

**KISII UNIVERSITY**

**FIRST-YEAR EXAMINATION FOR THE AWARD OF THE DEGREE OF**

**MASTER OF SCIENCE (PHYSICS)**

**(January 2022-May 2022)**

**PHYS 824: ATOMIC AND MOLECULAR PHYSICS**

**INSTRUCTIONS**

*Answer question one and any other two questions in the answer booklet provided.*

***Duration: 2 hours***

**QUESTION ONE**

- (a) Explain the Pauli Exclusion Principle. [2marks]
- (b) Describe Zeeman Effect and Paschen-Back Effect of an electron system. [4marks]
- (c) Explain significance of Fortrat Diagrams in structural analysis of materials. [2marks]
- (d) Discuss differences between atomic electronic spectra and molecular electronic spectra. [2marks]
- (e) Calculate the value of the rotational constant B for a molecule of carbon monoxide. The bond length (R) of CO is 0.113 nm. [4marks]
- (f) Explain the term Compton scattering. [2marks]
- (g) State four quantum numbers used to describe quantum states of an electron in an atom. [4marks]
- (h) Distinguish between symmetric top and asymmetric top molecules [2marks]
- (i) Define the term electron configuration. [2marks]
- (j) Describe two applications of microwave spectroscopy. [4marks]

(k) Define the term predissociation. [2marks]

### QUESTION TWO

(a) Distinguish between Microwave Spectroscopy and Infra-red Spectroscopy. [2marks]

(b) Differentiate between rigid and non-rigid rotators. [2marks]

(c) Explain two applications of Raman scattering. [4marks]

(d) Describe an equation that represents energy of ejected photoelectron during photoelectric effect. [3marks]

(e) With suitable examples, discuss any two groups of rigid rotors. [4marks]

### QUESTION THREE

(a) Define the term nuclear magnetic resonance. [2marks]

(b) Explain two applications of nuclear magnetic resonance. [4marks]

(c) Highlight two processes by which photons interact with the matter without appreciable energy transfer. [4marks]

(d) Write an expression for the moment of inertia of a polyatomic molecule. [2marks]

(e) Explain what happens when an atom is placed in an external magnetic field (assume the magnetic field is constant in time and direction). [3marks]

### QUESTION FOUR

(a) State three techniques used for molecular structure analysis. [3marks]

(b) Discuss two applications of Infra-red Spectroscopy. [4marks]

(c) From microwave spectroscopy, bond lengths can be determined with a correspondingly high precision. From the rotational microwave spectrum of  $^1\text{H}^{35}\text{Cl}$ , we find that  $B = 10.59342\text{cm}^{-1}$ . Given that the masses of  $^1\text{H}$  and  $^{35}\text{Cl}$  are 1.0078250 and 34.9688527 amu, respectively, determine the bond length of the  $^1\text{H}^{35}\text{Cl}$  molecule. [4marks]

(d) Differentiate between Main group elements and Transition elements of the periodic table. [2marks]

(e) What do you understand by the term spin-orbit interactions? [2marks]