2025/FYUG/ODD/SEM/
PHYDSC–301T/202

FYUG Odd Semester Exam., 2025

PHYSICS

(5th Semester)

Course No. : PHYDSC–301T

(Modern Physics)

Full Marks : 70
Pass Marks : 28

Time : 3 hours

The figures in the margin indicate full marks for the questions

UNIT—I

1. Answer any *two* of the following questions : 2×2=4

   (a) Name the phenomena, which can not be explained by classical mechanics and lead to the development of quantum mechanics.

   (b) State Bohr's complementary principle.

   (c) What is wave packet?

(Turn Over)

2. Answer any *one* of the following questions :

(a) *(i)* Explain Planck's quantum hypothesis. Derive Planck's radiation law. 10

(ii) Derive Wien's and Rayleigh-Jeans law as special case of Planck's radiation law. 2+5=7

(b) *(i)* Explain de Broglie's concept of wave particle duality. Find the expression for de Broglie wavelength. 3

(ii) Discuss Davisson and Germer experiment as evidence of wave particle duality. 2+2=4

UNIT—II

3. Answer any *two* of the following questions : 2×2=4

(a) State the fundamental postulates of quantum mechanics.

(b) Explain the significance of wave function.

(c) What are orthogonal and normalized wave functions?

(Continued)

Answer any *one* of the following questions : 10

(a) State Heisenberg's uncertainty principle and mention its significance. Explain how uncertainties are introduced in quantum mechanical description. With the help of uncertainty relation, show that an electron cannot stay within a nucleus. 3+2+5=10

(b) What are probability and probability current density? Derive an equation for probability conservation for the motion of the particle and compare it with the equation of continuity. 3+6+1=10

UNIT—III

5. Answer any *two* of the following questions : 2×2=4

(a) What are eigenvalues and eigenfunctions?

(b) What is the physical interpretation of the commutations of two operators?

(c) What is an operator? Define linear operator.

(Turn Over)

6. Answer any *one* of the following questions :

(a) (i) What is Hermitian operator? Prove that the eigenvalues of Hermitian operators are always real. Also show that momentum operator is a Hermitian operator. 10

(ii) Show that $[\hat{L}_x, \hat{L}_y] = i\hbar\hat{L}_z$, where the symbols have their usual meanings. 1+3+2=6

(b) (i) What is expectation value of a dynamical quantity? Find the expectation value of momentum. 4

(ii) Obtain the expression for 3-dimensional time independent Schrödinger equation. Show that operators having common set of eigenfunctions commute. 1+2=3 4+3=7

UNIT—IV

7. Answer any *two* of the following questions : 2×2=4

(a) What are the limitations of Rutherford's model?

(b) State Bohr's postulates to explain hydrogen spectra.

(c) What is gyromagnetic ratio?

(Continued)

Answer any *one* of the following questions : 10

(a) Discuss Rutherford's gold foil experiment. Derive Rutherford's differential scattering cross-section formula. 3+7=10

(b) Explain vector atom model. Discuss the different quantum numbers associated with vector atom model. 3+7=10

UNIT—V

Answer any *two* of the following questions : 2×2=4

(a) What is optical pumping?

(b) What are metastable states?

(c) State a few applications of LASER.

Answer any *one* of the following questions : 10

(a) (i) Explain spontaneous and stimulated emission. 3

(ii) What are Einstein's coefficients? Derive Einstein's relation between the coefficients. 3+4=7

(b) (i) Obtain the expression for the requisite condition for Laser action. 5

(ii) Explain the working of solid-state Ruby laser. 5

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