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5 SEM TDC PHYH (CBCS) C 11

2024

(November)

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) The de Broglie waves are

(i) electromagnetic waves

(ii) matter waves

(iii) mechanical waves

(iv) standing waves

(b) The solution of Schrodinger equation in three dimensions is expressed as

(i) $\psi(\vec{r}, t) = \psi(\vec{r}) e^{-iEt}$

(ii) $\psi(\vec{r}, t) = \psi(\vec{r}) e^{-\frac{iE}{\hbar}t}$

(iii) $\psi(\vec{r}, t) = \psi(\vec{r}) e^{\frac{iE}{\hbar}t}$

(iv) $\psi(\vec{r}, t) = \psi(\vec{r}) e^{-\frac{iE}{\hbar}k}$

(c) The energy of a one-dimensional harmonic oscillator in second excited state is

(i) $\frac{1}{2}\hbar\omega$ (ii) $\frac{3}{2}\hbar\omega$

(iii) $\frac{5}{2}\hbar\omega$ (iv) zero

(d) The angular momentum for an electron in the *d*-state of the hydrogen atom is

(i) 0 (ii) $\sqrt{2}\hbar$

(iii) $\sqrt{6}\hbar$ (iv) $\sqrt{10}\hbar$

(e) The values of orbital and spin gyromagnetic ratios for electron are

(i) $g_l = 0$ and $g_s = 2$

(ii) $g_l = 1$ and $g_s = 2$

(iii) $g_l = 1$ and $g_s = 1$

(iv) $g_l = 2$ and $g_s = 1$

(b) Obtain an expression for the wave function of a Gaussian wave packet. Briefly explain the spread of a Gaussian wave packet. 4+2=6

Or

Show that momentum space wave function is Fourier transform of the position space wave function. 6

(c) Obtain an expression for the energy of a simple harmonic oscillator using Frobenius method. 6

Or

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

(d) Obtain the Schrodinger equation in spherical polar coordinates from the corresponding equation in Cartesian coordinates. 7

Or

Obtain three independent differential equations from the Schrodinger equation in each of the spherical polar coordinates for the electron of the hydrogen atom.

5. Write short note on any *one* of the following : 4

(a) Stern-Gerlach experiment

(b) Space quantization

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2. Answer the following questions : $2\times5=10$

(a) Obtain the commutator relation for position and momentum operator.

(b) Show that probability density of a quantum mechanical particle is independent of time.

(c) How are the zero point energy and uncertainty principle related to each other?

(d) Define and write down the expression for Larmor frequency.

(e) Briefly discuss the spectra of alkali atoms.

3. (a) Find the expectation value of momentum of a particle whose normalized wave function is

$$\psi(x) = \frac{1}{\sqrt{2a}} e^{i(kx-\omega t)}$$

in the interval $(-a, a)$. 3

(b) Distinguish between normal and anomalous Zeeman effect. 3

(c) Briefly discuss the coupling of orbital and spin angular momenta in the vector model of atom. 3

4. (a) Show that the number of final levels is the same for L-S and J-J coupling for an electron in $4p\,4d$ configuration. 6