MODULE - V

Nanotechnology

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Numerical problems

Numerical problems

1. **Calculate the surface area to its volume ratio of a spherical particle of diameter 8 mm.**

Sol:

Given: Particle diameter =8mm= 8×10^{-3} **m.**

Particle radius=4×10^{-3} **m.**

Surface area to volume ratio = 3/r , r is radius.

= 3/(4×10^{-3}**)**

= 0.75×10^{3}**/m**

Numerical problems

2. If the radius of a sphere is made one-third, how its surface area to volume ratio changes.

Sol:

Given: Particle radius = r/3

Surface area to volume ratio = 3/r , r is radius.

= 3/(r/3)

= 9/r = 3 × (3/r)

Surface area to volume ratio increases by 3 times.

Numerical problems

3. If the dimension of a cube is doubled, how its surface area to volume ratio varies.

Sol:

Given: Volume of a cube = $a^3 = (2a)^3$

Surface area of a cube= $6a^2 = 6 \times (2a)^2 = 6 \times 4a^2 = 24a^2$

Surface area to volume ratio = $\dfrac{24a^2}{8a^3} = \dfrac{3}{a}$

The surface to volume ratio decreases by 2 times.

4. Calculate average particle size using X-ray diffraction pattern having 0.1541 nm of X-ray wavelength, 0.011radian of full width and half maximum and diffraction angle of 45◦.

Sol:

Given: Wavelength λ=0.1541 nm = 0.1541×10^{-9}**m.**

Full width half maximum B = 0.011 radian.

Angle of diffraction θ= 45◦.

Sherrer's formula D = Kλ/(B cos θ_B**)**

$$=(1 \times 0.1541 \times 10^{-9})/(0.011 \times \cos 45^o)$$

$$=1.98 \times 10^{-8} m$$

Numerical problems

5. A beam of X-rays is incident on a Nacl crystal with lattice spacing 0.282 nm. Calculate the wavelength of X-rays if the first order Bragg reflection takes place at a glancing angle of 8◦35′.

Sol:

Given: Lattice spacing d=0.282 nm = 0.282×10^{-9} **m**

Order of diffraction n = 1.

Angle of diffraction θ= 8◦35′ = 8.585

Bragg's law nλ = 2d sinθ

$$\lambda = 2 \times 0.282 \times 10^{-9} \times \sin(8^{o}35')$$

$$= 8.419 \times 10^{-11} m$$

6. X-rays of wavelength 1.5418 A◦ are diffracted by (111) planes in a crystal at an angle 30◦ in the first order. Calculate the interatomic Spacing.

Sol:

Given: Wavelength λ=1.5418 $A^o = 1.5418 \times 10^{-10} m$

Order of diffraction n = 1

Angle of diffraction θ = 30◦

Bragg's law nλ = 2d sinθ

$$d = \frac{n\lambda}{(2\sin\theta)} = 1.541 \times 10^{-10} m$$

Numerical problems

7. An X-ray beam of wavelength 3 A◦ is diffracted from (100) plane of a cubic crystal. The first order maximum is obtained for glancing angle of 40◦. Determine the space of the reflecting plane and also the volume of the unit cell.

Sol:

Given: Wavelength λ= 3 A◦=$3 \times 10^{-10} m$

Order of diffraction n=1.

Angle of diffraction θ= 40◦.

Bragg's law **nλ=2d sinθ,** $d = n\lambda/(2 \sin\theta)$=$2.33 \times 10^{-10} m$

Interplanar spacing $d = a/\sqrt{h^2 + k^2 + l^2}$ =$a/\sqrt{1 + 0 + 0}$

Volume of cube=a^3 =$12.64 \times 10^{-30} m^3$

8. In an X-ray diffraction experiment, peak width at half maximum is 0.6◦ and its corresponding Bragg angle is 24◦. Calculate the crystallite size using Scherer equation, the wavelength used in X-ray diffraction experiment is 1.54 A◦.

Sol:

Given: **Wavelength λ= 1.54 A◦=** $1.54 \times 10^{-10} m$

Full width half maximum B= 0.6◦ =0.01 radian.

Angle of diffraction θ= 24◦.

Scherrer's constant K=1.

Sherrer's formula D = Kλ/(B cos θ$_B$) = $1.68 \times 10^{-8} m$

Numerical problems

9. What is the angle at which the third order reflection of X-rays of 0.79 A◦ wavelength can occur in a calcite crystal of 3.04×10^{-8} cm spacing?

Sol:

Given: Wavelength λ = 0.79 A◦= $0.79 \times 10^{-10} m$

Order of diffraction n = 3.

Interplanar spacing d= 3.04×10^{-8} cm = $3.04 \times 10^{-10} m$

Bragg's law nλ = 2d sinθ

$$\theta = \sin^{-1}\left(\frac{n\lambda}{2d}\right) = 22.94^{o}$$

10. Monochromatic X-rays of wavelength λ= 1.5 AU are incident on a crystal face having an interplanar spacing of 1.6 AU. Find the highest order for which Bragg's reflection maximum can be seen.

Sol:

Given: Wavelength λ=1.5 A◦= $1.5 \times 10^{-10} m$

Interplanar spacing d=1.6 A◦ =$1.6 \times 10^{-10} m$

Bragg's law nλ=2d sinθ

$$n = \frac{2d\ sin\theta}{\lambda} = \frac{2 \times 1.6 \times 10^{-10} \times \sin(90^o)}{1.5 \times 10^{-10}}$$

$$n = 2.133 \sim 2$$

Summary & Discussion