S5 PHYSICS II

March, 2024

8:30 AM – 11:30 AM

NYAGATARE DISTRICT

ADVANCED LEVEL DISTRICT EXAMINATION, TERM II 2024

SUBJECT: PHYSICS

PAPER II: THEORY

COMBINATIONS:

- PHYSICS-CHEMISTRY-MATHEMATICS **(PCM)**
- MATHEMATICS-PHYSICS-COMPUTER SCIENCE **(MPC)**
- PHYSICS-CHEMISTRY-BIOLOGY **(PCB)**
- MATHEMATICS-PHYSICS-GEOGRAPHY **(MPG)**

DURATION: 3HOURS

TOTAL MARKS: 100

INSTRUCTIONS:

This paper consists of two sections **A** and **B**

1. **Section A:** this section is compulsory. **(55marks)**
2. **Section B:** answer **any three** questions. **(45marks)**
3. Non-programmable scientific calculators, Periodic table of elements and student geometrics instruments (mathematical set) may be used

Useful constants

$1eV=1.6\times10^{-19}J$; $h=6.63\times10^{-34}J.s$; Speed of light $c=3\times10^{8}m/s$; mass of electron $m_e=9.1\times10^{-31}kg$; $g=9.8m/s^2$; Charge of electron $e=1.6\times10^{-19}C$, gravitational constant $G=6.67\times10^{-11}Nm^2kg^{-2}$, coulomb's constant $k= 9\times10^{9}\ Nm^2c^{-2}$

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SECTION A: Attempt all questions (55marks)

1. Choose the correct answer (3mark

a) According to the modern theory of nature of light, the light has
   i) wave nature only
   ii) particle nature only
   iii) both wave and particle (dual) nature
   iv) neither particle nature nor wave nature.

b) The dual nature of light is exhibited by
   i) diffraction and photoelectric effect
   ii) photoelectric effect
   iii) Polarization and interference
   iv) Compton effect and photoelectric effect

c) The wavelength of light beam A is twice the wavelength of light beam B. The energy of a photon in beam A is
   i) half the energy of a photon in beam B
   ii) one-fourth the energy of a photon in beam B
   iii) equal to the energy of a photon in beam B
   iv) twice the energy of a photon in beam B

2. Hydrogen has a red emission line at 656.3 nm, what is the energy and frequency of photon of this light? **(3marks)**

3. (a) Define simple harmonic motion. **(1mark)**

(b) Sketch a graph of (not to scale)
   i) Velocity against displacement **(1mark)**
   ii) Acceleration against displacement for a body executing S. H.M. **(1mark)**

4. a) State any one factor that influences the period of a simple pendulum. **(1mark)**

b) A geologist uses a simple pendulum that has a length of 37.10 cm and a frequency of 0.8190 Hz at a particular location on the Earth. What is the acceleration due to gravity at this location? **(2marks)**

5. a) What are damped oscillations, and how do they differ from un-damped oscillations? **(2marks)**

b) A car's suspension system is designed to exhibit damped oscillations. Explain why damping is necessary in a car's suspension system and how it improves the ride comfort and stability of the vehicle. **(2marks)**

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6. Choose the best answer for the following questions, **(5marks)**

a) characterizes damped oscillations in a mechanical system?
   i) Constant amplitude over time
   ii) Decreasing amplitude over time
   iii) Increasing frequency over time
   iv) Conserved energy over time

b) Which of the following is an example of forced oscillation?
   i) Swinging pendulum
   ii) Vibrating guitar string
   iii) Car suspension system
   iv) Ticking clock

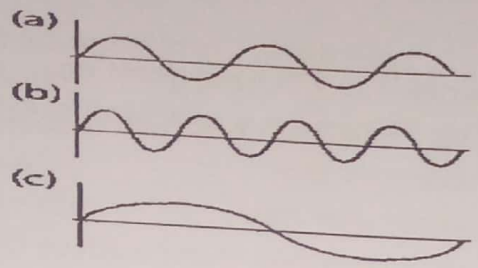
c) In a damped harmonic oscillator, what effect does increasing damping have on the natural frequency of the system?
   i) Increases the natural frequency
   ii) Decreases the natural frequency
   iii) No effect on the natural frequency
   iv) Causes the system to stop oscillating

d) What phenomenon occurs when the frequency of an external force matches the natural frequency of a system?
   i) Damping
   ii) Resonance
   iii) Forced oscillation
   iv) Harmonic motion

e) Which of the following statements about resonance is true?
   i) Resonance occurs only in undamped systems
   ii) Resonance always leads to a decrease in amplitude
   iii) Resonance can lead to catastrophic failure in mechanical systems
   iv) Resonance occurs when the driving frequency matches the natural frequency of the system

