KABARAK UNIVERSITY

EXAMINATIONS

2008/2009 ACADEMIC YEAR

FOR THE DEGREE OF BACHELOR OF EDUCATION SCIENCE

COURSE CODE: **PHYS 413**

COURSE TITLE: **NUCLEAR PHYSICS**

STREAM: **SESSION VII**

DAY: **THURSDAY**

TIME: **9.00 – 11.00 A.M.**

DATE: **13/08/2009**

INSTRUCTIONS

1. *Answer question 1 and any other two questions*
2. *Question 1 carries 30 marks and the others carry 20 marks each.*
3. *You may find the following information useful;*
    a. *Electronic charge $e = 1.602 \times 10^{-19} C$*
    b. *Avogadro's number $N = 6.022 \times 10^{23} mol^{-1}$*
    c. *Planck's constant $h = 6.63 \times 10^{-34} Js$*
    d. *Velocity of light $C = 3.0 \times 10^{8} ms^{-1}$*
    e. *1 a.m.u. $= 1.66 \times 10^{-27} kg = 931.5 MeV$*
4. *Rest mass and energy of particles;*
    a. *Neutron (n) $m = 1.6749 \times 10^{-27} kg = 1.0087$ a.m.u.*
    b. *Proton (p) $Mp = 1.6726 \times 10^{-27} kg = 1.0078$ a.m.u.*
    c. *Electron (e) $Me = 9.1 \times 10^{-31} kg = 0.000548$ a.m.u*
    d. *Deuterium ${}_1H^2$ (2.0141 a.m.u), ${}_1H^3$ (3.0160 a.m.u)*
    e. *${}_{42}Mo^{98}$ (97.906 u), Xe (135.9072), ${}_2He^4$(4.0026 u)*
5. *${}_{92}U^{235}$ (235.044 a.m.u), ${}_{56}Ba^{141}$ (140.914 a.m.u), ${}_{82}Pb^{214}$ (205.974 a.m.u.), ${}_{86}Rn^{222}$(220.011 a.m.u), ${}_{27}Co^{59}$ (58.933198a.m.u) ${}_6C^{12}$ (12.000 u)*

PLEASE TURN OVER

QUESTION 1 (30 MARKS)

a.) Define the term isotone nuclei. (1 mark)

b.) Assuming that a nucleus is a sphere of nuclear matter of radius 1.2 X $A^{1/3}$fm, A = 3 express the average nuclear density. (3 marks)

c.) Give three properties of nuclear forces. (3 marks)

d.) Describe Compton Effect of gamma rays absorption. (2 marks)

e.) Explain one application of radioisotopes in medicine. (2 marks)

f.) (i) Define mean life $\bar{T}$ of a radioactive substance. (1 mark)

ii) Show that the mean life $\bar{T}$ is given as

$$\bar{T} = \lambda \int_0^{\infty} te^{-\lambda t} dt$$

Hence show that $\bar{T} = \frac{1}{\lambda}$ where symbols have their usual meaning. (6 marks)

g.) Half life of a radioactive element is 560 years. Starting with 12g of the substance, find

i.) period taken for 2g to decay. (3 marks)

ii.) Period taken for the substance to reduce to 4g. (2 marks)

h.) Give the major difference between atom bomb and a nuclear reactor. (2 marks)

i.) Name any two gases commonly used in radiation detectors for ionization. (2 marks)

j.) A neutron is directed to a uranium nucleus to create a reaction below;

$$_0n^1 + {}_{92}U^{235} \rightarrow {}_{42}Mo^{98} + {}_{54}Xe^{136} + 2.{}_0n^1$$

Calculate the energy liberated in this reaction in joules. (3 marks)

QUESTION 2 (20 MARKS)

a.) Show that the proton-electron hypothesis of nuclear composition is not possible. (6 marks)

b.) Cobalt-59 emits alpha particles whose kinetic energy is 5.2 MeV. Determine the alpha disintegration energy. (3 marks)

c.) Give the difference between line spectrum and continuous spectrum. (2 marks)

d.) Calculate the binding energy per nucleon in $_6C^{12}$. (3 marks)

e.) Give two uses of nuclear reactors.

f.) Helium nucleus is formed by the fusion of two deuterium nuclei. Calculate the energy released in this reaction given that binding energy per nucleon of $_1H^2$ and $_2H^4$ are 1.1 MeV and 7.0 MeV respectively. (4 marks)

QUESTION 3 (20 MARKS)

a.) Using nucleus forces explain why protons inside the nucleus have minimal repulsion on each other.

b.) When a 4-MeV α particle is stopped in an ionization chamber, the voltage across the detector output undergoes a step change of 2 mV. If the energy to produce an ion pair in the gas is 34eV, calculate the capacitance of the chamber (in pF). Assume the time constant of the system is long compared with the pulse duration. (3 marks)

c.) i.) With a labeled diagram, describe the operations of a proportional counter as a radiation detector. (7 marks)

ii.) The counter above has an anode of 1.0×10^{-2}mm and the distance between the anode and the cathode is 9cm. Calculate the voltage across such a set up if it experiences an electric field of $2.31 \times 10^{7}\text{Vm}^{-1}$. (3 marks)

d.) i.) Define the term mass defect. (1 mark)

ii.) State three conditions necessary for a nucleus of an atom to remain stable. (3 marks)

QUESTION 4 (20 MARKS)

a.) Briefly explain the principles of collective model as a model of nuclear structure, giving the expression for energy total for this model. (4 marks)

b.) i.) Explain some difficulties in nuclear waste disposal. (2 marks)

ii.) Give one way of radiation protection method. (1 mark)

c.) Two deuterium nuclei fuse to form a single helium atom. Calculate the total energy liberated in such a reaction. (3 marks)

d.) State two sources of neutron. (2 marks)

e.) Describe the operations of a pressurized water reactor. (5 marks)

f.) Given that spin angular momentum L_S is

$$\sqrt{l(l+1)}\,\frac{h}{2\pi}$$

Show that the spin for a proton can be written as;

$L_S = \frac{\sqrt{3}}{2}\hbar$ (3 marks)