UNIVERSITY OF EMBU

2016/2017 ACADEMIC YEAR

FIRST SEMESTER EXAMINATION

FOURTH YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 401: ATOMIC PHYSICS

DATE: NOVEMBER 29, 2016 **TIME: 11:00-1:00**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions.

Constants:

$c = 3.0\times10^{8}$ m/s

$m_e = 9.1 \times 10^{-31}$ kg

$\square_0 = 8.86 \times 10^{-12}$ C^2/Nm^2

$h = 6.63 \times 10^{-34}$ js

$e = 1.6 \times 10^{-19}$ C

$q = 1.6 \times 10^{-19}$C

$1ev = 1.6\times 10^{-19}$ J

QUESTION ONE (30 MARKS)

a) Briefly explain two concepts which characterize the vector atomic model that differentiates it from the other models. (4 marks)

b) Lithium has a work function of 2.3 eV. It is exposed to light of wavelength 4.8×10^{-7} m. Find the maximum kinetic energy with which the electrons leave the surface. (3 marks)

c) In Compton scattering the incident photons have wavelength 3.0×10^{-10} m. Calculate the wavelength of scattered radiation if they are viewed at an angle of 60^{o} to the direction of incidence. (3 marks)

d) Using Pauli's exclusion principle explain how electrons form a closed shell.

(4 marks)

e) Briefly describe Zeeman's effect. (4 marks)

f) With respect to hydrogen explain hyper fine structure of an atom. 4 marks)

g) What is the significance of Lande's g-factor on an atom's energy spectrum? (4 marks)

h) A fourth year student assumed a wave mechanical concept of r, being radius of permitted orbits and an integer n. show that the only permitted orbits are those with angular momenta which are equal to an integer multiple of $h/2\pi$. (4 marks)

QUESTION TWO (20 MARKS)

Find the possible (n, l, j) values of electrons in the first three energy levels of an atom. Symbols have the usual meaning. (20 marks)

QUESTION THREE (20 MARKS)

a) Briefly describe the sodium atom spectrum. (10 marks)

b) A photon of wavelength 3310Å fell on a photocathode and ejected an electron of energy 3×10^{-19} J. If the wavelength of the incident photon is changed to 5000 Å, the energy of the ejected electron is 0.972×10^{-19} J. Calculate the work function for the photocathode. (10 marks)

QUESTION FOUR (20 MARKS)

a) Briefly explain the significance of the following quantum quantities associated with vector atomic model of an atom.

i) Spin quantum number, s. (7 marks)

ii) Total angular momentum vector. (8 marks)

iii) Total quantum number of electron, j. (5 marks)

QUESTION FIVE (20 MARKS)

a) You are provided with multi-electron atoms with weak spin-orbit coupling. Assuming that the orbital angular momenta of individual electrons add to form a resultant orbital angular momentum L, differentiate between L – S coupling and J – J coupling.

(15 marks)

b) A cobalt target was bombarded with electrons and the wavelengths of its characteristic x-ray spectrum were measured. There was also a second fainter characteristic spectrum, which was due to an impurity in the cobalt. The wavelengths of the Kα lines are178.9pm for cobalt and 143.5pm for the impurity. Find the atomic number of the impurity. (5 marks)

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