2021/TDC/CBCS/ODD/
PHSHCC–501T/155

TDC (CBCS) Odd Semester Exam., 2021
held in March, 2022

PHYSICS

(5th Semester)

Course No. : PHSHCC–501T

(Quantum Mechanics and Applications)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

Answer any *ten* of the following questions : 2×10=20

1. Give the physical interpretation of wave function.

2. State the principle of superposition of eigenstates.

3. What do you mean by conservation of total probability in quantum mechanics?

4. What are Hermitian operators?

5. Write the operators associated with *(a)* energy and *(b)* momentum.

6. What do you mean by the expectation values of dynamical quantities?

7. What do you mean by the term 'potential barrier' in quantum mechanics?

8. What is zero-point energy of a harmonic oscillator?

9. Mention two applications of Schrödinger equation.

10. What is Larmor's theorem?

11. What is Bohr magneton?

12. Define gyromagnetic ratio.

13. What is Zeeman effect?

14. Define Stark effect.

15. What is Pauli's exclusion principle?

SECTION—B

Answer any *five* of the following questions : 6×5=30

16. Obtain the general solution of three-dimensional Schrödinger time-dependent wave equation.

17. Derive the equation of continuity

$$\frac{\partial \rho}{\partial t} + \vec{\nabla} \cdot \vec{J} = 0$$

where $\rho = \psi^* \psi$ is the probability density and J = current density. What is its significance?

18. Define angular momentum operator and show that $[L_x, L_y] = i\hbar L_z$.

19. Prove Ehrenfest theorem.

20. Write down the Schrödinger equation for a linear harmonic oscillator and obtain the eigenvalues of the energy of the oscillator.

21. A particle is confined in a one-dimensional infinite square well.

$$V(x) = \begin{cases} 0, & 0 < x < a \\ \infty, & x < 0,\ x > a \end{cases}$$

Write down the time-independent Schrödinger equation for $0 < x < a$ and solve it.

22. Write down the Schrödinger wave equation for the motion of the electron in hydrogen atom in spherical polar coordinates and separate it into radial and angular parts.

23. Find the expression for the orbital and the spin magnetic moments associated with an electron.

24. Describe Stern-Gerlach experiment.

25. Describe vector atom model.

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TDC (CBCS) Odd Semester Exam., 2021
held in March, 2022

PHYSICS

(5th Semester)

Course No. : PHSHCC-502T

(Solid-State Physics)

Full Marks : 50
Pass Marks : 20

Time : 3 hours

The figures in the margin indicate full marks for the questions

SECTION—A

Answer any *ten* of the following questions : 2×10=20

1. Distinguish between crystalline and amorphous solids.

2. Show that in simple cubic lattice

$$d_{100} : d_{110} : d_{111} = 1 : 0{\cdot}71 : 0{\cdot}58$$

3. Define primitive cell and unit cell.

4. What do you mean by lattice vibration?

5. Define forbidden band in lattice vibration.

6. Discuss the limitations of Einstein's theory of lattice specific heat.

7. What is a magnetic material? What are its different classes?

8. Explain the difference among ferro-, antiferro- and ferrimagnetic materials.

9. What is hysteresis? State the significance of hysteresis loop.

10. What do you mean by dielectric polarization?

11. State the relation between electronic polarizability and relative permittivity.

12. Compare ferroelectricity with piezoelectricity.

13. What is Hall effect? Why is the Hall coefficient positive in some metals?

14. Discuss the effect of magnetic field on superconductivity.

15. State the variation of position of Fermi level in extrinsic semiconductor with temperature.

SECTION—B

Answer any *five* of the following questions : 6×5=30

16. *(a)* Show that in a cubic crystal of side a, the inter-planar spacing between consecutive parallel planes of Miller indices (hkl) is

$$d_{hkl} = \frac{a}{\sqrt{h^2 + k^2 + l^2}}$$ 3

(b) Draw the following planes in the case of an FCC structure : 3

(i) (100)

(ii) (110)

(iii) (112)

17. *(a)* What are Miller indices? Obtain the Miller indices of a plane having intercepts of a, $b/2$ and ∞ on the a-, b- and c-axis respectively. 1+2=3

(b) State Bragg's law of X-ray diffraction. The spacing between successive (100)-planes of NaCl is 2·82 Å. X-rays incident on the surface of the crystal is found to give rise to first-order Bragg reflection at glancing angle 8·8°. Calculate the wavelength of X-rays. 1+2=3

18. (a) What is a phonon? Name the different branches of the dispersion relation curve in case of diatomic lattice. What is the difference between the two branches? 3

(b) Explain the origin of acoustical and optical branches in linear diatomic lattice. Why are these branches named so? 3

19. (a) Give a comparative study of Einstein's theory and Debye theory of specific heat of solids. 3

(b) What is Debye temperature? Write down the Einstein's and Debye's expressions for the specific heat of solids. 3

20. (a) State Curie-Weiss law and discuss its application to ferromagnetic materials. 3

(b) Point out the essential difference between the classical theory and quantum theory of paramagnetism. 3

21. (a) If the magnetization and flux density of a magnetic material be 3200 A/m and 0·005 Wb/m^2, then calculate the relative permeability of the material. 3

(b) Explain the B-H loop with the help of domain theory. 3

22. (a) What is local field? Starting from Clausius-Mosotti equation, explain the origin of spontaneous polarization. 1+2=3

(b) What are the various components of the local electric field at an atom in a crystal? Obtain the Lorentz relation for the local electric field. 1+2=3

23. (a) Discuss the origin of ferroelectricity. What is polarization catastrophe? 2+1=3

(b) Write a short note on any *one* of the following : 3

(i) Relaxation time of polarization

(ii) Internal field of solids

(iii) Debye equation

24. *(a)* The solution of Schrödinger equation for one-dimensional periodic lattice is given by

$$P\frac{\sin\alpha a}{\alpha a}+\cos\alpha a=\cos ka$$

when $\alpha^2=\left(\frac{2mE}{\hbar^2}\right)$. The symbols have their usual significance. Discuss the formation of energy bands in a solid. 3

(b) What is Hall angle? Find an expression for Hall voltage and Hall coefficient. State the importance of this effect. 3

25. *(a)* Write down first and second London equations. What do you mean by London penetration depth? 3

(b) What is Meissner effect? Show that a superconductor behaves as a diamagnet. 3

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