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5 SEM TDC PHYH (CBCS) C 11

2022

(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

(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) ½

(iii) 1 (iv) 2

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 (Ψ_{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

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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