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QUALIFICATION : **BACHELOR OF SCIENCE**	
QUALIFICATION CODE: **07BOSC**	LEVEL: **6**
COURSE: **MODERN PHYSICS**	COURSE CODE: **MPH602S**
DATE: **JANUARY 2025**	SESSION: **1**
DURATION: **3 HOURS**	MARKS: **100**

SECOND OPPORTUNITY / SUPPLEMENTARY: 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 3 pages including the front page

Physical Constant

Electron mass	$m_e = 9.11 \times 10^{-31}$ kg
Proton mass	$m_p = 1.6736 \times 10^{-27}$ 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 **[20 MARKS]**

1.1 Calculate the values of a and b from the equation below

$$^{23}_{11}\text{Na} + ^{1}_{1}\text{H} \rightarrow ^{a}_{b}\text{Z} + ^{4}_{2}\text{He}$$ (5)

1.2 Determine the de Broglie wavelength of electrons with a velocity of 1.0×10^{3} m/s. (6)

1.3 Electrons are moving with a velocity of 4.0×10^{6} m/s.

1.3.1 What is the de Broglie wavelength of the electrons? (5)

1.3.2 If these electrons had started from rest, through what potential difference would they have had to be accelerated to attain the velocity? (4)

QUESTION 2 **[26 MARKS]**

2.1 Explain the ground state of an atom. (3)

2.2 Calculate the energy of the ground state and 1st excited state of the hydrogen atom. (4)

2.3 Calculate the frequency and wavelength of the photon emitted when an electron makes a quantum jump from the n = 3 state to the ground state of the hydrogen atom. [Take $h = 6.6 \times 10^{-34}$ Js; $c = 3.00 \times 10^{8}$]. (9)

2.4 Determine the wavelength of an electron in meters that has been accelerated through a potential difference of 100 V. (6)

2.5 Calculate the de Broglie wavelength of a 0.20 kg ball moving with a speed of 15 m/s.

(4)

QUESTION 3 **[20 MARKS]**

3.1 Explain the Heisenberg uncertainty principle. (3)

3.2 A electron moves in a straight line with a constant speed v = 1.10 x 10^{6} m/s which has been measured to a precision of 0.10%. What is the maximum precision with which its position could be simultaneously measured? [Take $\hbar$ = 1.06 x 10^{-34}]. (10)

3.3 A radioactive material has a half-life of 10 hours. What fraction of the original radioactive nuclei will remain after 30 hours? (7)

QUESTION 4 **[21 MARKS]**

4.1 Using Pauli Exclusion Principle, explain and show why sodium (Z = 11) is the next univalent atom after lithium. (10)

4.2 Using Balmer series determine the wavelength of light emitted when a hydrogen atom makes a transition from the n= 6 to the n= 2 energy level according to the Bohr model. [Take Rydberg constant, R= 1.0974 X $10^{7}m^{-1}$]. (6)

4.3 Explain Zeeman Effect and state what does the effect confirms. (5)

QUESTION 5 **[13 MARKS]**

5.1 Show the expression of a wave function of a particle in a state of definite energy. (4)

5.2 Showed that the ratio of the number of atoms disintegrating per unit time to the number of atoms in the source at that time is equal to a decay constant λ. Also show that $N = N_0 e^{-\lambda t}$ where all symbols have their usual meaning. (9)

END OF EXAMINATION QUESTION PAPER