MACHAKOS UNIVERSITY

University Examinations 2018/2019

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

APRIL SESSION EXAMINATION FOR

BACHELOR OF EDUCATION (SCIENCE)

SPH 402: QUANTUM MECHANICS II

DATE: SCHOOL BASED **TIME: 2 Hours**

INSTRUCTIONS

Answer Question One and Any Other Two Questions

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define angular momentum, the classical mechanics way or according to the way you learnt in Mechanics 2 (3 marks)

b) A particle is executing a horizontal circle in anti-clockwise direction, draw the scenario and show the direction of its angular momentum. (3 marks)

c) Explain what is meant by conservation of angular momentum and use this to explain why does the earth keep on spinning? (3 marks)

d) Jackline is a girl in a Quantum mechanics and in an end of semester party, while dancing she spins on her heel as shown in figure 1. Explain what happens to her speed of revolution with a reason if she spins when her hands are

i) Outstretched

ii) Folded to her chest (2 marks)

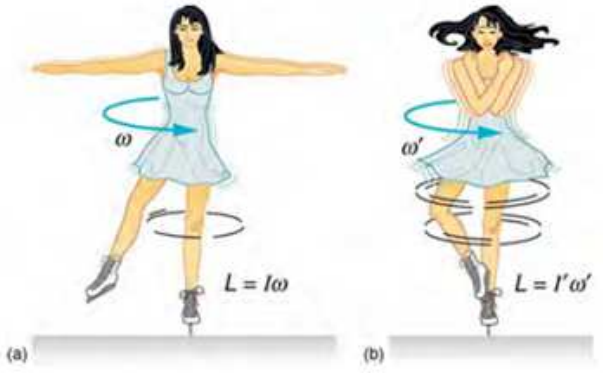

Figure 1

e) Our planet was born from a huge cloud of gas and dust, gravitational forces caused the cloud to contract. Explain the effect of this on its rate of rotation. (2 marks)

f) What happens to the speed of rotation of an electron when it jumps to an energy level further from the nucleus. (2 marks)

g) Given that plank's constant $h = 6.626\ x\ 10^{-34} j.s$. calculate *h*-bar (2 marks)

h) Using a diagram describe Zeeman effect (3 marks)

i) State the Paulli's exclusion principle (3 marks)

j) Consider the wave function $\psi(x) = A_1 e^{ikx} + A_2 e^{-ikx}$, where k is positive.

i) Determine if this is a valid stationary state wave function for a free particle (4 marks)

ii) Find the energy of this state (3 marks)

QUESTION TWO (20 MARKS)

a) In some situations, electrons behave like waves rather than particles; a wave function ψ is used to describe their dynamic states. State 5 of this dynamic states (5 marks)

b) The possible wave functions are labelled according to 3 quantum numbers.

i) Name the numbers (4 marks)

ii) Explain what each number refers to (6 marks)

c) The earth travels in nearly circular orbit around the sun and at the same time it rotates on its axis. Give and explain its analogy in atomic world. (3 marks)

d) List all possible states of a hydrogen atom that have energy E = -3.40 eV (2 marks)

QUESTION THREE (20 MARKS)

a) The earth acts like gigantic gyroscope with its angular momentum along its axis of rotation as shown in figure 2. Draw the path that will be traced by the tip P of its axis (2 marks)

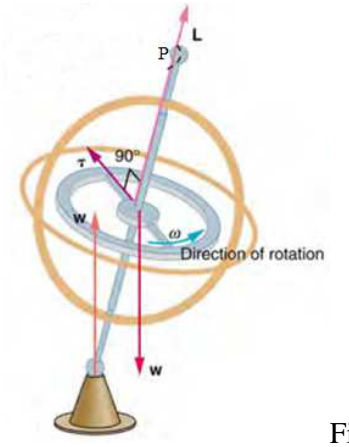

Figure 2

b) The discrete energy levels of a hydrogen atom are an example of a set of eigenvalues. Find the first 3 hydrogen atom eigenvalues. (6 marks)

c) Find the first 3 eigenvalues of the magnitude of the total angular momentum in a hydrogen atom (6 marks)

d) Given $\psi = Ae^{-i\omega(t-\frac{x}{v})}$ show that

i) $\psi = A\, e^{-2\pi i(ft-x/\lambda)}$ (3 marks)

ii) $\psi = Ae^{-(i/\hbar)(Et-px)}$ (3 marks)

QUESTION FOUR (20 MARKS)

A hydrogen atom in a state with n=6. Find expressions for the largest magnitude

i) L of angular momentum (3 marks)

ii) The largest positive value of L_z and (3 marks)

iii) Corresponding values of quantum numbers *l and* m_l (3 marks)

iv) For the corresponding quantum state, find the smallest angle that angular momentum vector can make with + z axis. (4 marks)

v) Make a list in form of a table of all the possible sets of quantum numbers, and thus of the possible states of electrons, in an atom a hydrogen atom with n = 6. (7 marks)

QUESTION FIVE (20 MARKS)

a) Define the terms

i) eigenvalues (2 marks)

ii) eigen functions and (2 marks)

iii) degeneracy (3 marks)

b) The atom having electron configuration $1s^2 2s^2 2p^6 3s^2 3p$ have how many orbital electrons. (4 marks)

c) State one application of the Pauli's exclusion principle together with list of electron energy states. (2 marks)

d) A hydrogen atom has n = 4. Find

i) How many distinct (n, l, m_l) states are there? (3 marks)

ii) Find the energy of these states (4 marks)