COURSE CODE: PHY 212

COURSE TITLE: MODERN PHYSICS

SUPPLEMENTARY PAPER (2016/2017 ACADEMIC YEAR)

INSTRUCTIONS

TIME: 3 HOURS

Answer **QUESTION ONE** and **ANY OTHER THREE** questions. Question one carries **28** Marks and all the others carry **14** marks each. 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	$\varepsilon_o = 8.854 \times 10^{-12}$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 (28 MARKS)

a) What is a baryon made of? (2 mark).

b) With relevant equations, define time dilation and length contraction. (4 marks)

c) 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. (2 marks).

d) 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? (4 marks)

e) State the two postulates of special relativity (2 marks)

f) Differentiate between continuous and emission spectra (2 marks)

g) Find the atomic spacing (lattice constant) of a crystal rock salt, NaCl, whose formula mass is 58.5u and whose density $2.16 \times 10^3 Kg/m^3$ (2 marks).

h) Two observers, A on earth and B in a space craft whose speed is 1.5×10^8m/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? (3 marks).

i) A meter stick appears only 60cm to an observer. What is its relative speed? How long does it take to pass the observer? (3 marks)

j) State the Paul exclusion principle. (2 mark)

k) 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? (2 marks)

QUESTION 2 (14 MARKS)

a) Name and describe the process by which the photoelectrons are released from the plate X by electromagnetic radiation. (6 marks)

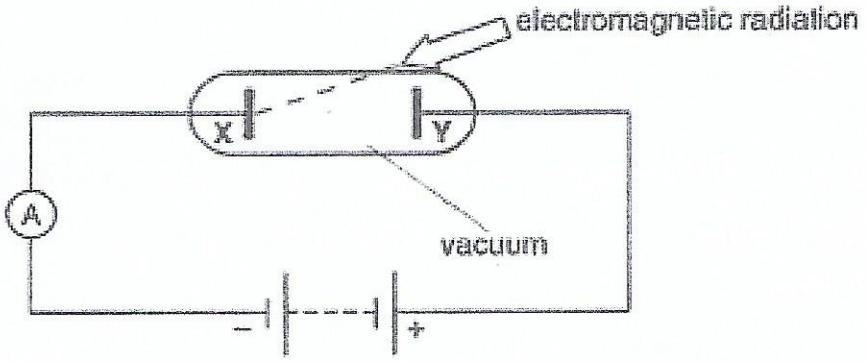

Figure 1: Showing an electrical circuit including a photocell

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. (4 marks).

c) Show that for massless particles, the relation between their energy and mass is E=Pc, where the symbols have their usual meaning (4 marks).

QUESTION 3 (14 MARKS)

a) State the Bohr's fundamental postulate of the atom (2 mark)

b) Find the de Broglie wavelength of an electron orbiting a hydrogen atom (5 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 $E=-e^2\frac{1}{8\pi\varepsilon_0 r}$ (7 marks).

QUESTION 4(14MARKS)

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 (2 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 $cot\frac{\theta}{2}=\frac{4\pi\varepsilon_0 K}{Ze^2}b$ 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 (2 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 (6 marks).

QUESTION 5 (14 MARKS)

a) Define the following terms: nuclear fission, nuclear fussion 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. (4 marks)

c) Derive the expressions for both the decay law and half-life (4 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? (3 marks).

QUESTION 6 (14 MARKS)

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

b) Utilizing the three types of baryons, determine the quark model for protons and neutrons and their antiparticles (6 marks)

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