

LAIKIPIA



UNIVERSITY

UNIVERSITY EXAMINATIONS

SECOND SEMESTER 2023/2024 ACADEMIC YEAR

**FIRST YEAR EXAMINATION FOR THE DEGREE OF
BACHELOR OF EDUCATION (SCIENCE) AND
BACHELOR OF SCIENCE (GENERAL)**

CHEM 121: INTRODUCTION TO QUANTUM CHEMISTRY

STREAM: R

TIME: 2 HRS

DAY: TUESDAY [8.30 A.M -10.30 A.M] DATE:16/04/2024

THIS QUESTION PAPER CONSISTS OF THREE (3) PAGES

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INSTRUCTIONS: Attempt All Questions**QUESTION ONE (30 MARKS)**

- a. (i) Distinguish between a continuous spectrum and atomic spectrum **(2 Marks)**
- (ii) State any **two** portions of the electromagnetic spectrum and each case describe a property of the wave that distinguishes one from the other. **(4 Marks)**
- b. Explain briefly how an atomic spectrum is produced **(3 Marks)**
- c. State three properties of a wave that are used to describe wave-like properties of a particle **(3 Marks)**
- d. (i) State **two** factors that determine the wavelength of the scattered radiation in the Compton effect. **(2 Marks)**
- (ii) Using an equation illustrate the 'Compton shift' **(2 Marks)**
- (iii) Write an equation that shows the Compton wavelength of an electron **(2 Marks)**
- e. (i) State **three** conclusions from the Rutherford's model of an atom **(3 Marks)**
- (ii) Explain the limitations of the Rutherford's model **(3 Marks)**
- f. State the Heisenberg's uncertainty principle **(1 Mark)**
- g. What is the significance of ψ^2 ? **(2 Marks)**
- h. Explain **three** limitations of Bohr's Model of an Atom **(3 Marks)**

QUESTION TWO (20 MARKS)

- a. (i) Write the equation that describes de Broglie wavelength **(1 Mark)**
- (ii) Find the wavelength of an electron moving with a speed $2.0 \times 10^6 \text{ ms}^{-1}$. (Planck's constant = $6.626 \times 10^{-34} \text{ Js}$; mass of electron = $9.1 \times 10^{-31} \text{ Kg}$) **(4 Marks)**
- b. Explain the following terms as used in photoelectric effect **(4 Marks)**
- (i) Threshold frequency
- (ii) Work function
- c. (i) Given that $h\nu = KE + \phi$ and $h\nu_0 = \phi$ describe a graphical method that can be used to determine threshold frequency ν_0 and work function ϕ . **(4 Marks)**
- ii) Using an illustration describe photoelectric effect and discuss the Einstein explanation of the phenomenon **(5 Marks)**

- (ii) Explain briefly why the photoelectric effect is a direct consequence of the particle character of electromagnetic radiation? **(2 Marks)**

QUESTION THREE (20 MARKS)

- a. (i) State Rydberg equation used to calculate the energy for the spectrum of the hydrogen atom **(2 Marks)**
- (ii) According to Paschen series, $n_1 = 3$ and $n_2 = 4, 5 \dots$ calculate the wavelength of the second line (Rydberg's constant = $1.097 \times 10^7 \text{m}^{-1}$) **(4 Marks)**
- (iii) Calculate the radius of 2nd orbit in He^+ ($a_0 = 5.29 \times 10^{-11} \text{m}$) **(4 Marks)**
- b. (i) What is significance the orbital angular momentum quantum numbers (ℓ)? **(3 Marks)**
- (ii) Name the possible subshells of the principle quantum number $n=3$ **(3 Marks)**
- (iii) What are the possible values of the magnetic quantum numbers m_ℓ for principle quantum number $n=3$ **(4 Marks)**

