MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

P.O. Box 972-60200 – Meru-Kenya.
Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293
Website: www.must.ac.ke Email: info@mucst.ac.ke

UNIVERSITY EXAMINATIONS 2023/2024

FOURTH YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE IN PHYSICS, BACHELOR OF SCIENCE (MATHEMATICS AND PHYSICS) AND BACHELOR OF SCIENCE (PHYSICS)

SPH 3454: MOLECULAR PHYSICS

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

QUESTION ONE (30 MARKS)

a) The Explain how hyperfine structure is produced (4 Marks)

b) For the sodium D line (7681.94×10^{-8}cm) the Doppler broadening is 770MHz. calculate the temperature of the potassium vapour (4 Marks)

c) Identify the properties of substances that can be analysed using Electron Spin Resonance (3 Marks)

d) The splitting between two lines in a free radical is 75.0 MHz and g=2.005 give this terms of militesla and wave number (5 Marks)

e) Calculate the frequency required to satisfy the resonance conditions for N^{14} in a magnetic field of 2.3487T; $g_N = 0.4036$ (4 Marks)

f) The relative velocity between the source and absorber is 100m/s for Fe-57. The energy difference between the ground and the excited state is 14400eV. Find the frequency shift (5 Marks)

g) Find the value of the rotational constant for the molecule Br^{79} F ^{19} if the highest intensity spectral line is J=17 to J=18 at 300K. (5 Marks)

QUESTION TWO (20 MARKS)

a) The $J = 0$ to $J = 1$rotational absorption line occurs at 1.153 x 10 ^{11} Hz in C^{12} 0^{16} and 1.102 x 10^{11} Hz for $0^{x}0^{16}$. Find the mass number of the unknown carbon atom (11 Marks)

b) A Hg^{200} Cl^{35} molecule emits 4.4cm photon when it undergoes rotational transition from $J = l$ to $J = O$. Find the interatomic distance in the molecule (9 Marks)

QUESTION THREE (20 MARKS)

a) The lifetime of Fe^{57} excited state is 1.5 x 10 $^{-7}$s. The excited state is 14.4 Kev above the ground state. Determine the line width τ and τ/E. (8 Marks)

b) The chemical shift of the CH3 proton in acetaldehyde is 2.2 and that of CHO proton is 9.8. what is the difference in local magnetic field between the two regions of the molecule when an external field of 7.0T is applied (12 Marks)

QUESTION FOUR (20 MARKS)

a) Determine the relative intensities of the five fine structures of Fe3+ in single crystal. The effective spin is 5/2 (10 Marks)

b) Show a schematic diagram of the hyperfine structure of the n=l to n=2 Of hydrogen (1=1/2) for hydrogen (10 Marks)