NKT/KS/17/5171

Bachelor of Science (B.Sc.) Semester—V (C.B.S.) Examination

PHYSICS

(Quantum Mechanics, Nanomaterials and Nanotechnology)

Paper–2

Time : Three Hours] [Maximum Marks : 50

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

(2) Draw neat diagrams wherever necessary.

EITHER

1. (A) Give the theory of Compton effect. Show that Compton shift is given by :

$$\Delta\lambda = \frac{h}{m_o c}(1 - \cos\phi)$$ 5

(B) (i) State de-Broglie's hypothesis for matter waves and establish the relation $\lambda = \frac{h}{p}$. 3

(ii) Calculate the de-Broglie wavelength of an electron accelerated through potential difference of 5 kV. (Given : e = 1.6 × 10^{-19} c, m = 9.1 × 10^{-31} kg, h = 6.63 × 10^{-34} J–S). 2

OR

(C) What is black body radiation ? How has classical mechanics failed to explain it ? 2½

(D) An electron and a bullet of mass 150 gms give travel with velocity of 220 m/s, measured to an accuracy of 0.005 %. Calculate and compare uncertainty in position of each. 2½

(E) Explain, how Davison and Germer's experiment process the wave nature of particle. 2½

(F) Describe the concept of wavepacket. 2½

EITHER

2. (A) Obtain an expression for eigen function and eigen value for energy of a particle in three dimensional box. 5

(B) (i) Derive Schrodinger's time independent equation for the matter wave. 3

(ii) Show that the function f(x) = sin ax is eigen function corresponding to the operator $\frac{d^2}{dx^2}$. 2

OR

(C) What are non-degenerate and degenerate energy levels ? Explain with examples. 2½

(D) Obtain an expression for quantum mechanical operator for linear momentum of a particle. 2½

(E) An electron is combined in a one dimensional box of length 1Å. Find the values of momentum and energy for the ground state. 2½

(F) State the postulates of quantum mechanics. 2½

EITHER

3. (A) Explain how the reduction of dimensions 3D, 2D, 1D and 0D materials take place. Explain diagrammatically density of states for 0D, 1D, 2D and bulk materials. 5

(B) (i) What are the induced effects due to increase in surface area of nanoparticles ? 3

(ii) What would be the surface to volume ratio of a nanosphere of radius 2 nm ? 2

OR

(C) Explain various morphologies of nanomaterials with examples. 2½

(D) Explain top down approach for synthesis of nanomaterials. 2½

(E) The surface to volume ratio of a nanocube is 1.5/nm. Calculate the side length of a nanocube. 2½

(F) Explain optical and electrical properties of nanomaterials. 2½

EITHER

4. (A) Explain the construction and working of Transmission Electron Microscope (TEM). 5

(B) (i) Explain sol-gel method for synthesis of nanomaterials 3

(ii) Find out the particle size of a nanomaterial which diffracts the incident radiation of wavelength $2A^0$ at an angle of 40^0 with FWHM at 2^0. 2

OR

(C) Calculate wavelength of X-rays, diffracted from nanomaterial having interplanar distance 0.889Å of an angle of 60^0 in first order. 2½

(D) How can the particle size of nanomaterials be analysed by BET technique ? 2½

(E) State and explain the important applications of nanomaterials in nanoelectronics. 2½

(F) Write any five disadvantages of SEM. 2½

5. Attempt any **ten** questions :

(i) Write down Wien's Radiation formula.

(ii) Define group velocity and phase velocity.

(iii) Calculate the energy of a gamma ray photon of wavelength $1A^0$.

(iv) State Schrodinger's time dependent equation.

(v) Calculate degree of degeneracy for (1, 2, 3) state of particle in 3-D box.

(vi) State condition for well behaved wave function.

(vii) Show that surface to volume ratio of a nano-particle increases with decrease in its size.

(viii) State two applications of nanowires.

(ix) What are quantum dots ?

(x) Write any two applications of SEM.

(xi) What are the advantages of wet-chemical method ?

(xii) Write value of FWHM of a diffraction peak 0.4^0 in radian. 10×1=10