JARAMOGI OGINGA ODINGA UNIVERSITY OF SCIENCE AND TECHNOLOGY
SCHOOL OF BIOLOGICAL AND PHYSICAL SCIENCES
UNIVERSITY EXAMINATION FOR DEGREE OF BACHELOR OF EDUCATION (SCIENCE)
2ND YEAR 2ND SEMESTER 2022/2023 ACADEMIC YEAR
MAIN
REGULAR

COURSE CODE: SPH 206

COURSE TITLE: EMPIRICAL IDEAS OF QUANTUM PHYSICS AND RELATIVITY

EXAM VENUE: **STREAM: EDUCATION**

DATE: **EXAM SESSION:**

TIME: 2:00 HRS

Instructions:

1. **Answer question 1 (Compulsory) and ANY other 2 questions.**
2. **Candidates are advised not to write on the question paper.**
3. **Candidates must hand in their answer booklets to the invigilator while in the examination room.**

Useful constants

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 = 6.63×10^{-34} Js

Mass of electron = 9.11×10^{-31} kg

Mass of hydrogen = 1.007825 u

Mass of neutron = 1.008665 u

1 u = 931.49 MeV

SECTION A

QUESTION ONE (30 MARKS)

a) Explain the meaning of time dilation (2 mark)

b) List two types of x-ray, and give conditions under which they are produced (2marks)

c) Ultraviolet light of wavelength 350nm and intensity $1W/m^2$ is directed at a potassium surface. Find the maximum K.E of the photoelectrons given that the work function of potassium is 2.2 eV (4 marks)

d) A luggage had mass of 90 kg on the ground. In an aircraft in flight, its mass is 92 kg as determined by an observer on the ground. What is the speed of the aircraft? (3 Marks)

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

f) Derive the de-Broglie wave-particle duality equation (3 marks)

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

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

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

j) What is half life? (2 Marks)

k) Show that Einstein's mass to energy equation is given by $E = mc^2$. Where the symbols have their usual meanings. (3 marks)

l) What are elementary particles? List some examples (3 marks)

QUESTION TWO (20 MARKS)

(a) Discuss main three types of radiations emissions (6 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 $I(\lambda) = \frac{2\pi hc^2}{\lambda^5\left(e^{\frac{hc}{\lambda KT}}-1\right)}$, h=6.626* 10^{-34} J.s, $c = 3 * 10^8$ m/s, $k = 1.381 * 10^{-23}$J/K) (10 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)

QUESTION THREE (20 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' obtain the expression connecting N and N_0. (5 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. (5 Marks)

(e) Describe the Lorentz-Fitzgerald contraction phenomena (4 Marks)

QUESTION FOUR (20 MARKS)

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

b) Show that the Compton's equation is given by $\Delta\boldsymbol{\lambda} = \frac{\boldsymbol{h}}{\boldsymbol{m_0 c}}\left(\mathbf{1} - \boldsymbol{cos}\,\boldsymbol{\phi}\right)$ where the symbols have their usual meanings. (7 marks)

c) 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)

d) An astronaut whose height on earth is exactly 1.8288 m 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 and by an observer on earth? (5 Marks)

QUESTION FIVE (20 MARKS)

(a) With aid of a diagram describe how x-ray can be produced (8 Marks)

(b) 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)

(c) State any **four** properties of x-rays. (4 marks)

(d) Highlight any four uses of x-rays (4 marks)

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