteristic spectrum

1-4 The characteristic spectrum. When the voltage on an x-ray tube is raised above a certain critical value, characteristic of the target metal, sharp intensity maxima appear at certain wavelengths, superimposed on the continuous spectrum. Since they are so narrow and since their wavelengths are characteristic of the target metal used, they are called *charac-*

3- absorption coefficient

the intensity I of an x-ray beam as it passes through any homogeneous substance is proportional to the distance traversed, x. In differential form,

$$-\frac{dI}{I} = \mu \, dx, \qquad (1\text{–}9)$$

where the proportionality constant μ is called the *linear absorption coefficient* and is dependent on the substance considered, its density, and the wavelength of the x-rays. Integration of Eq. (1–9) gives

$$I_x = I_0 e^{-\mu x}, \qquad (1\text{–}10)$$

where I_0 = intensity of incident x-ray beam and I_x = intensity of transmitted beam after passing through a thickness x.

4- Ionization device

Ionization devices measure the intensity of x-ray beams by the amount of ionization they produce in a gas. X-ray quanta can cause ionization just as high-speed electrons can, namely, by knocking an electron out of a gas molecule and leaving behind a positive ion. This phenomenon can be made the basis of intensity measurements by passing the x-ray beam through a chamber containing a suitable gas and two electrodes having a

5- composite materials

Composites - A combination of two or more of the above material types is called a composite material

6- polycrystalline materials

Is a crystal material consists of multi-unit cell

7- the main conditions to verify Bragg's low

3–3 The Bragg law. Two geometrical facts are worth remembering:

(1) The incident beam, the normal to the reflecting plane, and the diffracted beam are always coplanar.

(2) The angle between the diffracted beam and the transmitted beam is always 2θ. This is known as the diffraction angle, and it is this angle, rather than θ, which is usually measured experimentally.

As previously stated, diffraction in general occurs only when the wavelength of the wave motion is of the same order of magnitude as the repeat distance between scattering centers. This requirement follows from the Bragg law. Since $\sin\theta$ cannot exceed unity, we may write

$$\frac{n\lambda}{2d'} = \sin\theta < 1. \qquad (3\text{–}2)$$

Therefore, $n\lambda$ must be less than $2d'$. For diffraction, the smallest value of n is 1. ($n = 0$ corresponds to the beam diffracted in the same direction as the transmitted beam. It cannot be observed.) Therefore the condition for diffraction at any observable angle 2θ is

$$\lambda < 2d'. \qquad (3\text{–}3)$$

For most sets of crystal planes d' is of the order of 3A or less, which means that λ cannot exceed about 6A. A crystal could not possibly diffract ultraviolet radiation, for example, of wavelength about 500A. On the other hand, if λ is very small, the diffraction angles are too small to be conveniently measured.

The Bragg law may be written in the form

$$\lambda = 2\frac{d'}{n}\sin\theta. \qquad (3\text{–}4)$$

Since the coefficient of λ is now unity, we can consider a reflection of any order as a first-order reflection from planes, real or fictitious, spaced at a distance $1/n$ of the previous spacing. This turns out to be a real convenience, so we set $d = d'/n$ and write the Bragg law in the form

$$\boxed{\lambda = 2d\sin\theta}. \qquad (3\text{–}5)$$

This form will be used throughout this book.

This usage is illustrated by Fig. 3–3. Consider the second-order 100 reflection* shown in (a). Since it is second-order, the path difference ABC between rays scattered by adjacent (100) planes must be two whole wave-

* This means the reflection from the (100) planes. Conventionally, the Miller indices of a reflecting plane hkl, written without parentheses, stand for the reflected beam from the plane (hkl).

