KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2022/2023 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE (PHYSICS)

COURSE CODE: SPC 222

COURSE TITLE: MODERN PHYSICS

DURATION: 2 HOURS

DATE: 17/04/2023 **TIME: 9:00 – 11:00AM**

INSTRUCTIONS TO CANDIDATES

- Answer **QUESTION ONE** (Compulsory) and any other two (2) Questions.
- Indicate **answered questions** on the front cover.
- Start every question on a new page and make sure question's number is written on each page.

This paper consists of **3** printed pages. Please Turn Over

You may need to use the following constants:

Speed of light	$c = 3.0\times10^{8}$m/s
Planks constant	$h = 6.626\times10^{-34}$J.s
Electron charge	$e = 1.6\times10^{-19}$C
Rest mass of an electron	$M_e = 9.1\times10^{-34}$Kg
Rest mass of a neutron	$M_n = 9.1\times10^{-34}$Kg = 1.0087u = 939.6 Mev/C^2
Rest mass of a proton	$M_p = 9.1\times10^{-34}$Kg = 1.0078u
Mass of deuteron ($_1^2H$)	= 2.0141u
One atomic mass unit	$u=1.66\times10^{-27}$Kg = 931Mev/C^2
Compton formula	$\lambda' - \lambda = \frac{h}{m_o c}(1 - cos\phi)$
Stefan's constant	$\sigma=5.670 \times 10^{-8}$w/$m^2$.$k^4$
Chemical formula for gold	$^{197}_{79}Au$
Atomic mass of	$^{238}_{92}U$ = 238.0508u
Atomic mass of	$^{234}_{90}Th$ = 228.0436u
Atomic mass of	$^{4}_{2}He$ = 4.0026u
Permittivity of free space	$\varepsilon_o = 8.854 \times 10^{-12}$F/m
Paschen series formula	$\frac{1}{\lambda} = R\left[\frac{1}{3^2} - \frac{1}{n^2}\right]$
Half life of carbon	= 5760 years
Atomic spacing	$d=\left\{\frac{M}{k_\rho}(1.66 \times 10^{-27})\right\}^{\frac{1}{3}}$
Bionomial expression $(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)x^2}{2!} \pm \cdots \ldots \ldots \ldots$	
Wien's constant	$\omega_c = 2.898 \times 10^{-3}$m.K

QUESTION 1

(a) State the postulates of special relativity (2 marks)

(b) Define the term Lorentz transformation (1 mark)

(c) 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? (3 marks)

(d) What is a massless particle? (1 mark)

(e) Using a well labeled diagram, briefly describe the concept of classical Doppler's effect (4 marks)

(f) What is a black body? (1 mark)

(g) Deduce Stefan's Law from Planck's Law (3 marks)

(h) In a photoelectric effect, it was observed that for light of wavelength 4000 Å, a stopping potential of 2.0 volt is needed and for light of wavelength 6000 Å, a stopping potential of 1.0 volt. From these data, calculate the work function of the material and the Planck's constant. (4 marks)

(i) X-rays of wavelength 1.0 Å are scattered by a carbon block. The scattered radiations are observed at 60°, 90°and 180°. Find (i) Compton shift (ii) kinetic energy imparted to the recoil electron. (2, 2 marks)

(j) Find the de Broglie wavelength of (i) electron moving with velocity 1000 m/s (ii) an object of mass 100 gram moving with the same velocity (2, 2 marks).

(k) Experiments show that 13.6eV is required to separate a hydrogen atom into a proton and an electron, that is, its binding energy is -13.6eV. Find the orbital radius and velocity of the electron in a hydrogen atom (3 marks)

QUESTION 2

a) Show that for massless particles, the relation between their energy and mass is E=Pc, where the symbols have their usual meaning (5 marks).

b) State the Bohr's fundamental postulate of the atom (3 mark)

c) With an aid of a well labeled diagram, show that the total energy of an electron in a hydrogen atom whose orbit has a radius r is E= $-e^2 \frac{1}{8\pi\varepsilon_0 r}$ (12 marks).

QUESTION 3

a) Define the following terms; Length contraction and Time dilation (2 marks)

b) With a well labeled diagram, give a brief account of the Michelson-Morley experiment stating its significance in the study of modern physics (10 marks)

c) Using well labeled diagram, derive the Compton wavelength (8 marks)

QUESTION 4

a) Name and describe the process by which the photoelectrons are released from the plate X by electromagnetic radiation. (4 marks)

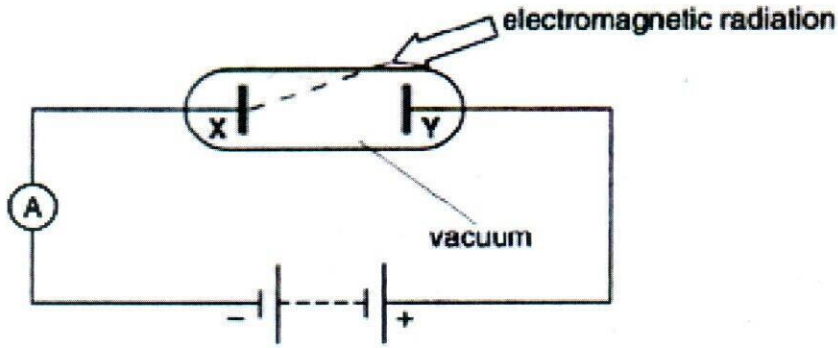

Figure 1: Showing an electrical circuit including a photocell

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b) Starting with the expression of the total energy as $E=E_0+K.E$, derive the expression for the low speed approximation for the Kinetic energy, K.E. (6 marks).

c) Utilizing the three types of baryons, determine the quark model for protons and neutrons and their antiparticles (4 marks)

d) Derive the expressions for both the decay law and half-life (3 marks).

e) A sample of 1g of $^{209}_{83}Bi$ with a half life of 2.7×10^7 yr decays into a stable isotope of thallium by emitting alpha particles. What would be the activity of the sample? (3 marks).

QUESTION 5

Using well labeled diagrams where necessary give a brief account on the following; Relativistic Doppler's Effects, classical Doppler's effect and Aberration of light (20 marks)