MACHAKOS UNIVERSITY

University Examinations 2019/2020Academic year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

SECOND YEAR FIRST SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

SPH 202: MODERN PHYSICS

DATE: 9/12/2019 **TIME: 2.00-4.00 PM**

INSTRUCTIONS TO CANDIDATES

- The paper consists of **two** sections.
- Section **A** is **compulsory** (30 marks).
- Answer any **two** questions from section **B** (each 20 marks).

You may choose constants that you need among the following

Atomic mass unit u= 1.66 x10^{-27}Kg, Avogadro's number 6.022 x 10^{23}particles/mol, boltzmann's constant k_B = 1.38x10^{-23}J/K, Deutron mass m_d= 3.343x10^{-27}Kg,electron mass m_e= 9.109x10^{-31}Kg, electron volt eV=1.602 x10^{-19}J, charge e= 1.602x10^{-19}C, Gas constant R= 8.314J/K.mol, Gravitational constant G= 6.672x10^{-11}N.m^2/kg, neutron mass m_n=1.674x10^{-27} kg, Permeability of free space $\mu_o = 4\pi\ x\ 10^{-7} T.m/A$, Permittivity of free space $\epsilon_o = 8.854\ x\ 10^{-12} C^2/N.m^2$. Plank's Constant $h = 6.626\ x\ 10^{-34} J.s$, ħ=1.054 x$10^{-34} J.s$, Proton mass $m_p = 1.672\ x10^{-27} kg$, Rydberg constant $R_H = 1.097\ X\ 10^7 m^{-1}$, speed of light in a vacuum c = 2.997 x $\frac{10^8 m}{s}$, One light year(1Ly)is the distance travelled by light in one year which is 9.4607 x 10^{12} Km

SECTION A

QUESTION ONE (30 MARKS)

a) Give a reason as to why there is a gradual decrease in binding energy from 8.8 to 7.6MeV (2 marks)

b) A radioactive sample contains 2.3 x 10^{16} atoms and has an activity of 6.0 x 10^{12}Bq. What is its half life? (3 marks)

c) State and explain the meaning of the Heisenberg uncertainty principle (2 marks)

d) A stationary body of mass 2.0 kg explodes into 4 fragments of mass 0.02kg, 0.34 kg and 0.12 kg that move apart at speeds of 0.6c, 0.9c and 0.95c respectively. If the speed of the fourth fragment is 0.4c, find it's.

i. Mass (5 marks)

ii. Total energy (3 marks)

e) Define the term red shift (2 marks)

f) Based on proton neutron ratio explain instability in nuclides. (2 marks)

g) Explain how the colour of radiation emitted by a blackbody, changes when its temperature is reduced from about 10000 K to about 500 K (3 marks)

h) Show that the

i) velocity of an electron in a hydrogen atom is given by

$$v = \frac{e}{\sqrt{4\pi\varepsilon_o\, mr}}$$ (4 marks)

ii) total energy in a hydrogen atom is

$$E = -\frac{e^2}{8\pi\varepsilon_o\, r}$$ (4 marks)

QUESTION TWO (20 MARKS)

a) i) Draw the set up for the Michelson interferometer (6 marks)

ii) Describe the features of the Michelson interferometer and explain how it works (6 marks)

b) Derive the expression for Bohr total energy of the atom and for Bohr radius (8 marks)

QUESTION THREE (20 MARKS)

a) A relativistic particle of mass *m* moving with a velocity *v* is acted upon by a constant force F which is parallel to *v*.

i. Show that its acceleration is given by

$$a = \frac{F}{m}\left(1 - {v^2}/{c^2}\right)^{3/2}$$ (6 marks)

ii. An electron in a free space is accelerated at 3.24 x $10^{12} m/s^2$ by a force of 2.5 x $10^{24}\ N$. Calculate its speed

(4 marks)

b) Show that the time difference between horizontal and vertical beams is

$\Delta t \approx \frac{LV^2}{C^3}$, where symbols have their usual meanings (10 marks)

QUESTION FOUR (20 MARKS)

a) Using a well drawn and described experiment, explain the concept of time dilation and show that $\Delta t = \gamma \Delta t_p$ (12 marks)

b) A space ship of mass 1.0 x 10^6 kg is to be accelerated to 0.6c.

i) how much energy does this require ? (4 marks)

ii) how many kilograms of matter would it take to provide this much energy?

(4 marks)

QUESTION FIVE (20 MARKS)

a) Astridon, a girl sets out to investigate some distant star like objects called *quarsars* 8 light years from the earth at a speed of 0.97c and leaves her twin sister Eartha behind who is just aged 18 years. On reaching there, she is repulsed by alien creatures and returns immediately. Find how old Eartha is when they reunite. (6 marks)

b) Show that if proper length of an object is L_p and moving with speed of v in a direction parallel to its length, it contracts to $L = \frac{L_P}{\gamma}$, where symbols have their usual meanings

(6 marks)

c) A spaceship flies by an observer with a speed of 0.99c. If its rest length is 60 m what does the observer measure as it bypasses her? (4 marks)

d) A deuteron contains one proton and one neutron and has a mass of 2.013553u. Calculate the mass difference between the deuteron and the sum of masses of proton and neutron and determine its binding energy. (4 marks)