7. Three waves of frequencies **fa**, **fb** and **fc** the corresponding wavelengths $\lambda a, \lambda b, and\ \lambda c$ respectively are shown in the figure below

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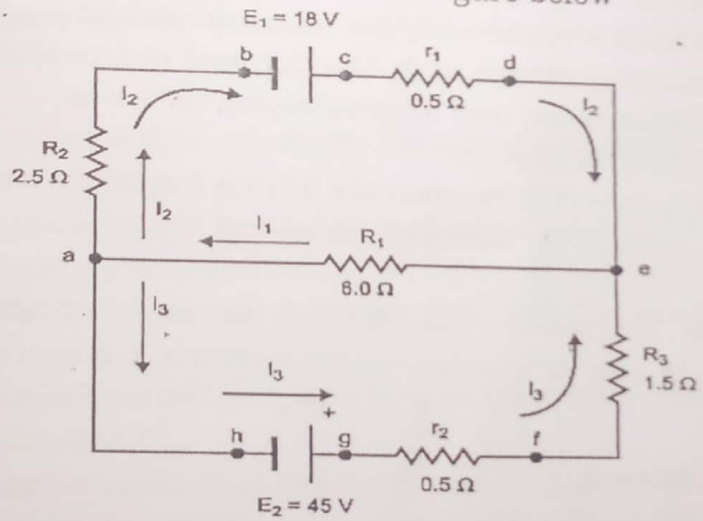
Write down

a) The frequencies **fa**, **fb** and **fc** in ascending order **(1mark)**
b) The wavelengths $\lambda a, \lambda b, and\ \lambda c$ in ascending order **(1mark)**

8. A travelling wave is described by following the equation y (x, t) = 0.003 cos (20x +200t) where y and x are measured in meters and t in seconds. Calculate the following physical quantities:

a) Angular wave number **(1mark)**
b) Wavelength **(1mark)**
c) Frequency **(1mark)**
d) The wave speed **(1mark)**
e) What is the direction in which the wave is travelling? **(1mark)**

9. a) State the Kirchhoff's junction rule **(1mark)**
b) Using Kirchhoff's voltage rule, formulate any two voltage equations from the circuit shown in the figure below **(2marks)**



10. A DC potentiometer uses a slide wire of 800 mm . A stand cell of emf 1.18 V obtains a balance point of 600 mm. A test cell is seen to obtain a balance length 660 mm. Find:

a) The potential gradient (voltage per length) of the potentimeter **(2marks)**
b) The emf of the test charge **(1mark)**

11. a) Give one example of energy source which is non-renewable and is a non-fossil fuel **(1mark)**
b) Differentiate between controlled nuclear fission and uncontrolled nuclear fission **(2marks)**

12. a) What do you understand by the term equipotential surfaces? **(1mark)**
b) An electron of charge is situated in a uniform electric field of intensity or field strength of 120000 V/m. Find the
i) force on it, **(2mark)**
ii) its acceleration, and **(2marks)**
iii) the time it takes to travel 20 mm from rest (electron mass) **(2marks)**

13. a) State the principle of superposition as applied to electric field. **(1mark)**
b)
i) What is the electric flux through a sphere that has a radius of 1.00 m and carries a charge of + 1.00 μC at its center? **(1mark)**
ii) What would be the electric field? **(1mark)**
iii) what would be the electric flux through the sphere if it had a radius of 0.500m? **(1mark)**

