MAASAI MARA UNIVERSITY

REGULAR UNIVERSITY EXAMINATIONS
2017/2018 ACA
DEMIC YEAR
FOURTH YEAR SECOND EXAMINATION

SCHOOL OF SCIENCE
BACHELOR OF SCIENCE IN PHYSICS

COURSE CODE: PHY 416
COURSE TITLE: ATOMIC AND NUCLEAR PHYSICS

DATE: 23/4/2018 **TIME: 1100-1300 HRS**

INSTRUCTIONS

1. This paper contains **FIVE**(5) questions in two sections A and B.
2. Section A is compulsory
3. Answer question **ONE (1)** in section A and any **Two** (2) questions from section B.
4. Do not forget to write your Registration Number.

QUESTION ONE

(i) Establish the relationship between the decay or disintegration constant and half-life of a radioactive element **(6marks)**

(ii) The half-value period of radium is 1590 years. In how many years will one gram of pure element Lose one centigram ? **(4 marks)**

(iii) 1 gram of radium is reduced by 2.1 mg in 5 years by alpha decay. Calculate the half-life period of radium **(4 marks)**

(iv) What is the difference between Zeeman splitting and fine structure splitting

(2marks)

(v) Define mean life and obtain the relationship between mean life and decay constant **(6 marks)**

(vi) 1 gram of a radioactive substance disintegrates at the rate of $3.7x10^{10}$ disintegration per second. The atomic weight of the substance is 226. Calculate its mean life. **(4 marks)**

vii) Write an account of the Bethe explanation of the apparent infinite supply of heat and energy in the hot stars **(4 marks)**

QUESTION TWO (20MARKS)

1. (a) (i) Obtain the relationship between the mass defect and packing fraction of a nuclide and explain why the mass defect is always negative, while the packing fraction can be either positive or negative**.** **(4 marks)**
   (ii) Calculate the packing fraction and binding energy per nucleon of the nuclide specified by $^{40}_{18}A$=39.962384u **(5 marks)**

   (b)I) Apply the basic ideas of the liquid drop of the nucleus to derive the Bohr-Wheeler semi-empirical binding energy formula for a nuclide. **(6 marks)**

   (ii) Use the relation between binding energy and the mass of a nuclide to calculate the atomic number of most stable nucleus for a given mass number A . In the formula for BE we can write $Z(Z-1)=Z^2$ and N-Z = A-2Z. a=15.760, b= 17.810, c=0.711, d=23.702, δ=34 **(5 marks)**

QUESTION THREE (20MARKS)

i) What are the deficiencies of the Bohr model of the atom? **(4 marks)**

ii) A form of the schrondinger equation for a particle moving in a one dimensional potential, V(x) is obtained by employing the operator

$$\hat{A} = -\frac{1}{2}\frac{d^2}{dx^2} + V(X)$$

show that for the particular case $V(X)=\frac{1}{2}X^2$, the function $Xe^{-\left(\frac{x^2}{2}\right)}$ is an eigenfunction of the operator Â, and obtain the corresponding eigenvalue.

(8 marks)

ii) Prove that the most likely distance from the origin of an electron in the n=2, l=1 state of hydrogen is $4a_0$ where a_0 is the Bohr radius. [the radial wavefunction, $R_{2,1}(r)$ is (8 marks)

$$R_{2,1}=\frac{1}{\sqrt{3}\,(2a_0)^{3/2}}\frac{r}{a_0}e^{-\frac{r}{2a_0}}$$ **(8mmarks)**

QUESTION FOUR (20MARKS)

a) i) Distinguish between nuclear fission and any other ordinary nuclear reaction.

(2 marks)

Ii) Present the basic theory of nuclear fission and obtain an expression for the critical fission energy for break up into two fission fragments.

(3 marks)

iii) Calculate the critical energy for the fsion of ${}^{235}_{92}U$ into two equal fragments.

(4 marks)

b) i) In the neutron – induced fission of =235.044u, two stable products, ${}^{98}_{42}Mo$ =97.905u and, are often found. Assuming that these stable isotopes are the end products of the original fission process, determine:

i) the number of neutrons and b-particles produced. **(3 marks)**

ii) The fission energy released . **(3 marks)**

iii) Calculate the total fission energy released in the complete fission 1kg of 23592U if the average energy released in each fission process is 200MeV.

(3 marks)

iv) Explain briefly the dangers involved in energy production through nuclear fission

(2 marks)

QUESTION FIVE (20MARKS)

a) i) Derive the basic energy and momentum conservation equations for nuclear reaction in which two nuclides interact to produce two product nuclides.

(4 marks)

ii) Calculate the rest mass of the isotope $^{15}_{7}N$ using the nuclear react$^{14}_{7}N\ (d, p)\ \ ^{15}_{7}N$ ion given and$^{2}_{1}H$=2.014102u; $^{1}_{1}H$=1.007825u: $^{14}_{7}N$=14.003074u 17u and Q-Value 8.61 MeV. Take u=931 MeV **(4 marks)**

iii) A light particle x collides with a heavy nuclide X at rest and a light parcticle y is emitted along with a heavy nuclide Y. If y is emitted in the same direction as that of x, show that the Q-value of the nuclear reaction B given by,

$$Q = Tx\left[\frac{mx}{MY} - 1\right] + \ Ty\left[\frac{my}{MX} - 1\right] - \frac{-2}{MY}\sqrt{TxTymxmy}$$

Where T, m, M denote kinetic energy and masses, respectively. **(8 marks)**

b) The disintegration constant of a radioactive element is 0.00231 per day. Calculate its half-life and average life. **(4 marks)**

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