KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2016/2017 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
SUPPLEMENTARY EXAMINATIONS

FOR THE DEGREE OF B.ED (SCIENCE) AND BSC (PHYSICS)

COURSE CODE: SPH 215

COURSE TITLE: MODERN PHYSICS

DURATION: 2 HOURS

DATE: 27TH SEPTEMBER 2017 TIME: 8 – 10AM

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 ($^{2}_{1}H$)	= 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	$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)x^2}{2!} \pm \cdots \ldots \ldots \ldots \ldots$
Wien's constant	$\omega_c = 2.898 \times 10^{-3}$m.K

QUESTION 1 (30 Marks)

a) What is the relativistic value of the de Broglie wavelength of a particle whose rest mass is m_o (3 marks).

b) Mention the two postulates of special relativity (2 marks)

c) Ultraviolet light of wavelength 360 nm and intensity 1w/m^2 is directed at a potassium surface. Determine the maximum kinetic energy (in eV) of photoelectrons given that the work function of potassium is 2.2 eV. (3 marks).

d) Find the atomic spacing (lattice constant) of a crystal rock salt, Nacl, whose formula mass is 58.5u and whose density 2.16×10^{3}Kg/m^3 (3 marks).

e) Two observers, A on earth and B in a space craft whose speed is 1.5×10^{8}m/s, both set their watches to the same time when the space craft is abreast of the earth. How much time must elapse by A's reckoning before the watches differ by 2s? (4 marks).

f) A stationary body explodes into fragments of rest mass 1 kg that moves apart at speeds of 0.8c. Find the rest mass of the original body? (2 marks).

g) State the Pauli exclusion principle (1 mark).

h) An astronaut whose height on earth is exactly 8ft is lying parallel to the axis f spacecraft moving at a speed of 0.7c relative to the earth. What is his height as measured by an observer in the same spacecraft by an observer on earth? (2 marks).

i) 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 (5 marks).

j) A measurement establishes the position of a proton with an accuracy of $\pm 10^{-11}$m. Find the uncertaininty in the protons position 2s later. Assume V<<<<<c. (3 marks).

k) A man has a mass of 100 Kg on the ground. When he is in an aircraft in flight, mass is 102 Kg as determined by an observer on the ground. What is the speed of the aircraft ? (2 marks).

QUESTION 2 (20 Marks)

a) Find the charge on the elementary particle Σ which is made up of uus quarks (2 mark).

b) i) Distinguish between nuclear fussion and nuclear fission (4 marks).

ii) Define the half life of an isotope (2 mark).

iii) Stating with the activity law, show that the wavelength of an isotope in terms of half life is expressed as $\lambda = \frac{0.693}{T_{\frac{1}{2}}}$ (4 marks).

c) A piece of wood from the ruins of an ancient dwelling was found to have a ${}^{14}_{6}C$ activity of 6 disintegrations per minute per gram. The activity of the living wood is 16 disintegrations per minute per gram. How long ago did the tree from which the wood sample come die? (2 marks).

d) Find the binding energy per nucleon of a hydrogen isotope deuterium (${}^{2}_{1}H$) atom (6 marks).

QUESTION 3 (20 Marks)

a) Consider a light pulse clock and a conventional clock. One set of the two clocks is on the earth while the other is on the spacecraft moving with a velocity v. with the aid of clearly labeled diagrams show that the time period T of an event taking place in the spacecraft as seen by an observer on earth who is watching both the two clocks is $T = \frac{T_o}{\sqrt{1-\frac{v^2}{c^2}}}$ where T_o is the proper time, while c is the speed of light. (12 marks).

b) Explain what will happen to the clocks discussed in in part (a) above if $v \geq c$ (2 mark)

c) Derive the relativistic length contraction using the Lorentz transformation (6 marks).

QUESTION 4 (20 Marks)

a) Give two examples of massless particles and write down their expressions for their energy (4 marks).

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

c) Show that for massless particles, the relation between their energy and mass is $E=Pc$, where the symbols have their usual meaning (10 marks).

QUESTION 5 (20 Marks)

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

b) Find the de Broglie wavelength of an electron orbiting a hydrogen atom (7 marks).

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 $E=-e^2\frac{1}{8\pi\varepsilon_o r}$ (10 marks).