THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

A. M. E. C. E. A

P.O. Box 62157

00200 Nairobi - KENYA

Telephone: 891601-6

Ext 1022/23/25

MAIN EXAMINATION

SEPTEMBER –DECEMBER 2021

FACULTY OF SCIENCE

DEPARTMENT OF NATURAL SCIENCES

REGULAR PROGRAMME

PHY 418: ATOMIC PHYSICS

Date: DECEMBER 2021	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any TWO Questions	

Physical constants

e = $1.6 \times 10^{-19} C$

$h = 6.63 \times 10^{-34} Js$

$m_e = 9.11 \times 10^{-31} Kg$

$\varepsilon_0 = 8.85 \times 10^{-12} F/m$

$1\,U = 1.66054 \times 10^{-27} Kg$

Atomic weight of gold = 197U

$c = 3.0 \times 10^{8} m/s$

Avagadros constant $N_A = 6.2 \times 10^{23}/mol$

$m_p = 1.673 \times 10^{-27} Kg$

Density of gold $\rho = 19.3\, g/cm^3$

Q1 (a) Distinguish between Rutherford and Bohr's models of the atom **(5marks)**

(b) Explain the meaning of the following terms;

(i) **Nucleons** **(2marks)**

(ii) Bremsstrahlung **(2marks)**

(iii) Impact parameter **(2marks)**

(c) Find the fraction of 7.7 MeV α- particles that would be deflected at 90° or more from a gold foil of thickness $10^{-6} m$. **(5marks)**

(d) Explain how we can determine the classical impact parameter for a bombarding particle and a target scatterer of like charges. **(4marks)**

(e) Show that a photon cannot produce an electron – positron pair in free space. **(6marks)**

(f) The mass decrease for the decay of one Radium atom is $8.8 \times 10^{-30} kg$. Find the energy equivalent of this mass change **(4marks)**

Q2. (a) An X-rays of wavelength 0.050nm scatters from gold target.

(i) Can the X-rays be Compton scattered from an electron bound by as much as 62000eV? **(3marks)**

(ii) What is the largest wavelength of the scattered photon that can be observed? **(3marks)**

(iii) What is the Kinetic energy of the most energetic recoil electron and at what angle does it occur? **(4marks)**

(b) In an experiment similar to Thompson's experiment, deflecting plates 7.0cm in length with an electric field of 1.0×10^4V/m. Without magnetic field, the angular deflection is 30° and with magnetic field of $8.0 \times 10^{-4} T$, there was no deflection. Calculate

(i) the initial velocity of the electron **(5marks)**

(ii) the ratio of charge to mass **(5marks)**

Q3. (a) An X-ray tube operates at 30 kV and the current through it is 2.0mA. Calculate:

(i) The electrical power input **(2marks)**

(ii) The number of electrons striking the target per second **(3marks)**

(i) The speed of the electrons when they hit the target and the lower wavelength limit of the X-rays emitted **(3marks)**

(b) Atomic hydrogen in its lowest energy state absorbs a photon, raising the electron to an n=3 state. If we assume the lifetime of an excited state is $10^{-10} s$, and if we make rudimentary assumption that electrons orbit around the protons, How many revolutions does an excited electron make before returning to the lower energy state? **(5marks)**

(c) Tungsten target has a work function of 4.63eV. The electron acceleration voltage is 35kV, What is the minimum wavelength of the X-rays produced? Why do we ignore the initial kinetic energy of the electrons from the filament and the work function of the filament and the anode. **(7marks)**

Q4. (a) In an experiment, its observed that backward scattered ($\theta \geq 90°$) $\alpha -$¿particles formed a beam That's energetic and directed at a gold foil as thin as6.0×10^{-7}m. Assuming an $\alpha -$¿ particles Scatters from an electron in the foil, what is the maximum scattering angle? **(6marks)**

(b) Calculate the fraction per square mm area of 7.7MeV $\alpha -$¿particle scattered at 45°from a gold foil of thickness $2.1 \times 10^{-7}\, m$ at a distance of 1.0cm from the target. **(6marks)**

(c) A spectrometer can resolve spectral in the visible region ($\lambda = 6000\, Å$ ¿ when separated by $\Delta_\lambda = 0.1\, Å$ What will be the magnitude of the magnetic field required to confirm experimentally

The normal Zeeman effect. **(8marks)**

Q5. (a) A photoemissive surface has a threshold wavelength of$0.65\, \mu m$. Calculate;

(i) Its threshold frequency **(2marks)**

(ii) Its workfunction in electronvolts **(3marks)**

(iii)The maximum speed of the electrons emitted by violet light of wavelength $0.40\, \mu m$.

(4marks)

(b) X-rays of wavelength 2.4Å are Compton scattered and the scattered beams are observed at 60°

Relative to the incident beam. Find

(i) The energy of the scattered X-ray photons **(5marks)**
(ii) The direction of travel of the scattered electrons **(6marks)**

END