ELIZADE UNIVERSITY
ILARA-MOKIN
ONDO STATE

FACULTY: Basic and Applied Sciences
DEPARTMENT: Physical and Chemical Sciences
FIRST SEMESTER EXAMINATIONS
2018/2019 ACADEMIC SESSION

COURSE CODE: PHY 303

COURSE TITLE: INTRODUCTION TO QUANTUM MECHANICS

DURATION: 3 HOURS

HOD's SIGNATURE

TOTAL MARKS:

Matriculation Number: ______________________________

INSTRUCTIONS:

1. Write your matriculation number in the space provided above and also on the cover page of the exam booklet.
2. This question paper consists of 2 pages with printing on both sides.
3. Answer all questions in the examination booklet provided.
4. More marks are awarded for problem solving method used to solving problems than for the final numerical answer.
5. Box your final answers.
6. **Attempt 2 of the 3 questions in each of the sections, making it a total of 4 out of 6 questions.**

SECTION A

QUESTION ONE

(a) What is meant by black body radiation? (ii) State Wien's Radiation formula and Rayleigh-Jean's formula, and how they explain the observed black body radiation

(b) What is meant by Ultraviolet (UV) catastrophe? (ii) Sketch the classically predicted spectral function, showing the ultraviolet catastrophe (iii) State the Planck's quantum hypothesis and explain how Planck theory avoids the catastrophe

QUESTION TWO

(a) State an experiment and effects that illustrate the following features of light and matter.

(i) The wave nature of light (ii) The particle nature of light (iii) The particle nature of an electron (iv) The wave nature of an electron

(b) A particle of mass m is trapped in a one dimensional box with a potential described by:

$$V(x)=\begin{cases}0 & 0\le x\le a\\ \infty & \text{otherwise}\end{cases}$$

Solve the Schrodinger equation for this potential

QUESTION THREE

(a) State four properties of a valid wavefunction. (ii) Let two functions Ψ and Φ be defined for $0\le x\le\infty$. Explain why $\Psi(x)=x$ cannot be a wavefunction but $\Phi(x)=e^{-x^2}$ could be a valid wavefunction.

(b) A particle is in an infinite square well potential with walls at x = 0 and x = L. If the particle is in the state $\Psi(x)=ASin\left(\frac{3\pi x}{L}\right)$ where A is a constant, what is the probability that the particle is between $x=\frac{1}{3}L$ and $x=\frac{2}{3}L$?

SECTION B

QUESTION FOUR

The Pauli matrices are defined by $\sigma_x=\begin{pmatrix}1 & 0\\ 0 & 1\end{pmatrix},\sigma_y=\begin{pmatrix}0 & i\\ -i & 0\end{pmatrix},\sigma_z=\begin{pmatrix}1 & 0\\ 0 & -1\end{pmatrix}$

(a) Find $\left[\sigma_x,\sigma_y\right]$ and $\left\{\sigma_x,\sigma_y\right\}$

(b) Express σ_z in outer product notation

QUESTION FIVE

Suppose that an operator $\hat{A}=2|\Phi_1\rangle\langle\Phi_1|-i|\Phi_1\rangle\langle\Phi_2|+i|\Phi_2\rangle\langle\Phi_1|+2|\Phi_2\rangle\langle\Phi_2|$, where $|\Phi_1\rangle$ and $|\Phi_2\rangle$ form an orthonormal and complete basis

(a) Show that $\hat{A}$ is Hermitian

(b) Find the eigenvalues and eigenvectors of $\hat{A}$

QUESTION SIX

Given that the state vector $|A\rangle$ is represented by $|A\rangle=(9-2i)|u_1\rangle+4i|u_2\rangle-|u_3\rangle+i|u_4\rangle$ where $|u_i\rangle$ are orthonormal basis. Determine

(a) The dual vector and the row vector representing it

(b) The inner product $\langle A|A\rangle$