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# **KIBABII UNIVERSITY**

**UNIVERSITY EXAMINATIONS  
2020/2021 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:** 11/1/2022

**TIME:** 8-10AM

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## **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: [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  $K_\alpha$  line in cobalt [4 marks]  
[ $Z = 27$  and  $R = 1.097 \times 10^7 m^{-1}$ ]
- 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]  
[ $1g = 10^{-4}T$ ,  $e = 1.602 \times 10^{-19}C$ ,  $m_e = 9.11 \times 10^{-31}kg$  and  $c = 3.0 \times 10^8 m/s$ ]
- 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  $K_\alpha$  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]

- 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.

$$[A_v = 6.02 \times 10^{23}, m_e = 9.11 \times 10^{-31} \text{ kg}, Z = 13, A = 27, \rho = 2.7 \text{ g/cm}^3, x_0 = 24 \text{ g/cm}^3]$$

- a) Obtain an expression for Rutherford's scattering in  $\text{cm/sr}$ . [4 marks]
- b) Compute the differential Rutherford scattering cross section in  $\text{cm/sr}$  at  $30^\circ$  [4 marks]
- c) How many protons per second will enter a 1cm radius circular counter at distance of 2m and at an angle of  $30^\circ$  with the beam direction? [3 marks]
- d) Compute the integrated Rutherford scattering cross section for angles greater than  $5^\circ$  [4 marks]
- e) How many protons per second are scattered out of the beam in angles greater than  $5^\circ$ ? [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  $\Delta T = 5.84 \frac{Z^4}{n^3 l(l+1)}$ . [12 marks]  
 Explain the meaning of each term.