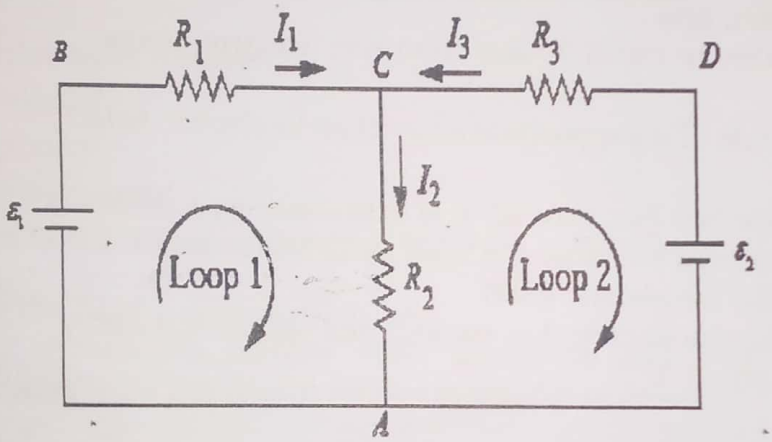
14. State the Kepler's three laws of planetary motion **(3marks)**
15. a) What do you understand by the term "Escape Velocity" as applied to motion in orbits? **(1mark)**
b) The escape velocity for a body at earth's surface is 11.2 km /s. If mass of Jupiter is 318 times that of Earth and its radius is 11.2 times that of Earth, then Estimate the escape velocity of a body from Jupiter's surface **(3marks)**

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SECTION B: attempt any three questions(45marks)

16. a) A battery is composed by 120 cells in series. Each element has an emf of 2V and an internal resistance of 0.001Ω. The combination is connected to an external resistance of 4.8Ω. Calculate:
    i) The intensity of the current in the circuit. **(2marks)**
    ii) The voltage at terminals of the battery. **(3marks)**
    iii) The energy dissipated by joule effect when the current flows in the circuit in one hour. **(3marks)**

    b) In the circuit shown in figure below, $\varepsilon_1 = 20V$, $R_1 = 8\Omega$, $R_2 = 4\Omega$, $R_3 = 5\Omega$ and the current $I_2 = 3A$. Find:
    i) The currents I_1 and I_3 respectively passing through the resistors R_1 and R_3. **(4marks)**
    ii) The value of ε_2. **(3marks)**



17. A 200g block connected to a light spring for which the force constant is 5N/m is free to oscillate on a horizontal, frictionless surface. The block is displayed 5cm from equilibrium and released from rest and started to oscillate in simple harmonic motion.
    a) Find the period of its motion. **(2marks)**
    b) Determine the maximum speed of the block. **(2marks)**
    c) What is the maximum acceleration of the block? **(2marks)**
    d) Calculate the total mechanical energy of the system. **(3marks)**
    e) Express the following as the functions of time.
    i) The displacement. **(2marks)**
    ii) Speed **(2marks)**
    iii) Acceleration **(2marks)**

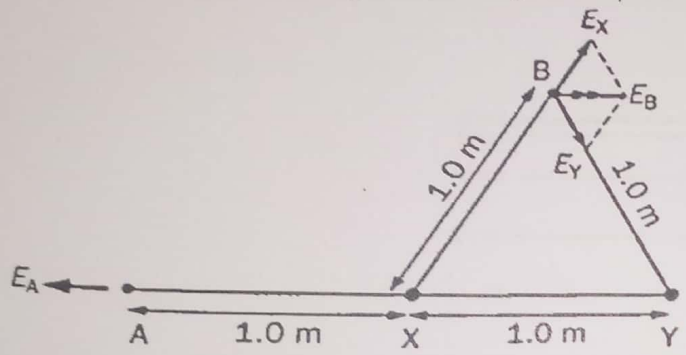
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18. a) An electron enters the region of a uniform electric field, with $v_{0x} = 3 \times 10^{6} m/s$ and E =200 N/C. Mass of electron m= 9.11×10^{-31} kg. The horizontal length of the plates is 0.100 m.

i) Find the acceleration of the electron while it is in the electric field. **(3marks)**

ii) If the electron enters the field at time t =0, find the time at which it leaves the field. **(3marks)**

b) The figure below shows two small spheres X and Y, 1m apart in air and carrying charges of $+2 \times 10^{-8}$c and -2×10^{-8}c respectively. Assume the permittivity of air is ε_o and $1/4\pi\varepsilon_o = 9 \times 10^{9} Nm^2c^{-2}$.



