SOUTH EASTERN KENYA UNIVERSITY

UNIVERSITY EXAMINATIONS 2016/2017

FIRST SEMESTER EXAMINATION FOR THE DEGREE OF BACHELOR OF SCIENCE (PHYSICS) and BACHELOR OF EDUCATION (SCIENCE)

SPH 402: NUCLEAR PHYSICS

9TH DECEMBER, 2016 **TIME: 10.30-12.30 P.M**

INSTRUCTIONS TO CANDIDATES

- This paper consists of FIVE questions.
- Answer question **ONE** and any other **TWO** questions.
- Question **ONE** carries 30 mark while the other **TWO** questions carry 20 marks each
- Use the following constants where necessary

  Proton mass $m_p = 938.3\,MeV/c^2 = 1.007276\,u$

  Proton mass $m_n = 939.7\,MeV/c^2 = 1.008665\,u$

  Avogadro number $A = 6.23\times10^{23}$

QUESTION ONE (COMPULSORY) (30 MARKS)

a) Define the following terms

(i). Mass defect. (2 marks)

(ii). Binding energy. (2 marks)

b) Explain why the binding energy is not usually determined from the nuclides masses. (2 marks)

c) Show that the number of nuclides N (t) after time t is given as $N(t) = N_o e^{-\frac{t}{\tau}}$ where N_o is the initial number of nuclides, and τ is the characteristic time. (5 marks)

d) With reference to -decay; explain the term Q-value (2 marks).

e) Bedlum $^{247}_{121}Bd$ decays by alpha decay to another element, tantrum (Tt) ;

(i). Write a balanced equation in isotope notation to describe the decay, (2 marks)

(ii). Explain why alpha decay is the most likely decay for this element. (2 marks)

(iii). Calculate the nuclear radius of Bedlum if $r_o = 1.4 \times 10^{-15}$. (2 marks)

f) Explain the following terms;

(i). Fluence, (2 marks)

(ii). Dose, (2 marks)

(iii). KERMA . (2 marks)

g) Explain how the binding energy of nuclides can be determined through the method of mass spectroscopy. (5 marks)

QUESTION TWO (20 MARKS)

a) Explain why the semi empirical mass formula is referred to as "Semi empirical". (2 marks)

b) Show that the semi empirical mass formula is given as $M(A,Z) = ZM_p + (A-Z)M_n - \alpha A + \beta A^{\frac{2}{3}} + \gamma \frac{(N-Z)^2}{A} + \varepsilon \frac{Z^2}{A^{\frac{1}{3}}} - \delta(N,Z)$. (13 marks)

c) Iron isotopes ^{49}Fe and ^{51}Fe are both known short lived radioactive positron emitters, but ^{50}Fe has not yet been discovered. Compute the expected value of the nuclear mass of ^{50}Fe. Take the Weisacker constants as, $\beta = 18.33$, $\alpha = 15.835$, $\varepsilon = 0.71$, $\gamma = 23.2$ and $\delta = \pm 12$. (5 marks)

QUESTION THREE (20 MARKS)

a) Define the following terms

(i). Mean life (1 mark)

(ii). Half life (1 mark)

b) Show that the kinetic energy of the α-particle is given as $T_\alpha = \frac{A}{A+4} Q_\alpha$ where A is the atomic mass and Q is the Q-value of the α-particle. (5 marks)

c) The binding energies of $^{228}_{90}Th$ is 1.743077 GeV, $^{224}_{88}Ra$ is 1.720301 GeV and that of $^{4}_{2}He$ is 28.296 MeV. Calculate the kinetic energy of the α-particle. (4 marks)

d) (i) Using relevant equations explain, β^--decay, β^+-decay and electron capture. (6 marks)

(ii). Explain why the (anti-) neutrino in the processes in d(i) above is necessary. (3 marks)

QUESTION FOUR (20 MARKS)

(a) Differentiate between;

(i). Elastic and in elastic scattering. (2 marks)

(ii). Differential and total cross section. (2 marks)

(b) Show that the nuclear form factor is given as $F_{nucl}(\Delta\vec{k}) = \int d^3x N(x) e^{-i\Delta k.x}$ where $N(x)$ is the normalized charge density and Δk is the change in momentum. (7 marks)

(c) Explain the following terms

(i).Pair production. (3 marks)

(ii).Compton scattering. (3 marks)

(iii).Radiation length. (2 marks)

QUESTION FIVE (20 MARKS)

(a) Explain the following application of nuclear physics in:

(i). Agriculture, (5 marks)

(ii). Medicine, (5 marks)

(iii). Trace element analysis. (4 marks)

(b) An 8 MeV proton beam facility employs a cylinder filled water of an -isotope of composition 2 atoms of hydrogen and 1 atom of -isotope for molecular weight of 20. The target has the area of 1 cm2 and is 1cm long. Calculate the maximum activity in the current of 8 MeV protons in 0.3-barn cross section. (6 marks)