CHUKA  **UNIVERSITY**

UNIVERSITY EXAMINATIONS

FOURTH YEAR EXAMINATION FOR THE AWARD OF DEGREE OF BACHELOR OF SCIENCE IN PHYSICS

PHYS 414: NUCLEAR AND ATOMIC PHYSICS

STREAMS: B.Sc PHYSICS Y4S1 **TIME: 2 HOURS**

DAY/DATE: FRIDAY 8/12/2017 **2.30 P.M - 4.30 P.M.**

QUESTION ONE [30 MARKS]

a). Define the terms nuclear fusion and nuclear fission [2 Marks]

b).The electron in the hydrogen atom makes a transition from the n=4 to the ground state .Find the wavelength and frequency of the emitted photon. (R_H =1.097 × 10^7 m^{-1}.) [4 Marks]

c).Show that $E_n = \frac{-m_e k_e^2 e^4}{2h^2}\left(\frac{1}{n^2}\right) n = 1,2,3 \ldots$ [4 Marks]

d).State Pauli's Exclusion principle [2 Marks]

e).Write electronic configuration of z = 21 utilizing the exclusion principle. [3 Marks]

f).Estimate the energy of the characteristic X-ray emitted from a tungsten target when an electron drops from a N shell (n =4) to a vacancy in the K shell (n =1). Z =74 [5 Marks]

g).Draw an energy level diagram for hydrogen and at least show four series [4 Marks]

h). The nuclear reaction ${}^{1}_{0}n + {}^{10}_{5}B \rightarrow {}^{7}_{3}Li + {}^{4}_{2}He$ is observed to occur even when very slow-moving neutrons (Mn=1.0087u) strike a boron atom at rest. For a particular reaction in which KE=0, the helium (M_{He}=4.0026u) is observed to have a speed of 9.30*106 m/s. Determine

i) The KE of the lithium(M_{Li}=7.0160) [4 Marks]

ii) The Q value of the reaction [2 Marks]

QUESTION TWO [20 MARKS]

a).For a hydrogen atom ,determine the the quantum numbers associated with the possible states that correspond to the principal quantum number n=5 [6 Marks]

b) In a certain experiment, 0.024″μCi 0f $^{32}_{15}P$is injected into a medium containing a culture of bacteria. After 2hours the cells are washed and adetector that is 70% efficient (counts 70% 0f emitted rays) records 1440 counts per minute from all the cells.What percentage of the original was taken up by the cells? [4 Marks]

c)Show that half-life of a radioactive material can be expressed as $t_{\frac{1}{2}} = \frac{0.693}{\lambda}$ Where λ=Decay constant [3 Marks]

d.An isotope of an element radon has half-life of 8 days, a sample of radon originally contains $8.2*10^{16}$ atoms, take one day to be 86×10^{3} seconds, calculate

i) the number of radon atoms remaining after 32 days [2 Marks]

ii) the rate of decay of the radon sample after 32 days [2 Marks]

e) Define the following [3 Marks]

i) LASER
ii) MASER
iii) Phosphorescence

QUESTION THREE [20 MARKS]

a) State any Four useful applications of radioactivity. [4 Marks]

b) Calculate the binding energy in alpha particle (Helium-4) nucleus in MeV. Take [3 Marks]

Mass of neutron=1.008665u
Mass of helium nucleus=4.001508u
Mass of a proton=1.007276u

c) State and explain briefly FIVE types of stationary power reactors [5 Marks]

d)State Neil Bohr's atomic model postulates [3 Marks]

e) State five Hazards of radioactivity [5 Marks]

QUESTION FOUR

a).Find the longest and the shortest wavelength photons emitted during Balmer series for the hydrogen atom and determine the energy of the shortest wavelength. [4 Marks]

b. Sketch a graph showing the average binding energy per nucleon as a function of mass number A . [4 Marks]

c) Estimate the temperature required for a deuterium-tritium fusion(d-t) to occur (rd=1.5fm and rt=1.7fm [4 Marks]

d) An animal bone fragment found in archaeological site has a carbon mass of 400g. It registers an activity of 20 decays/s. What is the age of the bone? (ratio of C-14:C -12 when the animal was alive was $1.3 * 10^{-12}$). [4 Marks]

e) Draw a well labeled diagram of a nuclear reactor [4 Marks]

QUESTION FIVE

a.Calculate the energy in MeV liberated when helium is produced.

i) by fusing two neutrons and two protons [3 Marks]

m_p=1.007825u, M_n=1.008665u

ii) by fusing two deuterium nuclei ${}^{2}_{1}H$=2.014102 [3 Marks]

iii) Why the difference? [2 Marks]

b) Calculate the total binding energy and the average binging energy per nucleon for ${}^{56}_{26}Fe$ the most common stable isotope of Iron (p=1.007825u ,n=1.008665u and Fe=55.9349u [5 Marks]

c) Compare at least THREE properties of alpha, beta and gamma decays. [3 Marks]

d) Describe the kind of decay particle in the following nuclear equations A,B,C and D

i) ${}^{1}_{0}n$ $+{}^{238}_{92}U \rightarrow {}^{239}_{92}U +$ A [4 Marks]

ii) ${}^{2}_{1}H + {}^{14}_{7}N \rightarrow {}^{12}_{6}C +$ B

iii) ${}^{212}_{83}Bi \rightarrow {}^{208}_{81}Tl +$C

iv) ${}^{2}_{1}H + {}^{2}_{1}H \rightarrow$D

……