Find:

(i) The potential at points A and B and

(ii) The field strength at points A and B due to small spheres X and Y. **(4marks)** **(5marks)**

19. a) The Earth may be considered to be a uniform sphere with its mass M concentrated at its center. A satellite of mass m orbits the Earth such that the radius of the circular orbit is r.

i. Show that the linear speed v of the satellite is given by the expression $v = \sqrt{\frac{GM}{r}}$ where G is the universal gravitational constant. **(4marks)**

ii. For this satellite write down expression in term of G, M, m and r for its kinetic energy. **(2marks)**

b) i) The Earth and the Moon may be considered to be isolated in space with their masses concentrated at their centers. The orbit of the Moon around the Erath is circular with a radius of 3.84×10^{5} km. The period of the orbit is 27.3 days and the universal gravitational constant G = 6.67×10^{-11} N m^2 kg^{-2}. Show that:

1) the angular speed of the Moon in its orbit around the Earth is 2.66×10^{-6} rad/s. **(3ma. (3mark.**

2) The mass of the Earth $M = 6.0 \times 10^{24}$ kg

ii) The mass of the Moon is 7.4×10^{22} kg

Using data from i) ,determine the gravitational force between the Earth and its Moon **(3marks)**

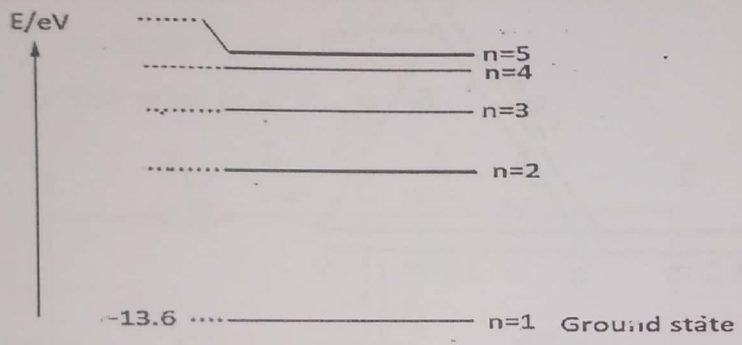
20. a) State the postulates of Bohr's atomic model **(3marks)**

b) What will happen if an electron in the ground state gains energy **(1mark)**

c) Distinguish between photoelectric effect and thermionic emission **(1mark)**

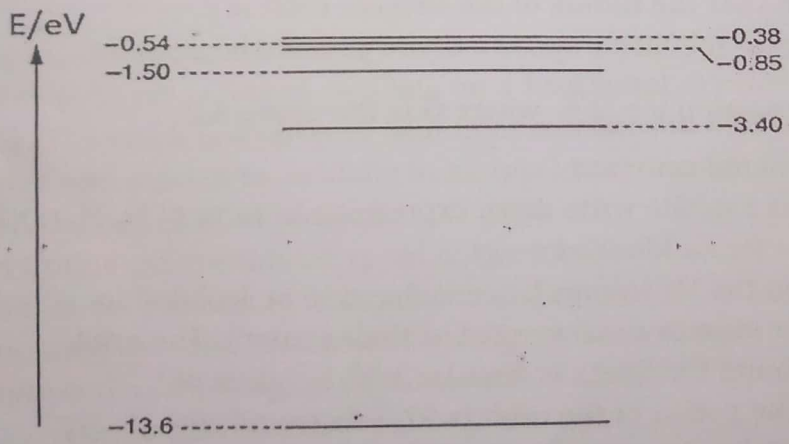
d) State the properties of cathode rays **(3marks)**

e) The 5 lowest energy levels in an isolated hydrogen atom are shown in the figure below



A photon is emitted as an atom of Hydrogen makes a transition from n = 4 to n = 2 level. Find the frequency of the emitted photon. **(2marks)**

f) The lowest electron energy levels in an isolated hydrogen atom are shown in the figure below.



State the total number of different wavelengths that may be emitted as the electron de-excites (loses energy).

(1mark)

An electron is initially at the energy level -0.85Ev.

g) The stopping potential when a frequency of 1.61×10^{15} Hz is incident on a metal is 3 V.

i) What is energy transferred by each photon? **(2marks)**

ii) What is the maximum speed of the ejected electrons? **(2marks)**

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