KENYATTA UNIVERSITY

UNIVERSITY EXAMINATIONS 2011/2012 *(MOMBASA CAMPUS)*

SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 301: QUANTUM MECHANICS

DATE: MONDAY 2ND APRIL 2012 TIME: 11.00 –1.00PM

INSTRUCTIONS

Answer Question ONE and any other two questions

Question 1

a. List the conditions necessary for acceptable wave function (3mks)

b. What is an operator? Find the value of linear momentum operators in Cartesian coordinates. (5mks)

c. When is a wave said to be normalized? The functions $F_1(x)$ and $F_2(x)$ are defined in the interval x=-a and x=+a as follows:

i. $F_1(x) = N_1(a^2 - x^2)$

ii. $F_2(x) = N_2 x(a^2 - x^2)$

Assuming the values of the functions to be zero for x⍰+a and x⍰-a, calculate the constants N_1 and N_2. (5mks)

d. Show that the functions $F_1(x)$ and $F_2(x)$ in (a) above are orthogonal. (3mks)

e. Define the following terms:

i. eigenvalue

ii. eigenfunction

Show that sin2x is not and eigenfunction of the operator d/dx but of d^2/dx^2. what is the eigenvalue? (4mks)

f. Explain why Schrödinger's equation is not valid for relativistic particles. (3mks)

g. A particle is moving in one dimensional potential box of infinite height and width 10×10^{-10}m. Calculate the probability of finding the particle within an interval of 4×10^{-10}m at the centre of the box when it is at the state if least energy. (4mks)

h. The lowest energy possible for a certain particle entrapped in a box is 40eV. What are the next two energies the particles can have? (3mks)

Question 2

a. Starting from the wave equation and introducing energy and momentum of the particle, obtain the expression for three dimensional Schrodinger's equation in time dependent form. (10mks)

b. Obtain three dimensional time independent scrodinger's wave equation from time dependent wave equation. (10mks)

Question 3

a. Describe the postulates of quantum mechanics. (10mks)

b. Define a Hermitian operator. List and prove the properties of a hermitain operator. (10mks)

Question 4

a. State Schrödinger's wave equation for a free particle in one dimensional closed box with infinitely hard walls, hence state the boundary conditions and solve it to obtain normalized wave function for the particle. (10mks)

b. How many maxima and minima are there in the: (10mks)
   a. ground state
   b. first excited state and
   c. second excited state of a particle in a square well?

Question 5

a. Differentiate between a potential step and a potential barrier. Give a physicsl example in each case. (4mks)

b. What is a harmonic oscillator? Give at least two examples. Obtain the energy levels for a harmonic oscillator according to quantum mechanics. Hence plot the energy levels of the oscillator and compare with energy levels of hydrogen atom. (16mks)