MACHAKOS UNIVERSITY

University Examinations for 2021/2022 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCE

SECOND YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR SCIENCE (TELECOMMUNICATION AND INFORMATION TECHNOLOGY)

BACHELOR SCIENCE (APPLIED PHYSICS AND TECHNOLOLOGY

BACHELOR OF SCIENCE (MATHEMATICS)

BACHELOR EDUCATION (SCIENCE)

SPH 202: MODERN PHYSICS

DATE: 14/12/2021 **TIME: 8:30 – 10:30 AM**

INSTRUCTIONS:

- 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 (COMPULSORY)

QUESTION ONE (30 MARKS)

a) Define the term event horizon relative to black holes (2 marks)

b) Black holes are thought to be gateways to other worlds.
   i. Explain what is a black hole
   ii. How a black hole is formed
   iii. Why it is called a black hole (6 marks)

c) Distinguish a white dwarf and a dwarf planet (4 marks)

d) Neutrinos are ghostly sub atomic particles.
   i. Explain their origin
   ii. They come in three flavors, name the flavors
   iii. They change flavor as they travel, give the reason. (3 marks)

e) Calculate the momentum of a relativistic particle travelling with a speed v = 0.95c m/s (3 marks)

f) Convert 8.4 MeV into joules (3 marks)

g) A relativistic particle is measured to possess a de Broglie wavelength of 2.3 x $10^{-16}m$. Calculate its kinetic energy in eV (4 marks)

h) The standing wave model of the atom suggested that, electrons orbiting the nucleus act like particles as well as waves of energy. With a diagram describe the standing wave model of the atom for C = 2λ and C = 4λ, where C stand for circumference (3 marks)

QUESTION TWO (20 MARKS)

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

b) 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)

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 bypass her? (3 marks)

d) 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? (4 marks)

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

QUESTION THREE (20 MARKS)

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

b) 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)

c) Show that in a hydrogen atom the

i) Relationship between mass of an electron and its velocity is given by

$$m = \frac{e^2}{4\pi\varepsilon_o r v^2}$$ (5 marks)

ii) Radial distance of an electron from the nucleus is

$$r = -\frac{e^2 E^{-1}}{8\pi\varepsilon_o r}$$ (5 marks)

QUESTION FOUR (20 MARKS)

a) A space ship of mass 2.0 x 10^6 kg is to be accelerated to 0.96c.

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)

b) Show $a = \frac{F}{m}\left(1 - \frac{v^2}{c^2}\right)^{\frac{3}{2}}$ (12 marks)

QUESTION FIVE (20 MARKS)

a) Sketch a graph of atomic number (Z) against neutron number (N), and use the sketch to explain nuclear stability (4 marks)

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

c) Differentiate between nuclear fission and nuclear fusion. Hence explain why nuclear fusion hasn't been exploited in production of energy. (6 marks)

d) 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)