# Bachelor of Science (B.Sc.) Semester—IV Examination

## PHYSICS

## (Solid State Physics, X-Ray & Laser)

## Paper—I

Time—Three Hours] [Maximum Marks—50

**Note :—** (1) All questions are compulsory.

(2) Draw neat diagram wherever necessary.

**EITHER**

1. (A) What are Miller indices ? How are they calculated ? Explain how the orientation of a plane is specified by Miller indicies. 5

(B) (i) Define :

(a) Periodicity in crystals

(b) Crystallographic axes

(c) Primitive unit cell. 3

(ii) Lead (Pb) is Face Centered Cubic with an atomic radius of 1.746 Å. Find the spacing of (200) and (111) planes. 2

OR

(C) Show that the Lattice constant for BCC crystal structure is given by :

$$a_{bcc} = \frac{4r}{\sqrt{3}}$$ 2½

(D) Show that for a simple cubic lattice of lattice constant a

$$d(h\,k\,\ell) = \frac{a}{\sqrt{h^2 + k^2 + \ell^2}}.$$ 2½

(E) Prove that the packing fraction in SC structure in $\pi/6$. 2½

(F) Find Miller Indices of the plane having intercepts $\left(a, \frac{b}{2}, 3c\right)$ in a simple cubic unit cell. 2½

**EITHER**

2. (A) Explain in brief the different type of X-ray spectra. Discuss their origins. Explain the emission of $K_\alpha$ and $K_\beta$ lines with the help of energy level diagram. 5

(B) (i) What is Moseley's Law ? Show how it has been used to remove discrepancies in periodic table. 3

(ii) An X-ray tube operates at 12.41 kV. Find the maximum speed of the electrons striking the target.

Given : Mass of electron = $9.1 \times 10^{-31}$ kg

Charge on electron = $1.6 \times 10^{-19}$C. 2

**OR**

(C) Explain Duane-Hunt Law regarding the continuous X-ray spectrum. Explain its origin. 2½

(D) What is the difference between optical spectra and X-ray spectra ? 2½

(E) What are Soft and Hard X-rays ? Give an example of each. 2½

(F) What would be the wavelength of $K_\alpha$ line for Copper if the wave length of $K_\alpha$ line for Tungsten is 0.21 Å.

(Given : Tungsten Z = 74 and Copper Z = 29). 2½

**EITHER**

3. (A) Derive Bragg's law of X-ray diffraction in crystal and discuss briefly a method for crystal structure determination. 5

(B) (i) Explain how Bragg's spectrometer can be used to determine wavelength of X-ray. 3

(ii) The distance between crystal planes is 9 Å. Find angle of diffraction in the second order if the wavelength of X-ray is 5 Å. 2

**OR**

(C) Describe Lave's method of X-ray diffraction. 2½

(D) Explain the construction of reciprocal lattice. 2½

(E) Define the term atomic radius and packing density of the crystal. 2½

(F) Calculate angle of diffraction for X-rays having wave length 1.58 Å in different order 1, 2, 3 if the inter planer distance is 2.69 Å. 2½

**EITHER**

4. (A) Explain the principal, construction and working of semiconductor laser. 5

(B) (i) What is temporal coherence and spatial coherence. 3

(ii) The Doppler width for orange line of Krypton is $550 \times 10^{-15}$m. If the wavelength of light is 605.8 nm. Calculate the coherent length. 2

**OR**

(C) State and explain Einstein coefficients A and B. 2½

(D) Calculate momentum of a photon of Laser beam of wavelength 6238 Å. 2½

(E) Define :

(i) Light amplification

(ii) Population inversion. 2½

(F) Explain the working of Ruby-Laser with proper diagram. 2½

5. Attempt any **TEN** questions (1 mark each) :

(i) Show (110) and (111) plane in simple cubic lattice.

(ii) Calculate the number of lattice points in FCC structure.

(iii) Define Unit Cell.

(iv) On what factors the $\lambda_{min}$ depends ?

(v) How will you believe that X-rays are electromagnetic ?

(vi) An X-ray tube operated by 50 kV produced X-rays having minimum wavelength 0.247 Å. Calculate Planck's constant.

(vii) What is void space ?

(viii) How is the Wigner Seitz Primitive cell constructed ?

(ix) Why are X-rays used for crystal structure analysis ?

(x) Compare the coherence times of two sources having coherence length of $3 \times 10^{-2}$m and $3 \times 10^{-1}$m respectively.

(xi) What are the special characteristics of LASER beam ?

(xii) Mention any two applications of LASER.

$10 \times 1 = 10$