



MAASAI MARA UNIVERSITY

SUPPLEMENTARY/SPECIAL EXAMINATIONS 2018/2019 ACADEMIC YEAR SECOND YEAR SECOND SEMESTER

SCHOOL OF SCIENCE BACHELOR OF SCIENCE

**COURSE CODE: PHY 212
COURSE TITLE: MODERN PHYSICS1**

**DATE: 24.4.2019
10.30AM**

TIME: 8.30AM -

INSTRUCTIONS TO CANDIDATES

1. Answer Question **ONE** and any other **two** questions
2. *Question one carries 30 marks while each of the others carries 20 marks*

3. Credit will be awarded for clear explanations and illustrations.

This paper consists of 5 printed pages. Please turn over.

Physical constants

Electron charge = $1.6 \times 10^{-19}\text{C}$; proton charge = $+1.6 \times 10^{-19}\text{C}$

Mass of electron $m_e = 9.11 \times 10^{-31}\text{kg}$

Speed of light $c = 3.0 \times 10^8 \text{ m/s}$; Avogadro constant $N_a = 6.023 \times 10^{23} /\text{mol}$

Planck's constant $h = 6.63 \times 10^{-34}\text{Js}$; Stefan constant $\sigma = 5.670 \times 10^{-8}\text{wm}^{-2}\text{k}^{-4}$

Rydberg constant, $R_{hc} = 1.097 \times 10^7\text{m}^{-1}$; Mass of proton $M_p = 1.67 \times 10^{-27}\text{kg}$

Rest energy of electron $E_e = 0.511\text{MeV}$; one atomic mass unit, $u = 1.66 \times 10^{-27}\text{kg}$

One electron volt, $1\text{eV} = 1.60 \times 10^{-19}\text{J}$; mass of neutron $m_n = 1.675 \times 10^{-27}\text{kg}$

1 curie = $3.7 \times 10^{10}\text{decay/s}$; a.m.u = 931.5MeV

QUESTION ONE (30MKS)

a. State the two postulates of relativity

(2mks)

b. Assuming that the tungsten filament of a bulb is a blackbody, determine its peak wavelength if its temperature is 2900K

(3mks)

c. Show that for $v \ll c$, relativistic kinetic energy

$$K = \frac{mC^2}{\sqrt{1 - \frac{U^2}{C^2}}} - mc^2 \quad \text{reduces to} \quad \frac{1}{2}mu^2$$

(4mks)

d. X-rays of wavelength $\lambda_0 = 0.200 \text{ 000nm}$ are scattered from a block of material. The scattered x-rays are observed at an angle of 45° to the incident beam

i. Calculate the wavelength of the x-rays scattered at this angle

(3mks)

ii. Compute the fractional change in the energy of a photon in the collision

(4mks)

e. The speed of an electron is measured to be $5.00 \times 10^3 \text{ m/s}$ to an accuracy of 0.003%. Find the minimum uncertainty in determining the position of this electron

(4mks)

f. (i) Define the term binding energy
(2mks)

(ii) Calculate the deuteron's binding energy in MeV, if it consists of a proton and a neutron, ($m_d = 2.014102u$, $m_p = 1.007825u$ and $m_n = 1.008665u$)

(3mks)

g. State Bohr's correspondence principle
(2mks)

h. Briefly explain the Ultraviolet catastrophe
(3mks)

QUESTION TWO (20MKS)

a. Explain briefly the following:

i. Heisenberg energy -time uncertainty principle
(3mks)

ii. De Broglie wavelength
(3mks)

b. Explain why wave properties of a baseball are not observable

(3mks)

c. The Balmer series for the hydrogen atom corresponds to the electronic transitions that terminate in the state with quantum number $n=2$

i. Find the longest wavelength photon emitted in the Balmer series and determine its frequency and energy

(6mks)

ii. Find the shortest wavelength photon emitted in the same series

(2marks)

d. State three failures of the Bohr model of atom

(3mks)

QUESTION THREE (20MKS)

a. State three consequences of relativity

(3mks)

b. State TWO reasons why modern Physics is studied.

(2mks)

c. A sodium surface is illuminated with light of wavelength $0.300\mu\text{m}$. the work function for sodium is 2.46eV . Calculate:

i. The energy of each photon in electron volts

(3mks)

ii. The maximum kinetic energy of the ejected photoelectron

(2mks)

iii. The cut-off wavelength for sodium

(2mks)

- d. Starting from definition of relativistic momentum , $F = \frac{dp}{dt}$
show that relative kinetic energy is expressed as

$$K = \frac{mc^2}{\sqrt{1 - \frac{u^2}{c^2}}} - mc^2 \quad \text{(8mks)}$$

QUESTION FOUR (20MKS)

- a. Explain briefly the following:

i. Pauli exclusion principle

(2mks)

ii. Nuclear fusion

(2mks)

iii. Nuclear fission

(2mks)

- b. The half life of the radioactive nucleus ${}^{226}_{88}\text{Ra}$ is 1.6×10^3 year. If a sample initially contains 3.00×10^{16} such nuclei, determine;

i. The initial activity in curies

(4mks)

ii. The number of radium nuclei remaining after 4.8×10^3 year

(3marks)

iii. The activity at this later time

(2mks)

- c. Determine whether the following reaction can occur based on the law of conservation of baryon number $p+n \rightarrow p+p+n+\dot{p}$

(2mks)

- d. If the spacing between certain planes in a crystal of calcite is 0.314nm; find the grazing angle at which the third order interference will occur for x-rays of wavelength 0.0700nm

(3mks)

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