

Bachelor of Science (B.Sc.) Semester—V (C.B.S.) Examination
QUANTUM MECHANICS, NANOMATERIALS AND NANOTECHNOLOGY

Paper—2
(Physics)

Time : Three Hours]

[Maximum Marks : 50

N.B. :— (1) **ALL** questions are compulsory.

(2) Draw neat diagram wherever necessary.

Given :—

$$h = 6.6 \times 10^{-34} \text{ J.sec}$$

$$c = 3 \times 10^8 \text{ m/s}$$

$$m_e = 9.1 \times 10^{-31} \text{ kg}$$

$$e = 1.60 \times 10^{-19} \text{ C}$$

EITHER

1. (A) State de-Broglie's hypothesis for matter waves. Explain Davission and Germer experiment. 5
- (B) (i) What is compton effect ? On what factors do compton shift depend ? 3
- (ii) An X-ray photon of initial energy 90 keV under-goes compton scattering at angle of 60° , find energy of recoiled electron. 2

OR

- (C) Calculate the de-Broglie wavelength of an electron accelerated through a potential difference of 1.25 kV. 2½

- (D) Show that $v_g = v_p - \lambda \frac{dv_p}{d\lambda}$

(Symbols used have their usual meaning). 2½

- (E) How the classical mechanics failed to explain black body radiation spectrum ? 2½
- (F) Give analytical treatment for the formation of wave packet. 2½

EITHER

2. (A) What is free particle ? Obtain an expression for eigen energy and eigen wave function of free particle in one dimensional box. 5
- (B) (i) What is operator ? Obtain an expression for momentum operator. 3
- (ii) Show that the function $f(x) = \sin ax$ is eigen function corresponding to the operator

$$\frac{d^2}{dx^2} \quad \text{2}$$

OR

- (C) Give physical significance of wave function ψ . 2½
- (D) Obtain Schrodinger's time dependent equation. 2½
- (E) What are the postulates of quantum mechanics ? 2½
- (F) Find the lowest energy of an electron confined to move in one-dimensional potential box of length 5\AA . 2½

EITHER

3. (A) Explain top down approach and bottom up approach for the synthesis of nanomaterials. 5
- (B) (i) What are physical and chemical properties of nanomaterials ? 3
- (ii) What would be the surface to volume ratio of a nanosphere of radius 2 nm ? 2

OR

- (C) Differentiate nanomaterials from bulk materials. 2½
- (D) What are quantum dots ? Enlist their properties. 2½
- (E) The surface to volume ratio of nanocubes is 0.5 per nanometer. What would be the side length of nanocubes ? 2½
- (F) What are fullerenes ? State their properties. 2½

EITHER

4. (A) What is transmission electron microscopy ? Explain the working of TEM with the help of neat diagram. State its dis-advantages. 5
- (B) (i) Explain synthesis of nanoparticles by ball milling method. 3
- (ii) Calculate the FWHM XRD pattern of Ni with crystallite size of 20 nm diffracting angle of 38.2° with X-rays of wavelength 1.54 Å. 2

OR

- (C) Explain sol-gel method for synthesis of nanomaterials. 2½
- (D) What are the different methods for determination of size of nanoparticles ? State Schever's formula with symbols. 2½
- (E) How nanotechnology is useful in home appliances ? 2½
- (F) X-rays of wavelength 1.54 Å are diffracted from nanoparticles at diffracting angle 27° with full width at half maxima of 1°. Calculate the size of nanocrystals. 2½

5. Attempt any *ten* :

- (i) State Planck's quantum hypothesis.
- (ii) Define wave packet.
- (iii) An electron has a speed of 300 m/sec accurate to 0.01% with what fundamental accuracy can we locate the position of electron.
- (iv) Define expectation value.
- (v) If wave function $\psi(x) = e^{3x}$, find eigen value for the operator $\frac{d}{dx}$.
- (vi) What is probability density ?
- (vii) What is quantum well ?
- (viii) State two examples of two dimensional nanomaterials.
- (ix) If radius of quantum dot is 1.5 pm. Calculate surface to volume ratio.
- (x) What are the limitations of SEM ?
- (xi) What is aero gel ?
- (xii) Convert F.W.H.M. of 0.7 radian into degree. 1×10