| Register Number: |
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| DATE: 23-10-2019 |

**ST. JOSEPH'S COLLEGE (AUTONOMOUS), BANGALORE-27**
**B.Sc. PHYSICS - V SEMESTER**
**SEMESTER EXAMINATION: OCTOBER 2019**

**PH5215 – Quantum Mechanics, Atomic and molecular Physics**

**Time 2 ½hrs** **Max Marks: 70**

**This paper contains 2 printed pages and 3 parts**

## PART A

Answer any **FOUR** of the following: (4x10 = 40)

1. a) What are the physical significance of a wave function?
   b) Set up Schrodinger's time dependent wave equation. (2+8)

2. a) Explain diffraction of electrons at a single slit to arrive at Heisenberg's uncertainty principle.
   b) If two operators commute, write the mathematical expression for that and explain the physical significance of that. Can kinetic energy and linear momentum of a quantum system be determined simultaneously and precisely? Explain. (6+4)

3. a) Using separation of variables method, obtain the expression for azimuthal equation ($\Phi$ - equation) for a spherically symmetric particle.
   (given: $\nabla^2 = \frac{1}{r^2}\frac{\partial}{\partial r}\left(r^2\frac{\partial}{\partial r}\right) + \frac{1}{r^2 sin\theta}\frac{\partial}{\partial \theta}\left(sin\theta\frac{\partial}{\partial \theta}\right) + \frac{1}{r^2 sin^2\theta}\frac{\partial^2}{\partial \emptyset^2}$ )

   b) Explain degeneracy of energy states with example. (5+5)

4. a) Explain zero point energy in the case of harmonic oscillator. Does this concept of zero point energy violate Planck's quantum idea? Justify your answer.

   b) Explain tunneling effect with one example. (5+5)

5. Explain 'spin' of an electron. Describe Stern- Gerlach experiment with relevant theory. (10)

6. What is coherent and incoherent scattering? Explain the experimental arrangement and quantum theory of Raman effect. Elaborate on stokes and antistokes lines. (2+6+2)

## PART B

Solve any **FOUR** problems: (4x5 = 20)

7. Show that sinx and sin2x with 0 < x < 2π, are the eigen functions of the operator $\hat{A} = -\frac{d^2}{dx^2}$ Find their eigen values.

8. A particle on the x-axis has the wave function $\varphi(x) = cx^2$, between x = 0 and x = 2 where c is the normalization constant. Normalize the wave function over the interval and find the expectation value of the particle's position $\langle x \rangle$.

9. An electron in a cubical box jumps from the state $n_x = 3$, $n_y = 3$, $n_z = 3$ to the state $n_x = 2$, $n_y = 2$, $n_z = 2$ releasing an electromagnetic wave of wavelength 4040nm. Find the sides of the box.

10. An electron is confined in a sphere of radius 1A°. Estimate uncertainty in the kinetic energy of the electron.

11. Find the possible values of the total angular momentum quantum number J under L-S coupling of two electrons whose orbital quantum numbers are $l_1 = 1$ and $l_2 = 2$. $s_1 = s_2 = ½$

12. The CO molecule has a bond length of 0.113nm. The masses of $^{12}C$ and $^{16}O$ atoms are $1.99 \times 10^{-26}$ kg and $2.66 \times 10^{-26}$ kg respectively. Find the moment of inertia of the molecule. If lowest rotational energy is $4.76 \times 10^{-4}$ eV, find the angular velocity of the molecule.

## PART C

13. Answer any **FIVE** of the following: (5x2 = 10)

a) A cricket ball of mass 0.5kg is moving with a velocity 189 km/s. Can we observe de-Broglie wave associated with it? Explain.

b) Can a single matter wave represent a physical particle? Explain.

c) The work function for a certain metal is 4.2eV. Will this metal give photo electric emission for incident radiation of wavelength 330nm? Explain.

d) A bound particle has quantised energy values. Explain.

e) What are the possible values of l and $m_l$ associated with the principle quantum number n = 2.

f) Differentiate between Normal Zeeman effect and anomalous zeeman effect.