2- a)-Sketch the x- ray tube and explain the production method. (15 Deg)

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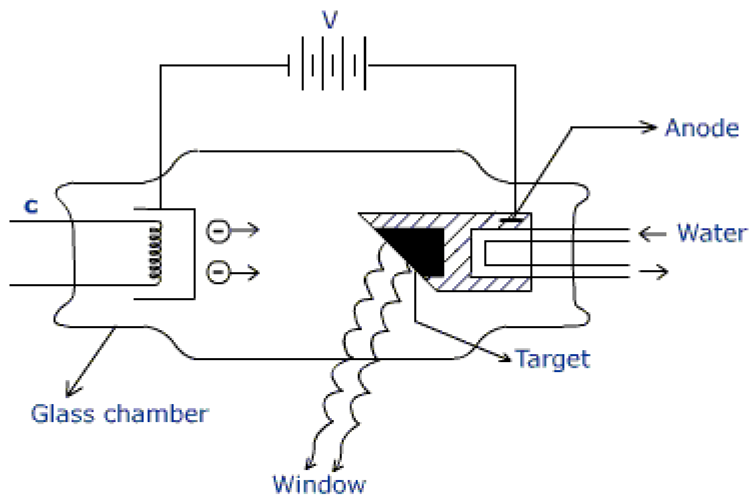

1–7 Production of x-rays. We have seen that x-rays are produced whenever high-speed electrons collide with a metal target. Any x-ray tube must therefore contain (*a*) a source of electrons, (*b*) a high accelerating voltage, and (*c*) a metal target. Furthermore, since most of the kinetic energy of the electrons is converted into heat in the target, the latter must be water-cooled to prevent its melting.

All x-ray tubes contain two electrodes, an anode (the metal target) maintained, with few exceptions, at ground potential, and a cathode, maintained at a high negative potential, normally of the order of 30,000 to 50,000 volts for diffraction work. X-ray tubes may be divided into two basic types, according to the way in which electrons are provided: filament tubes, in which the source of electrons is a hot filament, and gas tubes, in which electrons are produced by the ionization of a small quantity of gas in the tube.

b) - Draw only an example of x- Ray diffraction pattern for amorphous, short range crystal and crystal material. (5 Deg)

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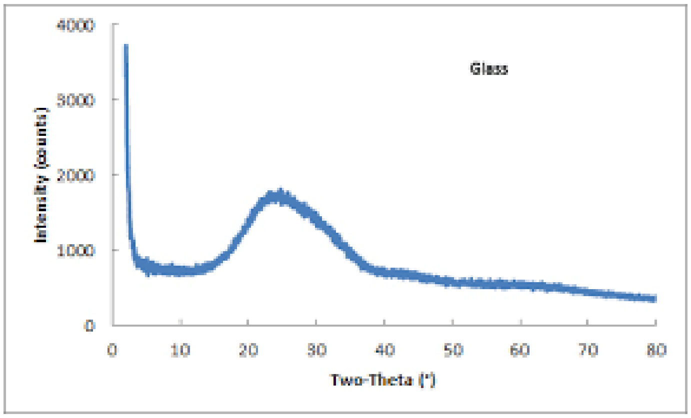
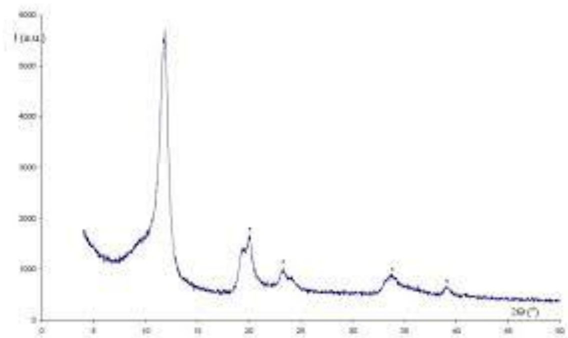
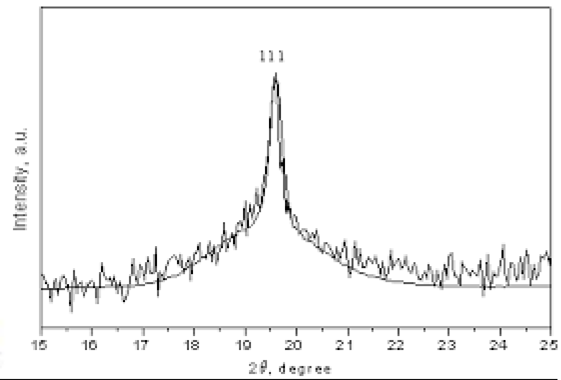
Amorphous

