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KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2015/2016 ACADEMIC YEAR

SECOND YEAR SECOND SEMESTER
MAIN EXAMINATIONS

FOR THE DEGREE OF B.Ed. (SCIE) & B.Sc. (PHYS)

COURSE CODE: SPH 215

COURSE TITLE: MODERN PHYSICS

DURATION: 2 HOURS

DATE: TUESDAY 10TH MAY 2016 **TIME:** 11.30 – 1.30PM

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 **4** 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=1.66×10^{-27}Kg = 931Mev/C^2
Compton formula	$\lambda' - \lambda = \frac{h}{m_o c}(1 - cos\phi)$
Stefan's constant	σ=5.670×10^{-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	ε_o = 8.854×10^{-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	$(1 \pm x)^n = 1 \pm nx + \frac{n(n-1)x^2}{2!} \pm \cdots\cdots\cdots\cdots$
Wien's constant	$\omega_c = 2.898 \times 10^{-3}$m.K

QUESTION 1(20 MARKS) - COMPULSORY

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

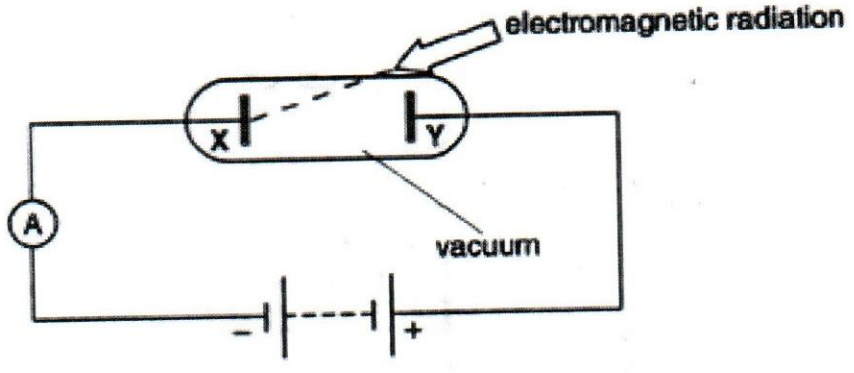

Figure 1: Showing an electrical circuit including a photocell

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 3 (20 MARKS)

a)X-rays of wavelength $10x10^{-12}$m are scattered from a target.

(i) Find the wavelength of x-rays scattered through 45^o (2 marks)

(ii) Find the maximum wavelength present in the scattered x-rays. (2 marks)

(ii) Find the maximum K.E of the recoil electrons. (λ_c of an electron is 2.424pm) (2 marks)

b) Find the de Broglie wavelength of :

(i) A 46-g golf ball with a velocity of 30m/s. (2 marks)

(ii) An electron with a velocity of 10^7m/s. (2 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).

QUESTION 4 (20 MARKS)

a) Define the following terms: nuclear fission, nuclear fusion and binding energy (3 marks).

b) The Polonium isotope $^{210}_{84}Po$ is unstable and emits a 5.3MeV alpha particle. The atomic mass of $^{210}_{84}Po$ is 209.9829u and that of $^{4}_{2}He$ is 4.0026u. Identify the daughter nucleus and find its atomic mass.
(2 marks)

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

d) A sample of 1g of $^{209}_{83}Bi$ with a half life of 2.7 x 10^7 yr decays into a stable isotope of thallium by emitting alpha particles. What would be the activity of the sample? (2 marks).

e) Using well labeled diagram, derive the Compton wavelength (6 marks)

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

QUESTION 5 (20 MARKS)

a) i) What do you understand by the term black body (2 mark)

ii) A patient waiting to be seen by a physician is asked to remove all his/ her clothes in a room whose temperature is 25°C. Calculate the rate of heat loss by radiation from the patient, if his /her skin is at a temperature of 36°C and his or her surface area is 1.6m^2. Assume an emissivity of 0.8 (3 marks).

b) i) Define the term impact parameter (2 mark).

ii) The impact parameter b is related to the scattering angle θ, by an expression $cot\frac{\theta}{2} = \frac{4\pi\varepsilon_o K}{Ze^2}b$ where the symbols have their usual meaning. Find the angle through which a 5 MeV alpha particle approaching a gold nucleus with an impact parameter of 2.5 x 10^{-13}m is scattered (4 marks).

c) Starting with the expression of angular velocity ω and the wave number k, show that the de Broglie wave group associated with the moving body travels with the same velocity as the body, i.e. u=v (9 marks).