THE CATHOLIC UNIVERSITY OF EASTERN AFRICA

A. M. E. C. E. A

P.O. Box 62157
00200 Nairobi - KENYA
Telephone: 891601-6
Fax: 254-20-891084
E-mail:academics@cuea.edu

MAIN EXAMINATION

JANUARY – APRIL 2018 TRIMESTER

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

REGULAR PROGRAMME

PHY 406: NUCLEAR PHYSICS

Date: APRIL 2018	**Duration: 2 Hours**
INSTRUCTIONS: Answer Question ONE and any other Two Questions	

Physical Constants
1 atomic mass unit = 931.5 MeV
Spin g – factor for proton, $g_s = 5.59$
Spin g – factor for neutron, $g_s = -3.83$
orbital g – factor for proton, $g_l = 1$
orbita g – factor for neutron, $g_l = 0$

Q1 a) Distinguish between the following terms:
- (i) Nuclear decay and Nuclear reaction **(2 marks)**
- (ii) Endoergic and exoergic reactions **(2 marks)**
- (iii) Pick up and stripping reaction **(2 marks)**
- (iv) Impact parameter and scattering angle **(2 marks)**

b) From the nuclear reaction X(a, b)Y, express the reaction Q- value in terms of
- (i) the rest mass **(2 marks)**
- (ii) excess kinetic energy **(2 marks)**

c)
- (i) Define the term degeneracy **(1 mark)**
- (ii) Determine the degeneracy for the level $l = 4$ **(3 marks)**
- (iii) If the spin orbit potential is included in d(ii) above, determine
  - I) The possible values of the total angular momentum **(3 marks)**

II) The degeneracy for each level **(3 marks)**

d) State the significance of the following terms in the semi empirical mass formula

(i) Coulomb term **(1 mark)**
(ii) Symmetry term **(1 mark)**
(iii) Surface energy **(1 mark)**

e) Determine the nuclear magnetic moment for $^{13}_{7}N$ nucleus **(5 marks)**

Q2 a) (i) What is a nuclear model? **(1 mark)**
(ii) State two characteristics of a successful model **(2 marks)**
(iii) State four reasons for using nuclear models **(4 marks)**

b) List six of the nuclear properties that the liquid drop model does not address. **(6 marks)**

c) Consider a circular loop carrying current and enclosing an area, A. Derive an expression for the magnitude of magnetic moment μ in terms of orbital angular momentum quantum number **(7 marks)**

Q3 a) (i) State the first ten shell model ordering of the nuclear levels **(3 marks)**

(ii) What is responsible for the splitting between $\mathrm{P}_{3/2}$ and $\mathrm{P}_{1/2}$? **(1 mark)**

b) Determine the ground state, spin – parity the shell model would predict for the following

(i) $^{13}_{5}\mathrm{B}$ **(3 marks)**
(ii) $^{13}_{6}\mathrm{C}$ **(3 marks)**
(iii) $^{13}_{7}\mathrm{N}$ **(3 marks)**

c) Consider the nuclear reaction $^{152}_{63}E_U\ (n,p)\ X$. Given that the masses of p = 0.000549 u, n = 1.008665 u, $^{152}_{63}E_U$ = 151.921749 u and X = 151.919756 u identify X and hence determine the Q- value of the reaction above **(7 marks)**

Q4 a) Derive an expression for the average value of the spin – orbit interaction and hence show that the energy splitting En is given as

$$\left(l+\tfrac{1}{2}\right)\hbar$$ **(10 marks)**

b) Show that the reaction cross – reaction σ can be expressed as

$$\sigma = \frac{\mathrm{R_b}}{\mathrm{I_a\ N}}$$

Where R_b, I_a and N have their usual meaning **(10 marks)**

Q5 a) Derive an expression for the transmission of a beam intensity through a material of thickness x in terms of the linear attenuation coefficient μ **(5 marks)**

b) The radioisotope 24 Na emits γ rays of energies 1.378 MeV and 2,754 MeV in succession, after passing through 27.5 g/cm^2 of lead (ρ = 11g/cm^3). Calculate their relative intensities given that the linear absorption coefficients are 48 and 62 respectively for the compounds **(5 marks)**

c) Sketch a graph of the relationship between the voltages applied to a gas filled counter and the charge collected indicating all the gas amplification region. **(10 marks)**

END