KNT/KW/16/5171

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

PHYSICS

Paper—2 (502)

(Quantum Mechanics, Nano Materials and Nano Technology)

Time : Three Hours] [Maximum Marks : 50

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

(2) Draw neat diagrams wherever necessary.

EITHER

1. (A) Explain the dual nature of matter. Describe Davission and Germer's experiment to prove the wave nature of material particle. 5

(B) (i) Discuss the experimental arrangement and results of compton effect. 3

(ii) A photon of energy 1.02 MeV undergo compton scattering through 180°. Calculate the energy of the scattered photon, if compton wavelength is 0.02426 Å. 2

OR

(C) Define phase velocity of a particle and group velocity of a wave packet. Derive the relation between them. 2½

(D) Derive Heisenberg uncertainty principle from a gamma ray microscope. 2½

(E) Explain the failures of classical mechanics to explain black body spectrum. 2½

(F) Calculate the de Broglie wavelength of an electron which has kinetic energy equal to 15 eV. $m_e = 9.1\times10^{-31}$ kg. 2½

EITHER

2. (A) State Ehrenfest theorem and prove that $\frac{d}{dt} <Px> = -\left[\frac{dV}{dx}\right] = <Fx>$. 5

(B) (i) What is wave function ? Give the physical interpretation of wave function. 3

(ii) Find eigen function of momentum operator $-i\hbar\frac{d}{dx}$ with eigen values λ. 2

OR

(C) Find the value of angular momentum operator in Cartesian co-ordinates. 2½

(D) What is well behaved wave functions ? State the conditions for it. 2½

(E) Normalise the given wave function $\psi_n(x) = A \sin \frac{n\pi x}{a}$. 2½

(F) State the postulates of quantum mechanics. 2½

EITHER

3. (A) Explain Top-down and Bottom-up approaches for the synthesis of nano materials. 5

(B) (i) Explain any two physical properties of nano materials. 3

(ii) Find out the surface to volume ratio of a quantum dot of radius 3 nm. 2

OR

(C) Differentiate between nano materials and bulk materials. 2½

(D) What would be the surface to volume ratio of a nano cube of side length 4 nm ? 2½

(E) Explain 0D, 1D, 2D and 3D materials with examples. 2½

(F) Why is surface to volume ratio very high for nano particles compared to bulk materials ? Explain with a simple example. 2½

EITHER

4. (A) Explain the construction and working of scanning electron microscope. What are the limitations of SEM ? 5

(B) (i) Explain how particle size can be determined by using Debye-Scherer's equation. What are the other techniques for determination of particle size ? 3

(ii) In the particles are diffracted by X-rays of wavelength 1.54 Å at diffracting angle of 27° with F.W.H.M. of 0.5°. Determine the crystallite size of the particles. 2

OR

(C) Distinguish between SEM and TEM. 2½

(D) Calculate wavelength of X-ray diffracted at 40° in first order from nano material having interplaner distance from 0.89 Å. 2½

(E) Explain the sol-gel technique for synthesis of nano materials. 2½

(F) Describe the application of nanotechnology in drug delivery and in medicine. 2½

5. Attempt any ***ten*** :

(i) Write Heisenberg's uncertainty relation in terms of energy and time.

(ii) Calculate energy of a photon of wavelength 5000 Å. Given h = 6.63×10^{-34} Js, C = 3×10^{8} m/s.

(iii) State de Broglie hypothesis.

(iv) Using momentum operator, find an operator for kinetic energy of a particle.

(v) Find the minimum energy of an electron constrained to move linearly in a box of length 10^{-11} m.

(vi) What is the normalization condition for wave function ?

(vii) What are nano materials ?

(viii) What do you understand by a quantum well ?

(ix) If surface to volume ratio of a quantum dot is 2/nm, then find the radius of the quantum dot.

(x) Write value of 0.67º of a diffraction peak in radians.

(xi) Name the different characterization techniques of the nano-particle.

(xii) How nanotechnology is useful to farmers ? 1×10=10