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OFFICE OF THE DEPUTY PRINCIPAL
ACADEMICS, STUDENT AFFAIRS AND RESEARCH

UNIVERSITY EXAMINATIONS

2019 /2020 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER REGULAR EXAMINATION

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: PHY 122

COURSE TITLE: MODERN PHYSICS

DATE: 16TH OCTOBER, 2020 TIME: 2.00 PM – 5.00 PM

INSTRUCTION TO CANDIDATES

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THIS PAPER CONSISTS OF 4 PRINTED PAGES PLEASE TURN OVE

PHY 122

REGULAR – MAIN EXAM

PHY 122: MODERN PHYSICS

STREAM: BED (Science) **DURATION: 3 Hours**

INSTRUCTIONS

*Answer ALL questions in section A and any other **THREE** questions in section B.*
Use the following constants where necessary.

$1\ Faraday = 96484.6\ Coulombs/mole$
$1eV = 1.6 \times 10^{-19}\ J$
$Avogadro's\ number = 6.022 \times 10^{23} mole^{-1}$
$\frac{h}{m_0 c} = 2.42 \times 10^{-3}\ nm$
$Stefan's\ constant = 5.67 \times 10^{-8} \frac{W}{m^2 k^4}$
$Planck's\ constant = 6.63 \times 10^{-34} Js$
$Mass\ of\ electron = 9.11 \times 10^{-31}\ kg$
$Mass\ of\ hydrogen = 1.007825\ u$
$Mass\ of\ neutron = 1.008665$ u
$1u = 931.49\ MeV$

SECTION A (28 MARKS)

Question One (14 Marks)

(a) What are inertial frames of reference? (1 Mark)

(b) Two observers, A on earth and B in a spacecraft whose speed is $2x10^8$m/s, both set their watches to the same time when the spacecraft is abreast of the earth. How much time must elapse by A's reckoning before the watches differ by 1s? (4 Marks)

(c) A body undergoes blackbody radiation at a temperature of $2000K$ determine the maximum possible wavelength of the radiation given that Wien's displacement constant is 2.898 mm.K (2 Marks)

(d) An x-ray tube operated at d.c potential difference of $40kV$ produces heat at the target at the rate of $720W$. Assuming 0.5% of the energy of the incident electrons is converted into x-rays, calculate the number of electrons per second striking the target (3 Marks)

(e) In a Compton scattering experiment, it was found that the fractional change in wavelength is 1.0% when the scattering angle is $30°$. Determine the wavelength of the incident photon. (2 Marks)

(f) State any TWO limitations of the Rutherford model of the atom. (2 Marks)

Question Two (14 Marks)

(a) Derive the deBroglie wave-particle duality equation (3 marks)

(b) Explain the significance of Young's double slit experiment (2 marks)

(c) State any TWO of Bohr's postulates within the Bohr's model of the hydrogen atom (2 Marks)

(d) Using Bragg's condition, calculate the electron wavelength of the third order diffraction of x-rays with a peak at 50° and atomic spacing of 2.15 Å. (2 Marks)

(e) What is half life? (1 Marks)

(f) Distinguish between nuclear fission and nuclear fusion. (1 Mark)

(g) A man has a mass of 100kg on the ground. In an aircraft in flight, his mass is 101kg as determined by an observer on the ground. What is the speed of the aircraft? (3 Marks)

SECTION B (42 MARKS)

Question Three (14 Marks)

(a) With aid of a diagram describe how X-rays can be produced (4 Marks)

(b) State any two differences between hard and soft X-rays (2 Marks)

(c) Find the shortest wavelength present in the radiation from an x-ray machine whose accelerating potential is 50,000V, and its corresponding frequency (4 Marks)

(d) State any **THREE** properties of X-rays. (4 marks)

Question Four (14 Marks)

a) Explain the term 'Compton effect'. (3 marks)

b) Show that the Compton's equation is given by $\Delta\lambda = \frac{h}{m_0 c}(1 - cos\phi)$ where the symbols have their usual meanings. (9 marks)

c) X-rays of wavelength $10 \times 10^{-12} m$ are scattered from a target, find the maximum kinetic energy of the recoil electrons. (λ_c of the electron is 2.424pm) (2 marks)

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Question Five (14 Marks)

(a) Explain the difference between nuclear fission and nuclear fusion (4 marks)

(b) Define the term radioactivity (2 Mark)

(c) By denoting the number of nuclides in a radioactive decay process at time $t_0 = 0$ by N_0 and the number of nuclides at the present time t by N' derive the expression connecting N and N_0. (4 Marks)

(d) Determine the number of years it takes for 60 % of a given mass of a radio-isotope whose half-life is 6 *years* to decay. (4 Marks)

Question Six (14 Marks)

(a) A certain particle has a lifetime of 10^{-7}s when measured at rest. How far does it go before decaying, if its speed is 0.99c when it was created? (5 Marks)

(b) Explain the Lorentz-Fitzgerald contraction phenomena (4 Marks)

(c) An astronaut whose height on earth is exactly 6ft is lying parallel to the axis of a spacecraft moving at a speed of 0.9c relative to the earth. What is his height as measured by an observer in the same spacecraft? By an observer on earth? (3 Marks)

Question Seven (14 Marks)

(a) Discuss the three types of radiations emissions (4 Marks)

(b) Estimate the intensity of light emitted from the surface of the sun in the wavelength range 600 nm-605nm, if the temperature of the sun T=5800 K. (Planks intensity distribution function is $I(\lambda) = \frac{2\pi hC^2}{\lambda^5\left(e^{\frac{hc}{\lambda KT}-1}\right)}$, where the symbols have their usual meanings

h=6.626*10^{-34} J.s, $c = 3 * 10^8$m/s, $k = 1.381 * 10^{-23}$J/K) (6 marks)

(c) A meter stick appears only 60cm to an observer. What is its relative speed? How long does it take to pass the observer? (4 Marks)

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