UG/5th Sem/Phys(H)/T/19



2019

B.Sc. (Honours)

5th Semester Examination

# PHYSICS

## Paper - C11T

Full Marks : 40 Time : 2 Hours

*The figures in the margin indicate full marks.*
*Candidates are required to give their answers in their own words as far as practicable.*

1. Answer any *five* questions from the following : 5×2=10

(a) Using relation $[\hat{x}, \hat{p}] = i\hbar$, prove

$$[\hat{p}, f(x)] = -i\hbar \frac{\partial f}{\partial x}.$$

(b) The eigenvalue of an operator $\left(x + \frac{d}{dx}\right)$ is $\alpha$.

Find eigenfunction.

*[ Turn Over ]*

(c) An electron has a speed of 300 m/s, accurate to 0.01%. With what accuracy can the position of the electron be located ?

(d) Write down the Hamiltonian of the electron in the hydrogen atom.

(e) In a many electron atom, the orbital, spin and total angular momenta are denoted by $\bar{L}$, $\bar{S}$ and $\bar{J}$ respectively. If $L=2, S=1$ and $J=2$, find the angle between $\bar{L}$ and $\bar{S}$ using vector atom model.

(f) A spectral line of wavelength 4500Å when produced in a magnetic field to 10 Tesla is observed to split to a normal zeeman triplet. Calculate the wavelength separation between components of the triplet.

(g) Compute the value of $\langle r \rangle$ in the ground state of hydrogen atom.

(h) Find Landé-g-factor and total magnetic moment for ${}^6S_{5/2}$ given $\mu_B = 9.27\times10^{-24}\ J/T$



2. Answer any *four* questions from the following : 5×4=20

(a) What is the physical significance of normalization of wave function ? Find normalization const. A and sketch the graph of the function.

$$\psi(x) = A(x-1)x, \quad 0 \le x \le l. \qquad 1+2+2$$



(b) (i) What is meant by space quantisation ?

(ii) In a Stern-Gerlach experiment, the gradient of magnetic field is 5 volt. $s.m^{-2}$/mm with pole pieces of 0.07m long. A narrow beam of silver atoms from an over at 1000K passes through the magnetic field. Calculate the separation of the beams as they emerge from the magnetic field. 2+3

(c) (i) What do you mean by stationary states ?

(ii) The wave function of a particle in a stationary state with energy $E_0$ at time $t=0$ is $\psi(x)$. After now much minimum

*[ Turn Over ]*

time will the wave function be again $\psi(x)$ ? 2+3

(d) A free particle which is initially localized in the range $-a < x < a$ is released at time $t = 0$.

$$\psi(x,0) = \begin{cases} A & \text{if } -a < x < a \\ 0 & \text{otherwise} \end{cases}$$

Calculate $\phi(x)$ {wave-vector function of $\psi(x, 0)$ in momentum space} and find $\psi(x, t)$. 3+2

(e) Write down the Hamiltonian and Schrödinger wave equation for hydrogen atom. Separate the Schrödinger equation for the motion of electron in hydrogen atom into radial and angular parts. 5

(f) Discuss briefly, with theory, the Stren-Gerlach experiment.

Justify the use of a beam of silver atoms in the experiment. 5



3. Answer any *one* question from the following : 10×1=10

(a) (i) Describe the theory of anomalous Zeeman effect.

(ii) Illustrate with appropriate diagrams the Zeeman splitting of sodium $D_1$ and $D_2$ lines.

(iii) Calculate the processional frequency of an electron orbit when placed in a magnetic field of strength 4*T*. 5+3+2

(b) (i) The potential energy of a linear harmonic oscillator consisting of a particle of mass m and executing oscillations with an angular frequency $\omega_0$ is $V(x) = \frac{1}{2} m\omega_0^2 x^2$.

Write down Hamiltonian operator and time independent Schrödinger equation for the oscillator. What are the eigenvalues and eigenfunctions of the Hamiltonian ? 2+3

*[ Turn Over ]*

(ii) What is Zero-point energy ? How does it reconcile with classical view point ? 2+2

(iii) Is it possible for a free particle to have negative energy ? 1

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