THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

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MAIN EXAMINATION

SEPTEMBER – DECEMBER 2019 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

REGULAR PROGRAMME

PHY 301: QUANTUM MECHANICS I

Date: DECEMBER 2019	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and ANY other TWO Questions	

CONSTANTS

$M_e = 9.1\ X\ 10^{-31}\ Kg$

$$h = 6.624\ X\ 10^{-34}$$
$$\varepsilon_0 = 8.85\ X\ 10^{-12}\ F/m$$
$$e = 1.6\ X\ 10^{-19}\ C$$
$$R_H = 1.09678\ X\ 10^{7}\ m^{-1}$$
$$R_{He} = 1.09722\ X\ 10^{-7}\ m^{-1}$$

Q1. (a) Explain the following terms:

(i) Energy quantization of atoms
(ii) Photoelectric effect
(iii) Compton effect
(iv) Heisenberg uncertainity principle.

(6marks)

(b) Distinguish between Paschen, Lymann and Balmer spectral series.

(3marks)

(c) (i) Calculate the radius of the first orbit in the Hydrogen atom (z = 1)

(3marks)

(ii) Also the velocity of the electron on the first orbit of the Hydrogen

atom (z = 1).

(3marks)

(d) Calculate the De Broglie wavelength of:

(i) a dust particle of mass $1.0\,X\,10^{-9}\,Kg$ driffting with a velocity of 2.0cm/s

(ii) An electron whose kinetic energy is 120eV

(7marks)

(e) (i) What do you understand by the term 'Black body radiation'?

(2marks)

(ii) Derive the Planck's radiation law

(6marks)

Q2. (a) (i) Calculate the energies of the electron (in Hydrogen atom) on the 1st, 2nd and 3rd orbits in Electron volts

(4marks)

(ii) Calculate the energy required to excite the Hydrogen atom from the ground state (n= 1) To the first excited state.

(4marks)

(b) The wavelength of the Balmer H_α line is 6563Å , Calculate the wavelength of the H_β line (2nd line) of the Balmer series.

(5marks)

(c) Calculate then energy in eV of the photoelectrons from the surface of a tungsten emitter When it is irradiated with light of wavelength 1800Å , Given that the threshold wavelength For photoelectric emission in this case is 2300Å.

(7marks)

Q3. (a) The size of an atom is approximately $10^{-8}cm$. To locate an electron within the atom, one should use Electromagnetic radiation of the wavelength no longer than $10^{-9}cm$.

(i) What is the energy of a photon with such a wavelength in electron volts.

(ii) What is the uncertainity in the electron's momentum if we are certain about its position by $10^{-9}cm$?

(10marks)

(b) The Rydbergs constant for Hydrogen is $1.09678\,X\,10^{7}m^{-1}$ and for ionized Helium is $1.09722\,X\,10^{7}m^{-1}$. Calculate the ratio of mass of the proton to that of electron assuming the helium nucleus to be four times the mass of the proton.

(10marks)

Q4. (a) State the Bohrs postulate for the theory of the Hydrogen atom.

(5marks)

(b) Derive an expression for the energy of this atom when the electron is in the nth orbit. What is the binding energy?

(9marks)

(c) What is the energy, linear momentum and the wavelength of a photon emitted by Hydrogen atom when an electron makes a transition from n = 2 to n = 1.

(6marks)

Q5. (a) An X-ray of wavelength 0.2400nm(2.4Å) are Compton – scattered and the scattered beam is observed at 60° relative to the incident beam. Find :

(i) The wavelength of the scattered X-rays
(ii) The energy of the scattered X – ray photons
(iii) The Kinetic energy of the recoiling electrons
(iv) The direction of travelling of the scattered electrons

(8marks)

(b) Consider a particle with energy E = $\frac{p_x^2}{2m}$ moving in one dimension (x – direction). The Uncertainity on its location is Δx. Show that if $\Delta x \Delta p_x = \frac{\hbar}{2}$, then $\Delta E \Delta t \geq \frac{\hbar}{2}$.

(6marks)

(c) (i) If the De Broglie wavelength of an electron is $9.0\,X\,10^{-10}\,m$. Find its Kinetic energy

(3marks)

(ii) Calculate the De Broglie wavelength of a beam of electrons whose kinetic energy is 100eV

(3marks)

END