Registration Number:

Date & Session

ST. JOSEPH'S COLLEGE (AUTONOMOUS), BENGALURU -27
B.Sc – V SEMESTER
SEMESTER EXAMINATION: OCTOBER 2022
(Examination conducted in December 2022)

PH 5218 : QUANTUM MECHANICS, ATOMIC AND MOLECULAR PHYSICS

Time: 2 ½ Hours **Max Marks: 70**

This paper contains 2 printed pages and 3 parts

PART-A

Answer any **FOUR** questions: [4X10=40]

1. a) With a neat diagram, describe Davisson and Germer's experiment. How did the result support the de-Broglie hypothesis?
   b) Give Born's interpretation of the wave function.
   [8+2]

2. a) What is wave-particle duality? Arrive at an expression for de-Broglie wavelength in terms of momentum, energy and temperature.
   b) Explain the failure of classical physics to explain the experimental facts on photoelectric effect. [7+3]

3. a) Obtain Schrodinger's time dependent wave equation for a moving particle.
   b) Write a note on expectation value. [7+3]

4. a) Set up the Schrodinger's equation for a free particle trapped in a one dimensional infinite potential well. Solve it to obtain the eigen values of energy.
   b) Write the equation of continuity in quantum mechanics and give its significance.
   [8+2]

5. With necessary theory, describe Stern-Gerlach experiment and mention its importance. [10]

6. a) Obtain an expression for the rotational energy levels of diatomic molecule and shows that the spectral lines equally spaced.
   b) Mention the applications of the Raman effect. [8+2]

PART-B

Answer any **FOUR** questions: [4X5 = 20]

Planck's Constant = 6.626 x 10^{-34}Js. Mass of electron = 9.1x10^{-31} kg, charge of electron =1.6 x10^{-19} C

7. A golf ball has a mass of 75 g and a speed of 56 m/s. Find the de-Broglie wavelength. If the speed can be measured with a precision of 1.5% with, what precision can one simultaneously measure its position?

8. Evaluate (i) the commutation value of $[x, \frac{\partial}{\partial x}]$ and $[\frac{\partial}{\partial x}, x]$ (ii) If $\Psi(x) = sin2x$, find the eigen value of the operator $\frac{d^2}{dx^2}$.

9. The energy of a linear harmonic oscillator in its 3rd excited state is 1eV. Calculate frequency of the oscillator. Also find out zero-point energy in joules and in eV of the oscillator.

10. Find the probability that a particle can be found between x = 0.25 and 0.55 when the particle is limited to the x-axis and has a wave function

$$\psi = \begin{cases} a\,x & \text{for } 0 \leq x \leq 1 \\ 0 & \text{for } x < 0 \text{ and } x > 1 \end{cases}$$

11. For an electron in an atom if the orbital quantum number is 3 then find the possible values of orientations of the orbital angular momentum with respect to an external magnetic field.

12. A substance shows Raman line at 4567 Å when exciting line 4358 Å is used. Deduce the positions of stokes line for the same substance when the exciting line 4047 Å is used.

PART-C

13. Answer any **FOUR** questions with proper justification. [4X2 = 10]

a) Is the colour of the spectral line emitted due to transition in a one-dimensional box related to its size? Explain.
b) Why does normal Zeeman effect occur only in atoms with an even number of electrons?
c) A beam of short wavelength gives accurately the position of a particle. Explain.
d) Can the wave function ψ be equal to a tan function?
e) Among electron and neutron which one should be heated more so that they have the same de Broglie wavelength?
f) Is the state $^2P_{1/2}$ allowed? Justify.