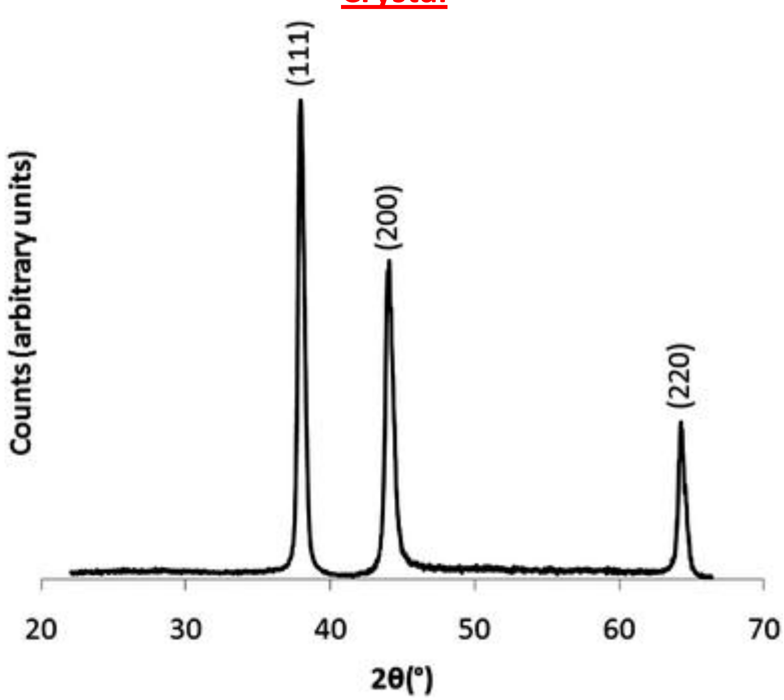


Short rang crystal



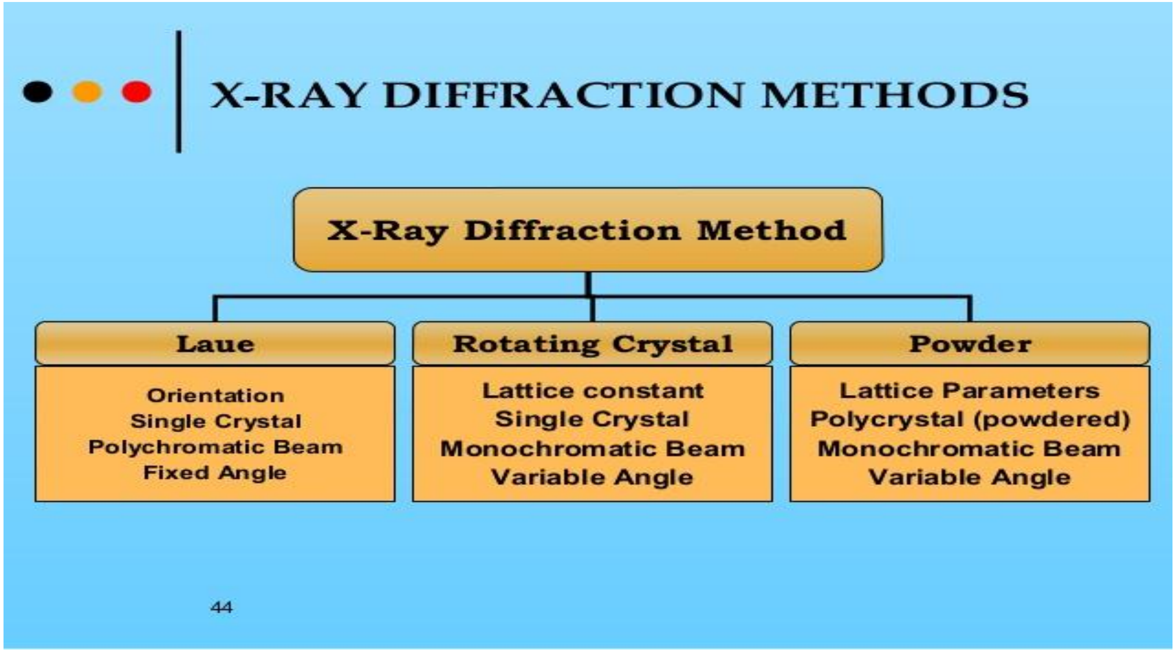


Crystal



<u>**3**</u>-a) - Compare between Laue and powder method in x-ray diffraction. (15 Deg)

