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 $l = 2 \text{ to } l = 1$. **(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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