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KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 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: 25/05/2022 **TIME:** 9:00AM-11:00AM

INSTRUCTIONS TO CANDIDATES

TIME: 2 HOURS

Answer question ONE and any TWO of the remaining

QUESTION ONE [30 MARKS]

a) Define the following terms: [5 marks]

Hund's rule, Auger effect, Lamb shift, Lande's interval rule and anomalous Zeeman effect.

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. [4 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. [4 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 $R = 1.097x10^7 m^{-1}]$

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

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]

a) Give main conclusions on the present day atomic model. [14 marks]

b) Calculate the radius and frequency of an electron in the Bohr's first orbit in hydrogen atom. $[\varepsilon_0 = 8.85x10^{-12}F/m$, $m_e = 9.11x10^{-31}kg$, $e = 1.6x10^{-19}C$, $h = 6.625x10^{-34}Js]$ [6 marks]

QUESTION FOUR [20 MARKS]

Explain how the following experiments led to the development of atomic physics.

a) Stern-Gerlach experiment. [7 marks]

b) Franck-Hertz experiment. [7 marks]

c) Lamb-Rutherford experiment. [6 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 where $l = 1$ and $s = \frac{1}{2}$. [14 marks]

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