LAIKIPIA UNIVERSITY

UNIVERSITY EXAMINATIONS

SECOND SEMESTER 2023/2024 ACADEMIC YEAR

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

PHYS 123: INTRODUCTION TO QUANTUM PHYSICS

STREAM: R ***TIME: 2 HRS***

DAY: THURSDAY [2.30P.M – 4.30P.M] ***DATE: 11/04/2024***

THIS QUESTION PAPER CONSISTS OF FOUR (4) PAGES

PLEASE DO NOT OPEN UNTIL THE INVIGILATOR SAYS SO.

INSTRUCTIONS

- ***The following constants may be useful***

  Mass of electron m_e=$9.11\times10^{-31}Kg$
  Planck's constant h= $6.63\times10^{-34}JS$
  Charge of electron$e$=$1.6\times10^{-19}C$
  - Wien's displacement constant=$2.898\times10^{-3}mK$
  - Stefan-Boltzman constant=$5.67\times10^{-8}Wm^{-2}K^{-4}$
  - Rydberg's constant =$1.1\times10^{7}m^{-1}$

SECTION A: (Compulsory) TOTAL MARKS FOR THIS SECTION IS (40 MARKS)

QUESTION ONE (40 MARKS)

a) Explain three Bohr's postulates of nuclear model of an atom after the discovery of protons **(6 Marks)**

b) State and prove De-Broglie hypothesis. **(4 Marks)**

c) Write and explain the equations of time dilation and length contraction **(4 Marks)**

d) Calculate the wavelength associated with a electron of mass 2 g moving with velocity of 3.3125km/s **(3 Marks)**

e) An electromagnetic radiation of frequency $5.2\times10^{15}\,Hz$ strikes a target and scattered at an angle of 30^0.

i) Find the wavelength of the scattered radiation **(4 Marks)**

ii) Calculate Compton shift **(4 Marks)**

f) Explain three failures of classical mechanics from the photoelectric experiment **(6 Marks)**

g) State and explain three the characteristics of x rays. **(6 Marks)**

h) State Wien's displacement law and give its mathematical expression **(3 Marks)**

SECTION B. TOTAL MARKS FOR THIS SECTION IS 30.

ANSWER ANY TWO QUESTIONS FROM THIS SECTION. EACH QUESTION IN THIS SECTION CARRIES 15 MARKS.

QUESTION TWO (15 MARKS)

a) Derive the basic equation of the Compton Effect $\Delta\lambda = \lambda' - \lambda = \frac{h}{m_0 c}(1 - \cos\theta)$ **(7 Marks)**

b) Show that $T_{½} = \frac{0.693}{\lambda}$ where the initials carry their usual meaning. **(4 Marks)**

c) A piece of wood from the ruins of an ancient dwelling was found to have carbon 14 activity of 13 disintegrations per minute per gram. The activity of the living wood is 16 disintegrations per minute per gram. How long ago did the tree from which the wood came die? **(4 Marks)**

QUESTION THREE (15 MARKS)

a) What is the energy in electron volts of green light of wavelength 546nm? **(2 Marks)**

b) Beam of electrons were accelerated by a potential difference of 500V and directed at a crystal with plane separation $X = 6.4\times10^{-9} m$. Calculate;

i) De-Broglie wavelength **(4 Marks)**

ii) Forth order angle of diffraction **(2 Marks)**

c) When two ultra violet beams of wavelengths $\lambda_1 = 280nm$ and $\lambda_2 = 490nm$ fall on a lead surface they produce photoelectrons with maximum energies 8.57eV and 6.67eV, respectively

i) Estimate the numerical value of the Planck's constant **(3 Marks)**

ii) Calculate the work function of lead **(2 Marks)**

iii) Calculate the cut off frequency of lead **(2 Marks)**

QUESTION FOUR (15 MARKS)

(a) describe how x rays are produced **(4 Marks)**

(b) Molybdenum x-ays have lambda=$7\text{x}10^{-11}$m find

(i) Minimum x-ray tube potential difference that can produce these x-rays **(3Marks)**

(ii) Explain how you can increase the quality and quantity of x rays produced **(4 Marks)**

c) Explain two applications of x-rays **(4 Marks)**

QUESTION FIVE (15 MARKS)

a) When two ultra violet beams of wavelengths $\lambda_1 = 280nm$ and $\lambda_2 = 490nm$ fall on a lead surface they produce photoelectrons with maximum energies 8.57eV and 6.67eV, respectively,(

i). Estimate the numerical value of the Planck's constant **(5 Marks)**

ii). Calculate the work function of lead **(2 Marks)**

b) Obtain an expression for the de Broglie wavelength associated with an electron accelerated through *V* volts. Also find the wavelength for *100V* and *54V*. **(3 Marks)**

c) Calculate the de Broglie wavelength of an electron moving with speed $1/10^{th}$ of the velocity of light (**5 Marks)**