



# MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

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## 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 3351: ATOMIC PHYSICS

DATE: APRIL 2024

TIME: 2 HOURS

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**INSTRUCTIONS: Answer Question ONE and any other TWO questions.**

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#### QUESTION ONE (30 MARKS)

- State any two successes of the Bohr atomic model (2 Marks)
- Using the infinite nuclear mass assumption in Bohr atomic model find the wave number of resonance for line in  $n=2$  to  $n=1$  for carbon-12 ( $Z=6$ ) (6 Marks)
- If the doublet splitting of the first excited state  $2^2P_{3/2}$  of He II is  $5.84\text{cm}^{-1}$  calculate the corresponding separation in Hydrogen (4 Marks)
- Predict the splitting of  $^3P_1$  level when the atom is in an external magnetic field of 2T (6 Marks)
- Calculate the atomic number of the element whose  $K_\alpha$  X-ray line wavelength is  $1.54443 \times 10^{-8}$  cm (4 Marks)
- The effective quantum number for the ground state of Rb is 1.805. Find the ionization potential of Rb ( $R_{\text{Rb}}=109737\text{cm}^{-1}$ ) (4 Marks)



MUST is ISO 9001:2015 and



ISO/IEC 27001:2013 CERTIFIED

- g) A Hydrogen atom initially in its ground state i.e.,  $n = 1$  level, absorbs a photon and ends up in  $n = 4$  level. What must have been the frequency of the photon? (4 Marks)

**QUESTION TWO (20 MARKS)**

- a) For an element atomic number 16 write all the possible values of  $n$ ,  $l$ ,  $m_l$  and  $m_s$  (9 Marks)
- b) An element has 1 unpaired electron in the p and 1 unpaired electron in the d orbital. Determine all the energy terms (11 Marks)

**QUESTION THREE (20 MARKS)**

- a) Compute the highest energy of the Balmer series and the lowest energy of the Lyman series of hydrogen hence show that they belong to different bands in the electromagnetic spectrum (9 Marks)
- b) Calcium is atomic number 20.
- Write the electronic configuration (1 Mark)
  - Determine its energy terms (10 Marks)

**QUESTION FOUR (20 MARKS)**

- a) Consider the sodium atom excited to the  $4^2D$  state. Deduce all the possible routes through which the electron can return to ground state (7 Marks)
- b) What is the minimum energy required to excite the Cd atoms ( $Z=48$ ) so that the L-series X-rays are observed  $\sigma = 7.4$  for L series (6 Marks)
- c) Calculate the separation between the adjacent normal Zeeman for 4D states of atom placed in a magnetic field of 1.5T. assume that the resultant spin angular momentum is zero ( $s=0$ ) (7 Marks)

