



K.R. MANGALAM UNIVERSITY
THE COMPLETE WORLD OF EDUCATION

Rollno.....

End Semester Examination, December 2024
B. Sc. Hons Physics – 5th Semester
Quantum Mechanics and Applications (BSPH301A)

Time: 2.5 hrs.

Max Marks: **50**

Note: *All Questions are compulsory. Marks are indicated against each question.*

Part A (2X5)

Q.1 Attempt any five questions.

(a) Tell the physical significance of wavefunction.

[CO1][L1] 2

(b) Given a one-dimensional wave function

$\Psi(x) = \sqrt{a} e^{-ax}$. Find the probability of finding the particle between $x = \frac{1}{a}$ and $x = \frac{2}{a}$.

[CO1][L1] 2

(c) Show that the commutation between time and Hamiltonian operator is not 0.

[CO1][L1] 2

(d) Solve the following commutation relation $[x, p^2]$.

[CO1][L3] 2

(e) A particle is described by a wavefunction $\Psi(x) = \frac{1+ix}{1-ix}$. Calculate the average value of the position of the particle.

[CO1][L3] 2

(f) Find the normalization constant for the given wavefunction

$$\psi = A e^{i\omega t} \cdot e^{\frac{-x^2}{2a}}$$

[CO1][L1] 2

(g) Prove that the cyclic commutation of operators $\hat{A}, \hat{B}, \hat{C}$ is 0.

[CO1][L5]

2

PART-B (4X10)

Q.2 (a) Prove that for the nth state of a particle in an infinite potential well (length 0 to L), there will be (n+1) nodes, also sketch the graph.

[CO2][L3,L5] 5

(b) Discuss the main conclusions which can be inferred from the energy and wavefunction of a particle in an infinite potential well.

[CO2][L6] 5

OR

Determine the energy of a particle in one dimensional square well potential defined as

$$V(x) = 0 \text{ for } x < 0$$

$$V(x) = -V_0 \text{ for } 0 < x < a$$

$$V(x) = 0 \text{ for } x > a$$

Where V_0 is the depth of the well and is a positive constant.

[CO2][L4]10

Q.3 (a) Define the Zero-point energy for a particle in an infinite potential well. [CO2][L1] 2

(b) Derive the expression for wavefunction for the n th level for a particle in an infinite potential well. [CO2][L3] 3

(c) Derive the expression for energy for the n th level for a particle in an infinite potential well. [CO2][L4] 5

OR

(a) Define the Zero-point energy for a quantum harmonic particle. [CO2][L1] 2

(b) Derive the expression for energy of a particle oscillating as a quantum harmonic oscillator. [CO2][L4] 8

Q.4 (a) Obtain the term symbol for the following states: 2p, 1s, 3d, 4f and 3p. [CO3][L3] 5

(b) Obtain the term symbols for 3p3d state of He by LS coupling. [CO3][L3] 5

OR

(a) Explain the Aufbau's principle, Hund's rule and the Pauli's exclusion principle, and apply these to give the ground state electronic configuration of Calcium (Ca). [CO3][L2, L3] 5

(b) For each set of quantum numbers, analyze which one is invalid and why? [CO3][L4] 5

(i) $n=1, l=1, m_l=0, m_s=+1/2$

(ii) $n=2, l=1, m_l=-1, m_s=+3/2$

(iii) $n=3, l=1, m_l=2, m_s=-1/2$

(iv) $n=0, l=0, m_l=0, m_s=+1/2$

Q.5 (a) Illustrate the Stern-Gerlach experiment with a well labeled diagram of its construction. Conclude the main outcome of this experiment. [CO4][L2, L4] 5

(b) Differentiate between the normal Zeeman effect and the anomalous Zeeman effect. [CO4][L4] 3

(c) Analyze which coupling explained the splitting of a greater number of spectral lines in the presence of weak magnetic field. [CO4][L3] 2

OR

(a) Illustrate which field differentiates between the Zeeman effect and the Stark effect. [CO4][L2] 2

(b) Derive and analyze the expression for Larmor's frequency and hence explain Larmor's precession. [CO4][L4] 8