The following information is supplied as an aid to memory

Speed of light,	$c = 3.00 \times 10^{8}$ m/s
Electron mass,	$m_e = 9.11 \times 10^{-31}$ kg
Planck's constant,	$h = 6.63 \times 10^{-34}$ J.s
Elementary charge,	$e = 1.60 \times 10^{-19}$ C
Permittivity of free space,	$\varepsilon_0 = 8.85 \times 10^{-12}$ $C^2/N.m^2$
Rydberg constant,	$R_H = 1.10 \times 10^{7}$ m^{-1}
Avogadro's constant,	$N_A = 6.02 \times 10^{23} mol^{-1}$
Stefan-Boltzmann constant,	$\sigma = 5.671 \times 10^{-8}$ $Wm^{-2}K^{-4}$
Bohr Magneton	$\mu_B = 9.27 \times 10^{-24}$ JT^{-1}

SECTION A: Answer **ALL** Questions from this section

Question 1(Compulsory)

(a) Define the following terms

(i) Photoelectric effect [1 marks]

(ii) Compton effect [1 marks]

(iii)Auger effect [1 marks]

(b) Given that each square centimeter of the earth's surface radiates energy at the rate of 6.3×10^{3} Js^{-1}, calculate the temperature of the sun's surface in ℃. Assume that Stefan's law applies and that the sun is a blackbody. [3 marks]

(c) If the mass of proton is 1860 times that of electron, compute the de Broglie's wavelength in Å of a photon whose kinetic energy is equal to the rest mass energy of an electron. [3 marks]

(d) Briefly explain how Einstein postulates in the theory of relativity accounts for the 'null' result of the Michelson-Morley experiment? [3 marks]

(e) What is the activity of one gram of ${}_{85}Ra^{226}$ whose half-life is 1860 years? [3 marks]

(f) Estimate the atomic number Z of atoms for which the lowest frequency X-ray emitted has wavelength $\lambda \sim 0.4$ Å [3 marks]

(g) The existence of photoelectric work function is not contrary to classical physics. Since the work function is equal to $h\nu_0$, why isn't the existence of a cut-off frequency also acceptable classically? [3 marks]

(h) Distinguish between Bohr's correspondence and Bohr's complementary principle [3 marks]

(i) Enumerate any three (3) basic experimental results obtained about photoelectric effect [3 marks]

(j) Calculate the fractional change in the wavelength of an X-ray of wavelength 0.400Å that undergoes 90˚ Compton scattering from an electron. [3 marks]

SECTION B: Answer **ONLY TWO** Questions from this section

Question 2

In a Compton scattering experiment, the scattered photon has energy of 140 keV and the scattered electrons kinetic energy is 40 keV. Find

(i) the wavelength of the incident photons, [4 marks]

(ii) the angle, θ, through which the photon is scattered, and [6 marks]

(iii)the angle at which the electrons move off [10 marks]

Question 3

(a) Show that the kinetic energy T, for one dimensional motion of a particle of rest mass m_0 and mass m, is given by

$$T = \int_{U=0}^{U} \boldsymbol{F}.d\boldsymbol{s} = mc^2 - m_0c^2$$

where the symbols have their usual meanings hence obtain the equivalence of mass and energy. [12 marks]

(b) A train moving at 0.6c relative to the ground has a measured length of 320 m in the ground frame. How long does it take to pass a tree as measured

(i) in the ground frame, and [4 marks]

(ii) in the train frame [4 marks]

Question 4

(a) Discuss the result of Stern-Gerlach experiment on space quantization. [7 marks]

(b) In an external magnetic field B=0.5 kT, what is the separation between adjacent energy levels of an atom whose magnetic moment is equal one Bohr magnetron? [5 marks]

(c) Sodium which has a single electron in the 3s state emits doublet lines at 589.0 nm and 589.6 nm in making transition to the ground state (which consists of a single level). What is the

(i) difference in energy between the excited states? [4 marks]

(ii) effective magnetic field experienced by the electron? [4 marks]

Question 5

(a) Describe the Bohr's theory of hydrogen atom and calculate the radius and energy (in eV) of the first orbital in terms of the fundamental constants [13 marks]

(b) Work function of potassium is 2.25 eV. A beam with a wavelength of 400 nm has an intensity of 10^{-9} Wm^{-2}. Find the

(i) maximum kinetic energy of the photoelectrons and [2 marks]

(ii) number of electrons emitted per meter squared per second from the surface assuming 3% of incident photons are effective in getting electrons [5 marks]

********** END OF SPH 206 EXAMINATIONS **********

MERRY XMAS AND A PROSPEROUS NEW YEAR