**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 $\lambda$. 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 = $6.63\times10^{-34}$ Js, C = $3\times10^{8}$ 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 $0.67^{o}$ of a diffraction peak in radians.

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

(xii) How nanotechnology is useful to farmers ? $1\times10=10$