(Knowledge for Development)

KIBABII UNIVERSITY

UNIVERSITY EXAMINATIONS - 2019/2020 ACADEMIC YEAR

FIRST YEAR SECOND SEMESTER

SPECIAL/SUPPLIMENTARY EXAMINATIONS

FOR THE DEGREE OF B.ED SCIENCE

COURSE CODE: SPH 122

COURSE TITLE: INTRODUCTION TO QUANTUM MECHANICS

EXAM DURATION: 2 HOURS

DATE: 17/2/21 **TIME:** 11-1 Pm

INSTRUCTIONS

a) Answer question ONE and any other TWO questions.
b) Question one carries 30 marks and the rest carry 20 marks each.
c) And you may use the following:
i. Mass of an electron = $9.1 \times 10-31Kg$
ii. Charge of an electron = $1.6 \times 10-19C$
iii. Plank's constant, h=$6.626 \times 10-34\ Js$
iv. Speed of light c=$3 \times 108m/\ s$
v. ε_o=$8.85 \times 10-12F/M$
vi. R_0=$1.097373 \times 107m^{-1}$

QUESTION ONE (30 marks)

a. Discus the wave particle duality of light. **(4 marks)**

b. Rutherford tested Thomson's hypothesis of the plum pudding model by devising his 'gold foil' experiment. He shot high velocity alpha particles at a gold atom then made observations that forced him to discard the plum pudding model.

i. State the three observations he made from the 'gold foil' experiment. **(3 marks)**

ii. Briefly describe Rutherford's reasoning about the structure of the atom from his 'gold leaf' experiment. **(3 marks)**

iii. State Bohr's postulate of the atom. **(3 marks)**

c. Based on Bohr's postulates, consider an atom with a nucleus whose positive charge is Ze and mass M. Let an electron of charge –e and mass m, move round the nucleus in an orbit of radius r

i) Derive the relation for the radii of the stationary state. **(4 marks)**

ii) Show that the velocity of the revolving electron is given by:

$$V = \frac{Ze^2}{2nh\varepsilon_0}$$ **(3 marks)**

d. State three drawbacks of Bohr's atomic model. **(3 marks)**

e. State the uncertainty principle. **(1 mark)**

f. The speed of an electron is measured to be $5.0 \times 10{-}3$ m/s to an accuracy of 0.003%.Find the minimum uncertainty in determining the position of this electron. **(2 marks)**

g. Consider two waves $y1$ and $y2$ with equal amplitudes but different frequencies f 1 and f 2 respectively superposed to generate a resultant wave y . Given that the speed of the wave packet (group speed) is $V_g = \frac{\Delta\omega}{\Delta k}$, show that this group speed of the wave packet is identical to the speed of the particle that its modelled to represent. **(4 marks)**

QUESTION TWO (20 marks)

a) A certain line in the emission spectra of hydrogen occurs at a frequency of 7.56×10^{14} Hertz. If is known that it belongs to the Balmer series determine the energy level from which the electron fell. **(3 marks)**

b) Derive the Compton shift equation. **(5 marks)**

c) State two properties an ideal particle. **(2 marks)**

d) Describe the spectral lines of hydrogen spectrum. **(5 marks)**

e) The ionization energy of the hydrogen ions in its ground state is $E=-13.6\ eV$ .Calculate the frequency, wavelength and wave number of the electromagnetic radiation that will just ionize the atom. **(5 marks)**

QUESTION THREE (20 marks)

a. Using the equation $\frac{1}{\lambda} = -R_0\left(\frac{1}{n_2^2} - \frac{1}{n_1^2}\right)$. . Determine the wavelengths of hydrogen emission spectrum for the case:

i. $n_1 = 1$ and $n_2 = 2$ **(2 marks)**

ii. $n_1 = 3$ and $n_2 = 4$ **(2 marks)**

b) Determine the frequency of the spectral lines in the Lyman and the Paschen series given in a (i) and (ii) above. **(4 marks)**

c) X- rays of wavelength $\lambda_0=0.2nm$ are scattered from a block material. The scattered X-rays are observed at an angle of 45^0 to the incident beam. Calculate their wavelength. **(2 marks)**

d) State the failures of classical physics in explaining the following:

ii. Black body radiation **(2 marks)**

iii. Photoelectric effect **(2 marks)**

e) State any three features of photoelectric effect and for each compare the predictions made by a classical approach, using the wave model for light with the experimental results. **(6marks)**

QUESTION FOUR (20 marks)

a) One characteristic of the black body radiation is that peaks of the curves shift towards the lower wavelength end as temperature increases.

(i) What is the prediction of the Weins Classical expression? **(5marks)**

(ii)Where does Weins prediction agree with the experiment? **(5marks)**