

Total No. of Printed Pages—4

**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

P23/429

( Turn Over )

( 2 )

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

3/429

( Continued )

( 3 )

2. Answer the following questions : 2×6=12
- (a) What are the conditions for a wave-function to be physically acceptable?
  - (b) Define wave packet. With what velocity does a wave packet move?
  - (c) Briefly describe the relation between zero point energy and uncertainty principle of a Harmonic oscillator.
  - (d) What is Larmor precession? Define Bohr magneton.
  - (e) Briefly discuss the fine structure in sodium atom.
  - (f) 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

P23/429

( Turn Over )

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  $4p4d$  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

\*\*\*