MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS

2018/2019 ACADEMIC YEAR

FOURTH YEAR *SECOND* SEMESTER

SCHOOL OF SCIENCE

BACHELOR OF SCIENCE IN PHYSICS AND BACHELOR OF EDUCATION (SCIENCE)

COURSE CODE: PHY 416

COURSE TITLE: ATOMIC AND NUCLEAR PHYSICS

DATE: 26TH APRIL 2019 **TIME: 11.00 AM – 1.00 PM**

INSTRUCTIONS TO CANDIDATES

Answer Question **ONE** and any other **TWO** questions

Question One

i) State the basic Postulates according to Bohr. **(3 marks)**

ii) i) The electron in a hydrogen atom make a transition from $n=2$ energy level to the ground level ($n=1$). Find the wavelength and frequency of the emitted photon. **(3 marks)**

ii) In Interstellar space, highly excited hydrogen atoms called Rydberg atoms have been observed. Find the wavelength of which radio astronomers must tune to detect signals from electrons dropping from $n=273$ level to the $n=272$. **(3 marks)**

iii) Using an appropriate selection criteria, find the values of l and m_l for $n=2$. **(4 marks)**

iii) Define the following terms as used in nuclear physics

i. Radioactivity

ii. Nuclear Reactor **(2 marks)**

iv) A piece of charcoal containing $25.0g$ of carbon is found in some ruins of ancient city. The sample shows a ^{14}C activity R of 250 decays/mine. How long has the tree from which this charcoal came been dead? **(4 marks)**

v) Describe briefly, the vector model of the atom and discuss the quantum number associated with it. **(6 marks)**

vi) Give two failures of Classical Mechanics. **(2 marks)**

vii) Find the longest wavelength present in the Balmer series of hydrogen corresponding to the H_α line. **(3 marks)**

Question Two

a) Use the method of separation of variable to explain the origin of quantum numbers n, l and m_l. **(8 marks)**

b) Briefly describe the two major coupling schemes in the vector model of an atom. **(4 marks)**

c) List the possible quantum energy states that an electron may have for $n=1$ and $n=2$. Derive the list from both,

i. The system of quantum numbers n, l, m_l and m_s

ii. The system of quantum numbers n, l, j and m_j **(4 marks)**

d) Calculate the angle between $\mathbf{L}$ and $\mathbf{s}$ for which $s=\frac{1}{2}$ and $l=2$ electron. **(4 marks)**

QUESTION THREE

a) Use Avogadro's number to show that 1 u 5 1.66 3 10227 kg. **(2 marks)**

b) Consider a nucleus of mass number A.

i) Find an approximate expression for the mass of the nucleus. **(1 mark)**

ii) Find an expression for the volume of this nucleus in terms of A. **(1 mark)**

iii) Find a numerical value for the density of this nucleus. **(2 marks)**

c) Briefly explain the two major nuclear models **(4 marks)**

d) The nucleus ^{64}Zn has a tabulated binding energy of 559.09 MeV. Use the semi empirical binding-energy formula to generate a theoretical estimate of the binding energy for this nucleus. (Use C_1 = 15.7 MeV, C_2 = 17.8 MeV, C_3 = 0.71 MeV, C_4 = 23.6 MeV) **(3 marks)**

e) The isotope carbon-14, 14 6C, is radioactive and has a half-life of 5 730 years. If you start with a sample of 1 000 carbon-14 nuclei, how many nuclei will still be un decayed in 25 000 years? **(3 marks)**

f) At time t 5 0, a radioactive sample contains 3.50 mg of pure 11 6C, which has a half-life of 20.4 min.

(i) Determine the number N_0 of nuclei in the sample at t = 0. **(2 marks)**

(ii) What is the activity of the sample initially and after 8.00 h? **(2 marks)**

QUESTION FOUR

a) Discuss the Stern Gerlach experiment **(6 marks)**

b) Define the term "Zeeman Effect" **(2 marks)**

c) Differentiate between normal and anomalous Zeeman effects. **(5 marks)**

d) Using the appropriate selection rule, draw the normal Zeeman effect for the spectral line $l = 2$ to $l = 1$. **(4 marks)**

e) A sample of a certain element is placed in a $0.0300T$ magnetic field and suitably excited. How far apart are the Zeeman components of the $450nm$ spectral line of this element? **(3 marks)**

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