EMBU UNIVERSITY COLLEGE

(A Constituent College of the University of Nairobi)

2015/2016 ACADEMIC YEAR

SECOND SEMESTER EXAMINATION

FOURTH YEAR EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE

SPH 402: NUCLEAR PHYSICS

DATE: APRIL 12, 2016 **TIME: 11:00-1:00**

INSTRUCTIONS:

Answer Question ONE and ANY Other TWO Questions

The following constants may be useful:

1 electron-volt = 1.6×10^{-19} J

Mass of a proton $m_p = 1.67 \times 10^{-27}$ Kg

Mass of a electron $m_e = 9.11 \times 10^{-31}$ Kg

$1u = 1.660559 \times 10^{-27}$ Kg = 931MeV

QUESTION ONE

a) Discuss any three general properties of a nucleus. (3 Marks)

b) Discuss 4 properties of the nuclear force. (4 Marks)

c) Distinguish between the "half-life period" and the "mean life time" of radioactive elements. (2 Marks)

d) The half life period of a certain radioactive sample is 1590 years. After how many years will one gram of the pure element, be reduced to one hundredth of a gram? (3 Marks)

e) Discuss with appropriate examples each of the following nuclear decay.

i) α- decay (3 Marks)

ii) β- decay (3 Marks)

iii) γ- decay (3 Marks)

f) What is the binding energy in MeV of the deuteron if $m_p = 1.007276u$, $m_D = 2.013553u$ and $m_n = 1.008665u$ for deuteron (3 Marks)

g) The gamma emission constant for Cs-137 = 3.3 rad/hr/mCi/cm^2. If the source strength is 20.31 mCi, find

i) the dose rate at 1 cm (2 Marks)

ii) the dose rate at 25 cm (2 Marks)

iii) the distance at which dose rate will be 200 mrad/hr. (2 Marks)

QUESTION TWO

a) What do you understand by isotopes. (1 Mark)

b) Give at least 5 examples of applications of isotopes in each of the following fields;

i) Medicine (5 Marks)

ii) Industry (5 Marks)

iii) Agriculture (5 Marks)

c) Given the following isotope masses;

$^{7}_{3}Li = 7.016004$, $^{6}_{3}Li = 6.015125$ *and* $^{1}_{0}n = 1.008665$, calculate the binding energy of a neutron in the $^{7}_{3}Li$ nucleus expressing your answer in MeV and Joules. (4 Marks)

QUESTION THREE

a) What is meant by "binding energy" and "mass defect" with respect to a nucleus? (2 Marks)

b) Calculate the binding energies of the following isobars and their binding energy per nucleon; $^{64}_{28}Ni = 63.9280$, $^{64}_{29}Cu = 63.9298$ (take M_n=1.009 and M_H=1.008) (6 Marks)

c) Discuss in details the Liquid-Drop model and Shell model. (8 Marks)

d) Estimate the number of ionizations produced per Kg of tissue for an absorbed dose of 1.0 rad. (4 Marks)

QUESTION FOUR

a) From the Mossbauer spectroscopy, state and explain three types of nuclear interactions that can be observed (6 Marks)

b) A beam of gamma rays has a cross-sectional area of 2 cm^2 and carries 7 x 10^8 photons through the cross-section each second. Each photon has an energy of 1.25 MeV. The beam passes through a 0.75 cm thickness of flesh ($\rho = 0.95\ g/cm^3$1) and loses 5 % of intensity in the process. What is the average dose (in rad) applied to the flesh each second? (5 Marks)

c) State 5 genetic effects caused by Over-exposure to radiation. (5 Marks)

d) The 226Ra nucleus undergoes α-decay with a product of 222Rn. Calculate the disintegration energy of the process. (Mass of 226Ra = 226.02540u, Mass of 222Rn = 222.017574u and Mass of He = 4.00260u). (4 Marks)

QUESTION FIVE

a) Describe briefly any two Particle accelerators in nuclear physics (4 Marks)

b) Show that half life $T_{½}$ of a radioactive sample is given by

$T_{½} = 0.693/\lambda$ where λ is the decay constant. (4 Marks)

c) The half-life of Radon is 3.8 days. After how many days will only one twentieth of Radon sample be left over (4 Marks)

d) Classify elementary particles into groups according to their mass and briefly discuss each of them. (8 Marks)

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