JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY

SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES

UNIVERSITY EXAMINATION FOR THE DEGREE OF MASTER OF SCIENCE IN PHYSICS

1ST YEAR 1ST SEMESTER 2018/2019 ACADEMIC YEAR

MAIN REGULAR

COURSE CODE: SPH 803

COURSE TITLE: Quantum Mechanics

EXAM VENUE: **STREAM: MASTERS**

DATE:

TIME: **EXAM SESSION:**

INSTRUCTIONS:

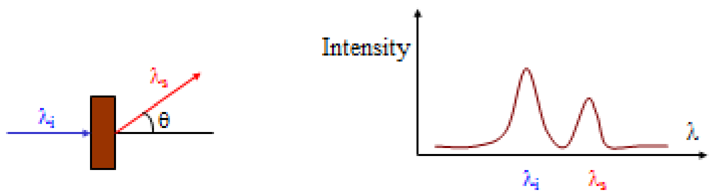
1. **Answer question 1 (Compulsory) in section A and ANY other 2 questions in Section B.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**
4. **Some important information/formulas are found on the last page of this question paper**

SECTION A

Question 1

a) Discuss the Bohr Model of H-atom emission spectrum and it is limitations in describing the emission spectrum of atoms (6 marks)

b) In an experiment of the Compton Effect (1923), a monochromatic beam of X-rays (λ_i) = incident on a graphite block. The observation in this experiment is that some of the X-rays passing through the block are found to have longer wavelengths (λs) as illustrated below. Briefly discuss the origin of the differing wavelengths. (6 marks)



c) Discuss briefly the properties of a Wavefunction in a 1 – D box.
(6 marks)

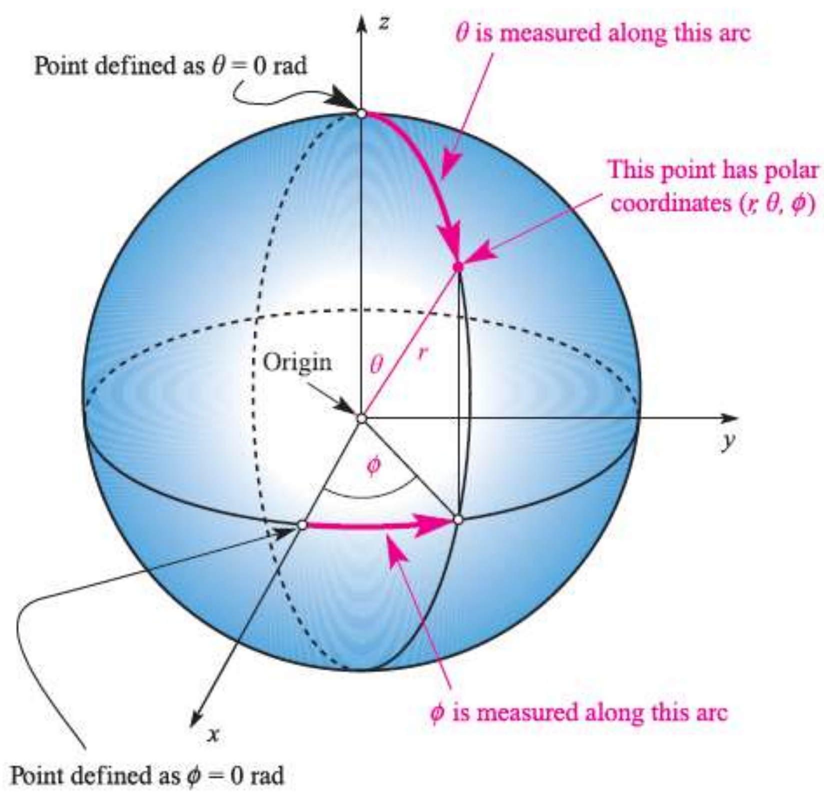
d) By use of a diagram, discuss the density distribution of a particle in a 1-D Box and briefly describe using equations the probability of finding a particle between x and x+dx (in the state represented by ψ_n) (6 marks)

e) Briefly discuss plots of the radial parts of the wavefunction *R(r)* against distance *r* from nucleus/atomic units for 1s, 2s, 2P, 3P, 3d, and 4p. The radial distribution function is $4\pi r^2 R(r)^2$. (6 marks)

Section B. Answer any <u>TWO</u> questions

Question 2

a) The figure below shows polar coordinates and radial coordinate of an electron in an orbit. Use the solutions to Schrodinger equation for the hydrogen atom to define the 1s, 2s, and 2p atomic orbitals. Use $R(r) = 2(z/a_0)e^{-zr/a_0}$, for hydrogen, Z = 1 and a_0 = 1atomic unit. (20 marks)



Question 3

a) Briefly describe the following representation pictures of a wavefunction.

i. The Schrodinger picture (6 marks)

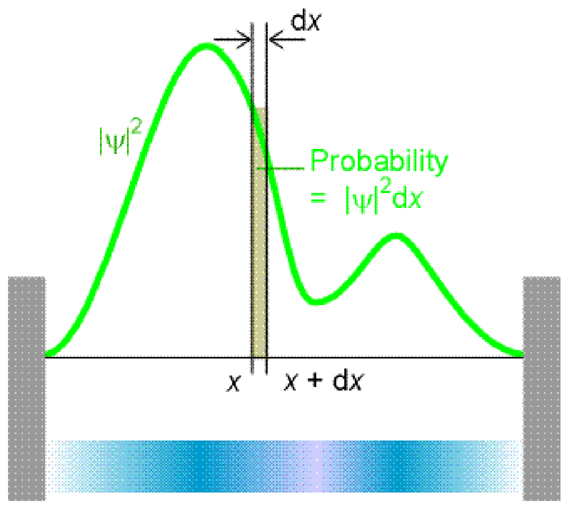
ii. Heisenberg picture (7 marks)

iii. The interaction picture (7 marks)

Question 4

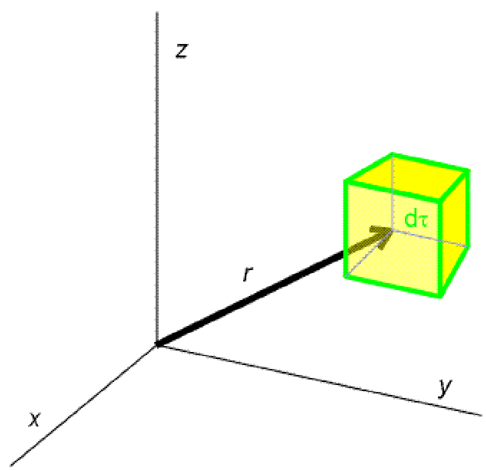
a) Given that the wavefunction at a point x in a one dimensional box is $\psi(x)$, determine the probability of finding the particle in the infinitesimally small region (dx) between x and x+dx as shown below.

(5 marks)



b) Given the wave function of a particle in a three dimensional box $\psi(x)$, determine the probability of finding the particle in the infinitesimal volume element $d\tau$(= dxdydz) as demonstrated in the figure below.

(5 marks)



c) Briefly discuss the process of 'Normalization of the Wavefunction'

(10 marks)