(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

UNIVERSITY EXAMINATIONS

2021/2022 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER MAIN EXAMINATIONS

FOR THE DEGREE

OF

BACHELOR OF SCIENCE IN PHYSICS

AND

BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: SPH 215

COURSE TITLE: MODERN PHYSICS

DATE: THURSDAY 21ST APRIL, 2022 **TIME:** 08:00 AM – 10:00 AM

INSTRUCTIONS TO CANDIDATES

TIME: 2 Hours

Answer question ONE and any TWO of the remaining.

Symbols used bear the usual meaning.

MMUST observes ZERO tolerance to examination cheating

This Paper Consists of 4 Printed Pages. Please Turn Over.

Useful constants

Earth – Sun distance= 1.5x 10^{11}m

Radius of sun = 6.89x 10^{8} m

Radius of earth = 6.37x 10^{6} m

Stefan's constant σ = 5.67x 10^{-8} Wm^2K^{-4}

Wiens constant = 2.9x 10^{-3} mK

Speed of light in vacuum, c= 3x10^{8} m/s

mass of electron =9.1x10^{-31} kg

charge of electron e= 1.6x10^{-19}C

Planck's constant, h =6.63x 10^{-34} Js

Rydberg's constant R= 1.09x 10^{7} m^{-1}

1 a.m.u, u =931MeV

1 Å, = 10^{-10}

QUESTION ONE (30 MARKS)

a.) State two postulates of special relativity and explain why Galilean transformations fail in special relativity. (6 marks)

b.) What factors affect the rate at which steady state is achieved when one end of a cold metal rod is heated? (4 marks)

c.) i.) From three postulates for hydrogen atom by Niehls Bohr, deduce the energy equation for the atom as

$$E_n = -\frac{me^4}{8\varepsilon_o^2 n^2 h^2}$$ (6 marks)

ii.) Estimate the longest wavelength for Lyman series. (4 marks)

d.) i. What is meant by Compton effect? (3 marks)

ii. If the Compton shift is given by

$\lambda' - \lambda = \frac{h}{mc}(1 - \cos\theta)$, for an incident radiation of λ = 1.372 Å, Find the wavelength of scattered radiation at an angle of 45 ^{0} and Velocity of the recoil electron. (4 marks)

e.) Explain the changes in structure of an atom which result from the emission of

i. An alpha particle

ii. A beta particle

iii. Gamma , γ ,rays, (3 marks)

QUESTION TWO (20 MARKS)

a.) Explain what is meant by black body radiation. (2 marks)

b.) State Wien's displacement law. (2 marks)

c.) State Stefan's law of blackbody radiation and explain the character of the radiating body for which it applies. (4 marks)

d.) A black body at 2000K emits radiation with λ_m= 1250 mm. Use this result to calculate the surface temperature of the star Sirius if λ_m for Sirius is 71 nm. Assume Sirius is a black body.[be careful. Check units properly.] (6 marks)

e.) If each square cm of the sun's surface radiates energy at the rate of 6.3×10^3 j/sec/cm ^{2}, Calculate the temperature of the sun's surface in Celsius assuming the Stefan's law applies.(radius of the sun R= 6.96×10^8 m) (6 marks)

QUESTION THREE (20 MARKS)

a.) What is photoelectric effect?. Discuss how observations of this effect support quantum theory of electromagnetic radiation. (4 marks)

b.) Explain the terms ' threshold frequency' and 'photon' (4 marks)

c.) Describe one experiment each in which light exhibits a wavelike character and another where it exhibits the existence of photons. (4 marks)

d.) A lithium surface for which the work function is 0.37 aJ is irradiated with light of the frequency 6.3×10^{14} Hz. Loss of electrons causes the metal to acquire a positive potential. What will this potential have become by the time its value prevents further loss of electrons from the surface? (prefix atto, a= 10^{-18}) (8 marks)

QUESTION FOUR (20 MARKS)

a.) State Lorentz transformations. (4 marks)

b.) Use these transformations in (a) above to explain length contraction and Time dilation. (6 marks)

c.) A proper life time of a muon is 2.2 μs . If the muon has a life time of 3.3 μs according to an observer on earth, What is the muon speed as a fraction of the speed of light, c, relative to the observer? (5 marks)

d.) A 28 year old scientist leaves the earth on a spacecraft that makes around trip to Pluto 20 light years away at a speed of 0.8c, (where c, is the speed of light in vacuum). He then returns to go back home from the planet Pluto. How many years younger is he upon his return than his twin brother who remained behind after 50 years? (5 marks)

QUESTION FIVE (20 MARKS)

a.) What do you understand in an atom, by

i. Excitation by collision?

ii. Ionization by collision? (4 marks)

b.) Describe a modern X-ray tube and explain its action. (10 marks)

c.) Electrons accelerated in an X- ray tube through a p.d of 25 kV. The emitted X-rays showed a well-defined cut off wavelength of 48 pm (pico= 10^{-12}). Calculate,

i. The maximum energy of the X rays

ii. The frequency of the X rays

iii. A value of Planck's constant, h. (6 marks)