KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS
2021/2022 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER
SUPP/SPECIAL EXAMINATIONS

FOR THE DEGREE OF B. ED (SCIENCE)

COURSE CODE: SPH 122

COURSE TITLE: INTRODUCTION TO QUANTUM PHYSICS

DATE: 25/07/2022 **TIME: 8:00AM-10:00AM**

INSTRUCTIONS TO CANDIDATES

- Answer question one (**Compulsory**) and any other **Two** questions.
- Attempted questions must be indicated on front cover of answer booklet.
- Every question should be started on new page and question indicated respectively.

List of constants

Speed of light, c=3.0× 10^8m/s
Mass of electron, $M_e = 9.1 \times 10^{-31}$kg
Planck's constant, h=6.6 × 10^{-34} J

Question one (30 Marks)

a. Define gravitational red shift (2mks)

b. With reference to quantum mechanics, discuss the meaning of a standard inertial frame of reference. (2mks)

c. Discuss wave-particle duality of matter in reference to light (3mks)

d. Find the wavelength of an electron moving with a speed of $2 \times 10^6\ ms^{-1}$ (3mks)

e. X-rays with an energy of 300 KeV undergo Compton scattering with a target. If the scattered X-rays are detected at 30° relative to the incident X-rays, determine the Compton shift at this angle, the energy of the scattered X-ray, and the energy of the recoiling electron. (4mks)

f. Discuss the Heisenberg Uncertainty (3mks)

g. An FM radio transmitter has a power output of 100 kW and operates at a frequency of 94 MHz. How many photons per second does the transmitter emit? (3mks)

h. Light source of wavelength 600nm illuminates a metal and ejects photoelectrons with a maximum kinetic energy of 1.00 eV. A second light source with half the wavelength of the first ejects photoelectrons with a maximum kinetic energy of 4.00 eV. Determine the work function of the metal. (3mks)

i. The earth and sun are 8.3 light-minutes apart. Ignore their relative motion for this problem and assume they live in a single inertial frame, the Earth-Sun frame. Events A and B occur at $t = 0$ on the earth and at t = 2 minutes on the sun respectively. Find the time difference between the events according to an observer moving at $u = 0{:}8c$ from Earth to Sun. Repeat if observer is moving in the opposite direction at $u = 0{:}8c$. (4mks)

j. Discuss the birth and development of the special relativity. (3mks)

Question Two (20 Marks)

a. Show that the low-frequency limit of Planck's Law reduces to the Rayleigh-Jeans Law and in the high-frequency limit reduces to Wien's Law. (6mks)

b. Discus the Wien's Displacement Law as outlined in quantum mechanics. (6mks)

c. Suppose in the Michelson-Morley experiment, it is given that $\Delta L = L_1 - L_2 \neq 0$ and that there is a contraction by a factor of $\sqrt{1 - \frac{v^2}{C^2}}$ in the direction of the ether wind. Then show that (8mks)

$$\Delta t = \frac{2}{C}\Delta L(1 + \frac{v^2}{2C^2})$$

Question Three (20 Marks)

a. Derive the Einstein photoelectric equation and discuss it basing on Einstein's explanation on existence of threshold frequency, effect of intensity of the incident light and possible maximum energy. (6mks)

b. Derive the Stefan Boltzmann Law for the energy density of black-body radiation. (6mks)

c. Derive the Compton equation the proofs the existence of quantum mechanics. (8mks)

Question Four (20 Marks)

a. Show that the standard space and time Lorentz transformation equation is given respectively by the equation below. (8mks)

$$x' = \frac{x - vt}{\sqrt{1 + \frac{v^2}{a}}}, \qquad t' = \frac{\frac{xv}{a} + t}{\sqrt{1 + \frac{v^2}{a}}}$$

b. Show that De Broglie formular is given by $\lambda = \frac{h}{mv}$ where m is the mass, v the velocity and λ is the wavelength. (6mks)

c. Discuss the Davison-Gerner experiment stating how the finding relate with Bragg's law, de Broglie law and the acceleration through a given voltage V. (6mks)