NRJ/KW/17/3138

Bachelor of Science B.Sc. Semester–V (CBS) 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 diagrams wherever necessary.

1. **EITHER**

(a) What is de-Broglie concept of matter waves ? Describe Davisson and Germer's experiment. 5

(b) (i) State Planck's quantum hypothesis. Obtain Planck's radiation formula. 3

(ii) Photons of energy 0.1 MeV undergo Compton scattering. Find the energy of photon a scattered at 60°.

($h = 6.63 \times 10^{-34}$ Js, $M_o = 9.1 \times 10^{-31}$ kg ; $C = 3 \times 10^8$ m/s). 2

OR

(c) State Heisenberg's uncertainly principle. Explain its Physical significance. 2½

(d) Obtain the relation between group velocity and phase velocity. 2½

(e) The velocity of electron is 3×10^4 m/s measured with accuracy of 0.01%. Find the uncertainty in measurement of its position. ($m_e = 9.1 \times 10^{-31}$ kg, $h = 6.6 \times 10^{-34}$ J-s). 2½

(f) What is a wave packet ? Give the analytical treatment for the formation of a wave packet. 2½

2. **EITHER**

(a) Derive Schrodinger's time dependent equation. Give the physical significance of wavefunction. 5

(b) (i) What is eigen function and eigen value of a state ? Explain with an example. 3

(ii) Show that the function $f(x) = \cos 3x$ is an eigen function corresponding to the operator $\frac{d^2}{dx^2}$. 2

OR

(c) Obtain an expression for momentum operator in quantum mechanics. 2½

(d) What are the conditions for well-behaved, wave function ? 2½

(e) Calculate first two energy levels for :

(i) A 1 μgm dust particle moving in 1-D box of 0.1 mm,

(ii) An electron confined to 1A°. 2½

(f) What is degeneracy ? Calculate the degree of degeneracy for (231) state of particle in three dimensional box. 2½

3. (a) What are nanomaterials and nano technology ? Explain Bottom up approach for manufacturing process of nanomaterials. 5

(b) (i) What are quantum well quantum wire and quantum dots ? Give one example of each. 3

(ii) Calculate the surface to volume ratio of a nanosphere of radius 2nm. 2

OR

(c) Differentiated nanomaterials from the bulk materials. 2½

(d) Describe top-down method for the synthesis of nano materials. Mention any two methods. 2½

(e) What are the properties and applications of carbon nanotubes (CNTs) ? 2½

(f) A block has a surface are a of $6m^2$ and volume of $1m^3$. Calculate the surface to volume ratio of the block system. 2½

4. **EITHER**

(a) What are the different methods of synthesis of nanomaterials ? Explain wet chemical method for synthesis of nanomaterials. 5

(b) (i) Explain the formation of image in SEM. 3

(ii) Particles are diffracted by Xrays of wevelength 1.54A° at diffracting angle 27° with FWHM of 0.5°. Determine the crystallite size of the particle. 2

OR

(c) What are the advantages of TEM over SEM ? 2½

(d) Explain the applications of nano technology in drug delivery and in medicine. 2½

(e) Explain how particle size can be determined by BET method. 2½

(f) Calculate the interplanar spacing of nanocrystalline material of crystallite size 70nm and FWHM 2°. Given : Wavelength of Cu K_α X-ray is 1.54A°. (Take only first order) 2½

5. Attempt any **TEN** of the following :

(i) Mention two failures of Classical theory.

(ii) What is Compton effect ?

(iii) Calculate de-Broglie's wavelength for an electron moving with momentum 6.6×10^{-24} kg m/sec.

(iv) State Schrodinger's time independent equation for free particle.

(v) What is an expectation value of a dynamical variable ?

(vi) A wave function is given by $\psi(x) = e^{kx}$. Find the eigen value for the operator $\frac{d}{dx}$.

(vii) State any two applications of nanowires.

(viii) Why does the melting point of nanoparticles decrease with the decrease in size of nano particles ?

(ix) Why is the surface/volume ratio very large for nanoparticles compared to bulk materials ?

(x) What are the applications of nano electronics ?

(xi) Why are nanoparticles highly reactive ?

(xii) Express 0.8° in radians. 1×10