<u>**ANS**</u>



b) - Calculate the number of lattice point if the cubic unit cell contains 15 point. (5 Deg)

<u>Ans</u>

<u>The number of lttice point are given by</u>

$$N = N_i + \frac{N_f}{2} + \frac{N_c}{8},$$

Nc= 8 , Ni=1 , then Nf= 6

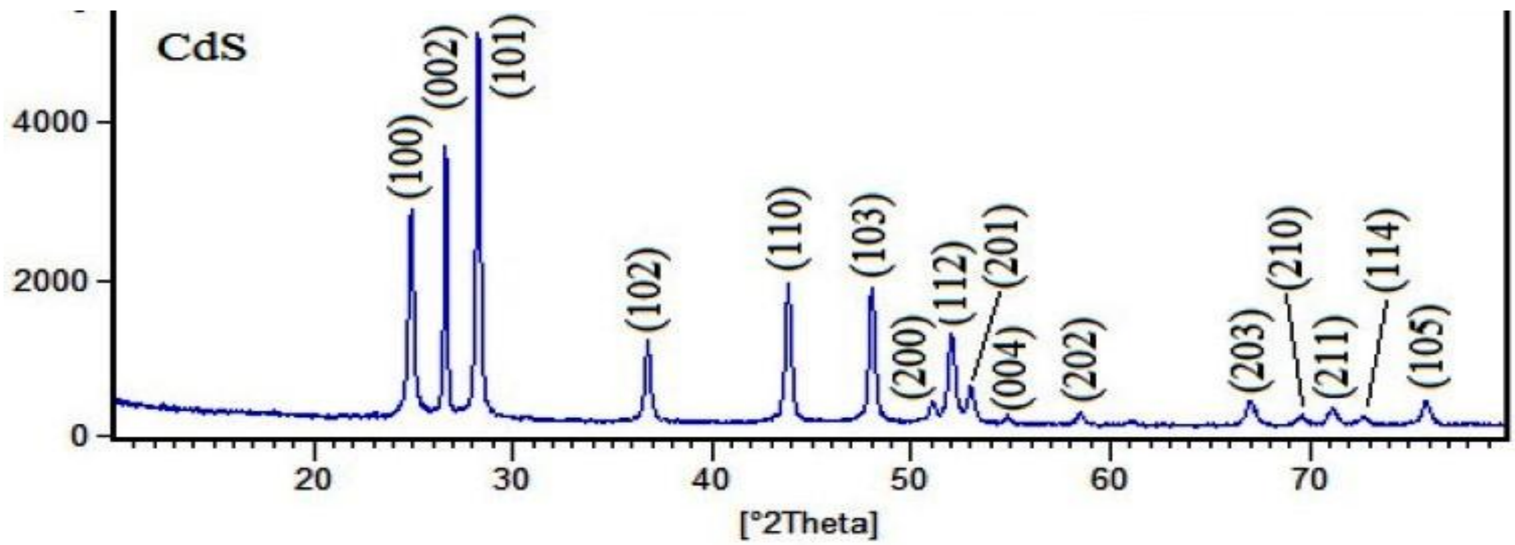
N= 1+ (6/2) + (8/8)= 5

<u>4</u>- From the figure below

a) What are the parallel planes. (5 Deg)

b) Calculate the available lattice Constance. (10 Deg)

c) Estimate the average particle size. (5 Deg)



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A) the parallel planes are : (002) , (004) and (101) , (202) and (100), (200)
B) Lattice Constance can be calculated from the main hkl @ (100) , (002) and (101) peaks
2θ for (100) = 25^o , for (002) = 26.5^o and for (101) = 28.5^o

$N\lambda = 2d \sin\theta$ n=1, $\lambda = 1.54$ A^o then $d = \lambda/2 \sin\theta$,
A= 11 A B= 1.6 A C= 1 A

C) we can use the three beaks

$$D = \frac{k\lambda}{\beta \cos\theta}$$

K= 0.9 , λ = 1.54 A^o θ= 12.5 , 13.25 and 14.25
B= 0.3 for all