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QUALIFICATION : **BACHELOR OF SCIENCE**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **6**
COURSE: **MODERN PHYSICS**	COURSE CODE: **MPH602S**
DATE: **NOVEMBER 2024**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

FIRST OPPORTUNITY: EXAMINATION QUESTION PAPER

EXAMINER: **PROF SYLVANUS ONJEFU**

MODERATOR: **PROF DIPTI SAHU**

INSTRUCTIONS:

1. Answer all questions on the separate answer sheet.
2. Please write neatly and legibly.
3. Do not use the left-side margin of the exam paper. This must be allowed for the examiner.
4. No books, notes and other additional aids are allowed.
5. Mark all answers clearly with their respective question numbers.

PERMISSIBLE MATERIALS

1. Non-Programmable Calculator

ATTACHMENTS

1. None

This paper consists of 4 pages including the front page

Physical Constant

Electron mass	$m_e = 9.11 \times 10^{-31}$ kg
Proton mass	$mp = 1.6736 \times 10^{-27}$ kg
Planck constant	$h = 6.625 \times 10^{-34}$ J
Speed of light	$c = 3 \times 10^{8}$ m/s
1eV	1.6×10^{-19}

QUESTION 1 **[22 MARKS]**

1.1 A radioactive element has 3.0×10^6 atoms and the decay constant = $5.4 \times 10^{-7} s^{-1}$. Calculate (a) its half-life (b) the rate of disintegration (c) average life. (6)

1.2 When a nucleus of $^{228}_{88}$Ra emits
(i) alpha particle (ii) beta particle (iii) gamma ray (iv) neutron. What is the resulting nucleus in each case? (8)

1.3 Assuming that photon obeys plank's energy rule. At what frequency will photons have the following energies (a) 0.010 eV and (b) 3.0 eV. In each case, determine the wavelength in micrometers. (8)

QUESTION 2 **[16 MARKS]**

2.1 Explain how band spectra is obtained in an atom. (2)

2.2 When light of wavelength 450 nm is incident on a certain metal, electrons are emitted with kinetic energies up to 2.0 eV.

2.2.1 What is the work function of the metals? (4)

2.2.2 What is the minimum frequency needed to emit any photoelectrons? (4)

2.4 An electron falls from rest through a potential difference of 100 V. What is its de Broglie wavelength? (6)
The KE gained $1/2mv^2$ is equal to the electrical PE lost Vq. Therefore,

QUESTION 3 **[20 MARKS]**

3.1 Determine the de Broglie wavelength for a particle moving with a speed 2.0×10^{6} m/s if the particle is;

3.1.1 a 0.20 kg. (5)

3.1.2 an electron. (5)

3.1.3 a proton. (5)

3.2 Explain a blackbody and a blackbody radiation. (5)

QUESTION 4 **[20 MARKS]**

4.1 Using **Compton Effect**: X-rays of wavelength 0.140 nm are scattered from a thin slice of carbon. What will be the wavelengths of X-rays scattered at;

4.1.1 0^{o} (3)

4.1.2 90^{o} (3)

4.1.3 180^{o} (3)

4.2 What wavelength does a hydrogen atom emit as its excited electron falls from the $n = 5$ state to the $n=2$ state? Answer to three significant figures. (7)

4.3 Compute the energy of a photon of blue light of wavelength 450 nm. Give your answer in electron volt. (4)

QUESTION 5 **[22 MARKS]**

5.1 State one important idea that Plank used in other to obtain the correct spectral distribution for the blackbody radiation. Write down the Plank spectra distribution law in frequency space. (4)

5.2 Explain the Pauli Exclusion Principle. (3)

5.3 Using Pauli Exclusion Principle determine the quantum numbers for the electrons in the lithium atom (Z = 3) when the atom is in its ground state. (6)

5.4 Show the expression for one-dimensional Schrodinger equation for a particle with a definite energy E. (3)

5.5 Consider the wave function $\psi(x) = A_1 e^{ikx} + A_2 e^{-ikx}$, where k is positive. What is the energy? Is this a valid stationary-state function for a free particle? (6)

END OF EXAMINATION QUESTION PAPER