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**JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES**

**UNIVERSITY EXAMINATION FOR THEDEGREE OF BACHELOR OF EDUCATION (SCIENCE)**

**4THYEAR 2NDSEMESTER**

**MAIN**

**REGULAR**

**COURSE CODE: SPH 403**

**COURSE TITLE: QUANTUM MECHANICS II**

**EXAM VENUE: STREAM: (BED SCI)**

**DATE: EXAM SESSION:**

**TIME: 2:00HRS**

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**Instructions:**

1. **Answer question 1 (Compulsory) and ANY other 2 questions.**
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.**

***QUESTION 1 ( 30 MARKS )***

a)

1. State **TWO** postulates of Quantum mechanics**(1 mark)**
2. Show that the solution of the time-dependent Schrӧdinger equation takes the form where the symbols have their usual meanings.**(3 marks)**

b) Using Dirac’s notation of eigenfunctions, state the Riesz variational

principle. **(1 mark)**

c) Define the following terms as used in Quantum mechanics.

1. Spin-orbit coupling**(1 mark)**
2. Schrӧdinger picture**(1 mark)**
3. Heisenberg picture**(1 mark)**
4. Interaction picture **(1 mark)**

d) Show that the x-component of the orbital angular momentum is given by

**(4 marks)**

e) Show that the time-independent Schrӧdinger equation of a hydrogenic atom

is given by where the symbols have their usual

meanings. **(4 marks)**

f) Distinguish between time-independent perturbation theory and time-

dependent perturbation theory. **(2 marks)**

g) State the selection rules for allowed transitions in hydrogen atom. **(2 marks)**

h) Account for the Pauli exclusion principle for fermions.**(2 marks)**

i) Derive the Heisenberg’s equation of motion. **(4 marks)**

j) The spin-up and spin-down state vectors of an electron are respectively

defined by ;. Write down the Hermitian conjugate state

vectors ; and show that they satisfy the orthonomality relations

; **(3 marks)**

**SECTION B**

***Attempt any TWO questions in this section.***

***QUESTION 2 (20 MARKS)***

(i)Express the Hamiltonian of a one-dimensional linear harmonic oscillator in

the form  where , are the usual annihilation and creation

operators which must be defined in the derivation. **(7 marks)**

(ii) Calculate the energy spectrum of the oscillator in the number state .

**(4 marks)**

(iii) Show that the ground state of the oscillator is a minimum uncertainty state,

hence give the physical interpretation of such a state. **(9 marks)**

***QUESTION 3 (20 MARKS)***

a) (i) Matrix operators for the angular momentum operators can be defined by

; ;. Determine the

commutator . **(3 marks)**

(ii) Show that the ladder operator , of the angular momentum in spherical

coordinates takes the form**(7 marks)**

b) A particle moves in the one-dimensional potential defined by

. By treating the potential as a perturbation, obtain

the first order energy correction, given that the unperturbed eigen function is

. **(10 marks)**

***QUESTION 4 ( 20 MARKS)***

1. Using , the radial equation for a one-electron atom is obtained in the form  where the symbols have their usual meanings.

(i) By completing the square of the effective potential, determine the

quantized orbit energy in the form . **(5 marks)**

(ii) Show that the radial equation can be factorized in the form

 where the parameter 

must be defined in the derivation. **(8 marks)**

1. Determine the highest quantized orbit solution of the factorized radial equation in a(ii) above in the form : where  is the Bohr radius. **(7 marks)**

***QUESTION 5 (20 MARKS)***

1. A two-level system described by the wave function

 experiences a time-dependent perturbation. Suppose the system is in state intially, derive the expressions for the first order approximations of probability amplitudes, and . **(12 marks)**

1. If the perturbation in 5 (a) above is of the form , show that the transition probability is given by **(8 marks)**