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UNIVERSITY EXAMINATIONS 2023/2024

SECOND YEAR, SECOND SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (PHYSICS OPTION) AND BACHELOR OF SCIENCE IN PHYSICS

SPH 3253: MODERN PHYSICS

DATE: APRIL 2024 **TIME: 2 HOURS**

INSTRUCTIONS: Answer Question ONE and any other TWO questions.

Important constants and quantities: Electron mass (me) = 9.1 x 10 ^{31} kg Electron charge = 1.6 x 10 ^{19} C
Mass of proton = 1.7 x 10-27 kg
Permittivity of free space = 8.85 x 10 ^{12} F m ^{I}
Planck's constant = 6.62 x 10-34 Js
Avogadro's Number = 6.02 x 10^{23} mol ^{I} lev= 10 ^{19} J
Speed of light = 3 x 10 ^{8} m/s 1 atomic mass unit (a.m.u) = 1.66 x 10-27 kg

QUESTION ONE (30 MARKS)

a) Derive the Lorentz transformation expression for the length of an object moving parallel direction to its length at a velocity (V) past a stationary observer (7 Marks)

b) Define the following terms

i. Nuclear fusion (1 Mark)

ii. Nuclear fission (1 Mark)

c) Show that the length of a metre rule would appear to reduce to zero when moving at a speed approximately equal to that of light past a stationary observer (3 Marks)

d) Describe the Einstein's Postulates on relativity (2 Marks)

e) Calculate the wavelength of the X-rays generated when electrons are accelerated to the anode of the x-ray tube at a potential difference of 20000V (4 Marks)

f) Discuss the findings and implication of Michelson-Morley experiment (4 Marks)

g) Describe the Rutherford atomic model (4 Marks)

h) Define threshold frequency (2 Marks)

i) State the uncertainty principle (2 Marks)

QUESTION TWO (20 MARKS)

a) A photon in the light of frequency 10^{15} Hz strikes a material whose work function is 2.28 eV. Calculate:

i. Energy in the photon (3 Marks)

ii. Maximum kinetic energy of the liberated electrons (2 Marks)

iii. The threshold frequency of the material used (3 Marks)

iv. The stopping potential required to stop the electrons from reaching the anode. (3 Marks)

b) Photons of light whose wavelength is m collides with free electron and scattered at an angle of 60^0 Calculate:

i. The shift in the wavelength (5 Marks)

ii. The energy transferred (4 Marks)

QUESTION THREE (20 MARKS)

a) i. Define nuclear binding energy (2 Marks)

ii. Determine nuclear mass defect and the binding energy (eV) in the formation of Helium nucleus whose atomic number is 2 and mass number is 4 (2He4) using 2 protons and 2

neutrons. (1 p = 1.007277 a.m.u, 1 n = 1.008666 a.m.u, actual mass of Helium = 4.001509 a.m.u) (9 Marks)

b) Derive the expression for Bohr's atomic radius. Hence show that the radius of the orbits is proportional to the square of the orbit number (9 Marks)

QUESTION FOUR (20 MARKS)

a) Describe the inertial frame of reference in relation to relativistic physics (2 Marks)

b) An electron is accelerated at a velocity of m/s. Calculate the observed mass (4 Marks)

c) Explain the Compton Effect (3 Marks)

d) determine how long it can take a Radium 88Ra226 (radioactive substance) for its mass to reduce by half from the initial mass of2g (decay constant R = 1.36 x 10-1 1 s-l) (8 Marks)

e) Discuss the shortcomings of the Rutherford atomic model (3 Marks)