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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 2000MeV/c momentum.

This beam passes through 0.01 cm aluminium window.

$[A_v = 6.02x10^{23}, m_e = 9.11x10^{-31}kg,\ Z = 13, A = 27, \rho = 2.7g/cm^3, x_0 = 24g/cm^3]$

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 30^0 [4 marks]

c) How many protons per second will enter a 1cm radius circular counter at distance of 2m and at an angle of 30^0 with the beam direction? [3 marks]

d) Compute the integrated Rutherford scattering cross section for angles greater than 5^0 [4 marks]

e) How many protons per second are scattered out of the beam in angles greater than 5^0? [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 $\Delta T = 5.84\frac{Z^4}{n^{3l(l+1)}}$. [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 $R = 1.097x10^7m^{-1}]$

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]
$[1g = 10^{-4}T, e = 1.602x10^{-19}C, m_e = 9.11x10^{-31}kg$ and $c = 3.0x10^8m/s]$

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]