KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER
MAIN EXAMINATIONS

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

COURSE CODE: SPH 316/SPC 314

COURSE TITLE: ATOMIC PHYSICS

DATE: 19/12/2022 **TIME:** 9:00-11:00AM

INSTRUCTIONS TO CANDIDATES

TIME: 2 HOURS

Answer question ONE and any TWO of the remaining

KIBU observes ZERO tolerance to examination cheating

QUESTION ONE [30 MARKS]

a) Define the following terms:

Auger effect, Anomalous Zeeman effect , Lande's interval rule and Lamb shift [4 marks

b) Calculate the spin-orbit interaction splitting of a level corresponding to $n = 2$, $l = 1$ of the hydrogen atom. [3 marks

c) Show that the average speed of an electron in the first Bohr orbit of an atom of atomic number Z is given by $Z/137$. [3 marks

d) Calculate the spin-orbit splitting of hydrogen $2p$ state. [3 marks

e) Couple a p-state and an s-state electron via Russell-Saunders 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 and hence find the wavelength of the K_α line in Aluminum. [4 marks
$[Z = 13$ and $R = 1.097x10^7 m^{-1}]$

h) Calculate the normal Zeeman splitting of the line 6438Å in a magnetic field of $0.5T$. [3 marks
$[e = 1.602x10^{-19}C$, $m_e = 9.11x10^{-31}kg$ and $c = 3.0x10^8 m/s]$

i) Find the angle between $\boldsymbol{l}$ and $\boldsymbol{s}$ in $^2P_{3/2}$ state of one electron atom. [3 marks

QUESTION TWO [20 MARKS]

a) Explain how any two of the following experiments led to the development of atomic physics: [10 marks

(i) Stern-Gerlach experiment

(ii) Franck-Hertz experiment

(iii) Lamb-Rutherford experiment

b) In the Stern-Gerlach experiment:-

(i) Obtain the expression of the force acting on the atomic magnetic moment. Why must the magnetic field be inhomogeneous? And how is the inhomogeneous field obtained? [5 marks

(ii) For hydrogen atom, what determines the number of lines one sees? What features of the apparatus determine the magnitude of the separation between the lines? [5 marks

QUESTION THREE [20 MARKS]

a) Calculate for He^+:-

i) Radius of the first Bohr orbit [3 marks

ii) Velocity of the electron moving in the first orbit. [3 marks

iii) Orbital frequency in the first orbit [3 marks

iv) Wavelength of the resonance line emitted in the transition $n = 2 \rightarrow n = 1$. [3 marks]
$[a_0 = 0.529\text{Å}, Z = 2, \varepsilon_0 = 8.85x10^{-12}F/m, e = 1.602x10^{-19}C,$
$m_e = 9.11x10^{-31}kg,\ R_\infty = 1.097x10^{7}m^{-1}, \hbar = 1.055x10^{-34}Js]$

b) Give main conclusions on the present day atomic model. [8 marks]

QUESTION FOUR [20 MARKS]

a) Sodium chloride forms cubic crystals with four sodium and four chloride atoms per cube. Calculate the longest wavelength for which X-rays can be Bragg reflected given that the atomic weights of Na and Cl are 23.0 and 35.5 respectively and the density of $NaCl$ is $2.16g/cc$. $[N_A = 6.02x10^{23}]$ [6 marks]

b) For X-rays of wavelength 4Å, determine the number of Bragg reflections and the angle of each. [6 marks]

c) Derive an approximate formula for λ as a function of Z for the K X- ray lines and show that the Moseley plot ($\lambda^{-1/2}$vs Z) is linearly a straight line. [8 marks]

QUESTION FIVE [20 MARKS]

a) Find the values of S, L and J in the following states 1_{S_0}, 3_{P_2}, $2_{D_{3/2}}$ and $6_{H_{5/2}}$. [12 marks]

b) Obtain an expression for the doublet separation caused by the spin-orbit interaction in alkali atoms. Interpret the results obtained. [8 marks]