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**5 SEM TDC PHYH (CBCS) C 11**

**2 0 2 2**

( Nov/Dec )

PHYSICS

( Core )

Paper : C-11

**( Quantum Mechanics and Applications )**

*Full Marks : 53*

*Pass Marks : 21*

*Time : 3 hours*

*The figures in the margin indicate full marks  
for the questions*

1. Choose the correct answer from the following : 1×5=5

(a) Planck constant has the dimensions of

(i) force

(ii) energy

(iii) action

(iv) linear momentum

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- (b) The momentum space wave functions are the Fourier transforms of
- expectation value of momentum
  - position space wave functions
  - momentum eigenvalues
  - energy eigenfunctions
- (c) The energy of a one-dimensional harmonic oscillator in first excited state is
- infinite
  - zero
  - $\frac{3}{2}\hbar\omega$
  - $\frac{1}{2}\hbar\omega$
- (d) The value of spin angular momentum for a one-electron atom is
- $\frac{1}{2}\hbar\omega$
  - $\frac{\sqrt{3}}{2}\hbar\omega$
  - $\hbar$
  - $-\frac{\hbar}{2}$
- (e) The value of Lande's g-factor for an s-electron is
- 0
  - $\frac{1}{2}$
  - 1
  - 2

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( Continued )

2. Answer the following questions :  $2 \times 6 = 12$
- What are the conditions for a wave-function to be physically acceptable?
  - Define wave packet. With what velocity does a wave packet move?
  - Briefly describe the relation between zero point energy and uncertainty principle of a Harmonic oscillator.
  - What is Larmor precession? Define Bohr magneton.
  - Briefly discuss the fine structure in sodium atom.
  - State the basic differences between Paschen-Back and Stark effect.
3. (a) Prove the commutation relation  $[x, p_x] = i\hbar$  3
- (b) Write down the wavefunction for ground state ( $\Psi_{100}$ ) of a hydrogen atom. Show diagrammatically the polar representation of probability densities for s, p and d shells. 1+2=3
- (c) What are orbital quantum number and magnetic quantum number? Write down the values of these quantum numbers for s, p and d shell. 2+2=4

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4. (a) What are momentum space wave functions? Show that momentum space wave function is Fourier transform of the position space wavefunction. 1+6=7

Or

Obtain an expression for the wavefunction of a Gaussian wave packet. Briefly explain the spread of a Gaussian wave packet. 5+2=7

- (b) Obtain an expression for the energy of a simple harmonic oscillator using Frobenius method. 7

Or

Obtain the energy eigenvalues for a particle confined in a one dimensional square well potential. 7

5. (a) Show the L-S coupling for an electron in  $4p\ 4d$  configuration and determine the spectral terms. 5

- (b) Distinguish between normal and anomalous Zeeman effect. Obtain an expression for the magnetic interaction energy for a single valence electron experiencing normal Zeeman effect. 7

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