# MERU UNIVERSITY OF SCIENCE AND TECHNOLOGY

**P.O. Box 972-60200 – Meru-Kenya.**
**Tel: +254(0) 799 529 958, +254(0) 799 529 959, +254 (0)712 524 293**
**Website: www.must.ac.ke Email: info@mucst.ac.ke**


**UNIVERSITY EXAMINATIONS 2022/2023**

SECOND YEAR, SECOND SEMESTER SPECIAL/SUPPLEMENTARY EXAMINATION FOR DEGREE OF BACHELOR OF SCIENCE IN MATHEMATICS AND PHYSICS AND BACHELOR OF EDUCATION SCIENCE

**SPH 3251: MODERN PHYSICS**

**DATE: AUGUST 2023** **TIME: 2 HOURS**

**INSTRUCTIONS: Answer Question ONE and any other TWO questions.**

## QUESTION ONE (30 MARKS)

a) State and explain two possible outcomes of a photon colliding with an electron. (5 Marks)

b) What is the uncertainty in the momentum of an electron if its uncertainty in position is 0.25 mm. (5 Marks)

c) Explain the relationship between the intensity of radiation and the number of emitted photoelectrons. (5 Marks)

d) A 1500W electric bulb has a filament which is 0.6m long and has a diameter of $6.89 \times 10^{-6}$ m. Estimate the working temperature of the filament if its total emissivity is 0.7 (stefan's constant = $5.7 \times 10^{-5} Wm^{-2}K^{-4}$. (5 Marks)

e) A sample of radioactive material contains $1.60 \times 10^{9}$ atoms. The half-time of the material is 7 years. Calculate

i. The fraction of the sample remaining after 10 years. (5 Marks)

ii. The activity of the sample after 10 years (5 Marks)

## QUESTION TWO (20 MARKS)

a) Derive the mass-energy relationship from first principles. (10 Marks)

b) Einstein's equation for the photoelectric emission of electrons from a metal surface under radiation of frequency v can be written as.

$hv = \frac{1}{2}m_e v^2 + \emptyset$ where $m_e$ is the mass of an electron, v is the greatest speed with which an electron can emerge and $\emptyset$ is a quantity called the work function of the metal. For sodium the value of $\emptyset$ is $3.12 \times 10^{-19} j$, and the wavelength of sodium yellow is $590\ nm$.

i. Explain why electrons are emitted when a sodium surface is irradiated with sodium yellow light. (5 Marks)

ii. Calculate the greatest speed of the emitted electrons. (5 Marks)

**QUESTION THREE (20 MARKS)**

a) Briefly explain Compton effect? (2 Marks)

b) If the mass of a proton is $m_p = 1.67 \times 10^{-27} kg$, calculate the Compton wavelength of a proton. (3 Marks)

c) Calculate relativistic ally the amount of work in Me V that must be done

i. To bring an electron from rest to a velocity of 0.4c. (5 Marks)

ii. What is the ratio of the Kinetic energy of the electron at the velocity of 0.8c to that of 0.4 c when computed.

1. From relativistic values. (5 Marks)
2. From classical values? (5 Marks)

**QUESTION FOUR (20 MARKS)**

a) Briefly explain what you understand by

i. Simultaneity (4 Marks)

ii. Failure of classical theory (4 Marks)

b) If the mass of a proton is $m_p = 1.67 \times 10^{-27} kg$, calculate the Compton wavelength of a proton. (3 Marks)

c) Explain why the Compton wavelength of an electron is different from the Compton wavelength of a proton. (2 Marks)

d) The rest mass of a body is 90 $kg$ moves at a velocity of 0.85c. Determine its

i. Relativistic mass (3 Marks)

ii. Its classical momentum (2 Marks)

iii. Its relativistic momentum (2 Marks)