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: **TUESDAY**

TIME: **2.00 – 4.00 P.M.**

DATE: **25/11/2008**

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)*
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)*

PLEASE TURN OVER

QUESTION 1 (30 MARKS)

a.) Give two characteristics of a gamma ray. (2 marks)

b.) Define the terms i.) Isotones and ii.) Isotopes (2 marks)

c.) Calculate the binding energy of alpha particle expressing result in joules. (3 marks)

d.) Show that nuclear density ρ_N is given as

$$\rho_N = \frac{3M_N}{4\pi r_o^3}$$ where the symbols have their usual meaning. (3 marks)

e.) Define the term mass defect. (1 mark)

f.) Show that half life period of an element is given as

$$T_{1/2} = \frac{\ln 2}{\lambda}$$ (5 marks)

g.) Define the term packing fraction as used in the nuclear binding. (1 mark)

h.) Give three applications of radioisotopes. (3 marks)

i.) State two theories of nuclear composition. (2 marks)

j.) Find the energy release if two $_1H^2$ nuclei can fuse together to form $_2He^4$ nucleus. The binding energy per nucleon of H^2 and H^4 is 1.1 MeV and 7.0 MeV respectively.

(2marks)

k.) Complete the following nuclear reactions;

a. $_4Be^9 + _2He^4 \rightarrow ? + _0n^1$

b. $_3Li^7 + _1H^1 \rightarrow ? + _4Be^7$ (2 marks)

l.) Using a diagram describe the operations of an ionization chamber. (4 marks)

QUESTION 2 (20 MARKS)

a.) Define half-life of a radioactive element. (1 mark)

b.) Give two similarities between a nucleus structure and a liquid drop. (2 marks)

c.) Calculate the atomic of the most stable nucleus for a given mass number A given that the binding energy is given as

$$BE = aA - bA^{2/3} - \frac{cZ(z-1)}{A^{1/3}} - \frac{d(N-z)^2}{A} \pm \frac{\delta}{A^{3/4}}$$ (5 marks)

a = 15.76, b = 17.810, c = 0.711, d = 23.702 and $\delta = 34$

d.) What amount of energy (in MeV) is liberated by the following fission reaction?

(3 marks)

$$_0n^1 + _{92}U^{235} \rightarrow _{56}Ba^{141} + _{36}Kr^{92} + 3\ _0n^1$$

e.) Give the difference between natural and artificial radioactivity. (2 marks)

f.) define the term mean-life. Hence derive the mean – life in terms of the radioactive constant (1 + 4 marks)

g.) Give two advantages of GM counter. (2 marks)

QUESTION 3 (20 MARKS)

a.) Describe pair production of gamma absorption by matter. (2 marks)

b.) The linear attraction coefficient for 2 MeV gamma rays in water is about $5m^{-1}$.

i.) Find the relative intensity of a beam of 2 MeV gamma rays after it has passed through 0.1m of water. (2 marks)

ii.) How far must such a beam travel in water before its intensity is reduced to 1% of its original value? (3 marks)

c.) Give three sources of neutron. (3 marks)

d.) Give two ways of reducing radiation exposure. (2 marks)

e.) Calculate the energy released in joules when a single nucleus of helium is formed by the fusion of two deuterium nuclei. (3 marks)

f.) Alpha particles of energy 5 MeV pass through an ionization chamber at the rate of 10 per second. Assuming all the energy is used in producing ion pairs, calculate the current produced (35eV is required for producing an ion pair. (3 marks)

g.) Give two major sources of radiation hazards. (2 marks)

QUESTION 4 (20 MARKS)

a) a.) Write down three distinct qualities of nuclei with values of either Z or N = 2, 8, 20, 28, which qualifies them to be called 'magic numbers'. (6 marks)

b) Briefly describe some of the difficulties experienced in nuclear waste disposal. (3 marks)

c) With a well labeled diagram, describe the operations of pressured water reactor. (5 marks)

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

e) Calculate the binding energy per nucleon in $_6C^{12}$ (mass of $_6C^{12}$ atom is 12.000u) (3 marks)

f) How does the meson theory of nuclear forces explain the co-existence of nucleons in a nucleus? (2 marks)