CHUKA UNIVERSITY

PHYS 414 :NUCLEAR AND ATOMIC PHYSICS

QUESTION ONE(30mks

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

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}.)
[4marks]

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

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

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

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
[5marks]

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

h). The nuclear reaction $^1_0n + ^{10}_5B \rightarrow ^7_3Li + ^4_2He$ 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)
[4marks]

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

QUESTION TWO 20 Marks

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

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?
(3mks)

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
(3mks)

iii) Why is the quantity of energy different in the two
(1mks)

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
(2marks)

ii) the rate of decay of the radon sample after 32 days
(2marks)

e) Define the following (3 marks)

i) LASER

ii) MASER

iii) Phosphorescence

QUESTION THREE 20 MARKS

a) State any Four useful applications of radioactivity (4marks)

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

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

c) State and explain briefly FIVE types of stationary power reactors (5marks)

d)State Neil Bohr’s atomic model postulates
(3marks)

e) State five Hazards of radioactivity (5marks)

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.
[4marks]

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

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

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 $1.3 * 10^{-12}$). [4marks]

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

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_1H=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
[5marks]

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

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

i)$^1_0n + ^{238}_{92}U \rightarrow ^{239}_{92}U$+ A [4marks]
ii)$^2_1H + ^{14}_7N \rightarrow ^{12}_6C$+ B

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

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