KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

THIRD YEAR FIRST SEMESTER
SUPPLEMENTARY/SPECIAL EXAMINATIONS

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

COURSE CODE: SPH 316/SPC 314

COURSE TITLE: ATOMIC PHYSICS

DATE: 14/11/2022 **TIME:** 2:00PM-4:00PM

INSTRUCTIONS TO CANDIDATES

TIME: 2 HOURS

Answer question ONE and any TWO of the remaining

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 splitting of the hydrogen 2p state. [3 marks]

$[\hbar cR = 13.6eV, \alpha = \frac{1}{137}]$

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) A beam of neutral atoms passes through Stern-Gerlach apparatus, five equally spaced lines are observed. What is the total angular momentum of the atom? [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 $R = 1.097x10^7m^{-1}]$

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

i) Estimate the electric field needed to pull an electron out of an atom in time, comparable to that of an electron to go around the nucleus of an atom of atomic number Z. $[a_0 = 0.53x10^{-8}cm]$ [3 marks]

QUESTION TWO [20 MARKS]

a) Explain how the following experiments led to the development of atomic physics:

(i) Stern-Gerlach experiment [5 marks]

(ii) Compton effect [5 marks]

(iii) Franck-Hertz experiment [5 marks]

(iv) Lamb-Rutherford experiment [5 marks]

QUESTION THREE [20 MARKS]

Calculate for He^+:-

a) Radius of the first Bohr orbit [3 marks]

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

c) Orbital frequency in the first orbit [3 marks]

d) Kinetic energy and binding energy of an electron in the grounds state. [4 marks]

e) Ionization potential and the first excitation potential [4 marks]

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

QUESTION FOUR [20 MARKS]

a) 100 keV electrons bombarded a tungsten target $Z = 74$. Sketch the spectrum of resulting X-rays as a function of $1/\lambda$. Mark the K X-ray lines. [8 marks]

b) 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. [7 marks]

c) Show that the ratio of the slopes of the Moseley plot for K_α and K_β is $(27/32)^{1/2}$. [5 marks]

QUESTION FIVE [20 MARKS]

Explain the following atomic models

a) Rutherford atomic model [5 marks]

b) Bohr's atomic model [5 marks]

c) Sommerfeld-Wilson atomic model [5 marks]

d) Vector atomic model [5 marks]