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**UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR**

**THIRD YEAR FIRST SEMESTER
SPECIAL/SUPPLEMENTARY EXAMINATIONS**

FOR THE DEGREE OF B.ED (SCIENCE) AND BSC (PHYSICS)

COURSE CODE: SPH 316/SPC 314

COURSE TITLE: ATOMIC PHYSICS

DATE: 16/8/2023

TIME: 2:00-4:00PM

INSTRUCTIONS TO CANDIDATES

TIME: 2 HOURS

Answer question ONE and any TWO of the remaining

- b) Bohr's atomic model [5 marks]
- c) Sommerfeld-Wilson atomic models [5 marks]
- d) Vector atomic model [5 marks]

QUESTION FOUR [20 MARKS]

An accelerator supplies a proton beam of 10^{12} particles per second and $2000\text{MeV}/c$ momentum. This beam passes through 0.01 cm aluminium window.

$$[A_v = 6.02 \times 10^{23}, m_e = 9.11 \times 10^{-31} \text{ kg}, Z = 13, A = 27, \rho = 2.7 \text{ g/cm}^3, x_0 = 24 \text{ g/cm}^3]$$

- a) Obtain an expression for Rutherford's scattering in cm/sr . [4 marks]
- b) Compute the differential Rutherford scattering cross section in cm/sr at 30° [4 marks]
- c) How many protons per second will enter a 1 cm radius circular counter at distance of 2 m and at an angle of 30° with the beam direction? [3 marks]
- d) Compute the integrated Rutherford scattering cross section for angles greater than 5° [4 marks]
- e) How many protons per second are scattered out of the beam in angles greater than 5° ? [2 marks]
- f) Compute the rms Coulomb scattering angle for the proton beam (take 15 MeV) [3 marks]

QUESTION FIVE [20 MARKS]

- a) Calculate the following the magnitude of orbital, spin and total angular momenta and also the angles between l and s for p electron in a one electron atom. [8 marks]
- b) Show that for a one electron atom the term separation of spin-orbit doublet is given by $\Delta T = 5.84 \frac{Z^4}{n^3 l(l+1)}$. [12 marks]
 Explain the meaning of each term.

QUESTION ONE [30 MARKS]

- a) Define the following terms: [4 marks]
Hund's rules, Compton wavelength, Blackbody and stopping potential.
- b) Calculate the hyperfine splitting in hydrogen in a ground state. [3 marks]
- c) Obtain an expression of the average speed of an electron in first Bohr orbit of an atom of atomic number Z . [3 marks]
- d) What is the magnetic moment of an atom in the state 3P_0 ? [3 marks]
- e) Couple a p-state and an s-state via j-j coupling. [3 marks]
- f) What is Lande's g-factor? Find the Lande's g-factor of the state $^2p_{3/2}$. [4 marks]
- g) State Moseley's law hence find wavelength K_α line in cobalt [4 marks]
[$Z = 27$ and $R = 1.097 \times 10^7 m^{-1}$]
- h) Compute the separation of the outer lines, two lines of a normal Zeeman pattern for spectral lines of wavelength 612nm in a magnetic field of 10kg. [3 marks]
[$1g = 10^{-4}T$, $e = 1.602 \times 10^{-19}C$, $m_e = 9.11 \times 10^{-31}kg$ and $c = 3.0 \times 10^8 m/s$]
- i) State any three experiments that lead to the development of atomic physics. [3 marks]

QUESTION TWO [20 MARKS]

- a) Describe an experimental arrangement for determining the characteristic lines in an X-ray spectrum. [8 marks]
- b) From measurement of X-ray emission spectra a variety of elements, Moseley was able to assign an atomic number Z to each of the elements. Explain explicitly how this assignment can be made. [4 marks]
- c) Discrete X-ray lines emitted from a certain target cannot in general be observed as absorption lines in the same material. Explain why, for example, the K_α lines cannot be observed in the absorption spectra of heavy elements. [4 marks]
- d) Explain the origin of the continuous spectrum of X-ray emitted when a target is bombarded by electrons if given energy. What feature of the spectrum is inconsistent with classical electromagnetic theory? [4 marks]

QUESTION THREE [20 MARKS]

Explain the following atomic models

- a) Rutherford's atomic model [5 marks]