PHYSICS

PAPER – 1

(THEORY)

(Three hours)

(Candidates are allowed additional 15 minutes for only reading the paper.
They must NOT start writing during this time.)

Answer **all** *questions in* ***Part I*** *and* ***six*** *questions from* ***Part II****, choosing* **two** *questions from* **each** *of the Sections* ***A, B*** *and* ***C****.*

All working, including rough work, should be done on the same sheet as, and adjacent to, the rest of the answer.

The intended marks for questions or parts of questions are given in brackets [ ].

(Material to be supplied: Log tables including Trigonometric functions)

A list of useful physical constants is given at the end of this paper.

PART I (20 Marks)

Answer **all** *questions.*

Question 1

A. Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below: [5]

(i) Relative permittivity of water is 81. If ϵ_w and ϵ_o are permittivities of water and vacuum respectively, then:

(a) $\epsilon_o = 9\epsilon_w$

(b) $\epsilon_o = 81\epsilon_w$

(c) $\epsilon_w = 9\epsilon_o$

(d) $\epsilon_w = 81\epsilon_o$

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(ii) Five resistors are connected as shown in ***Figure 1.***

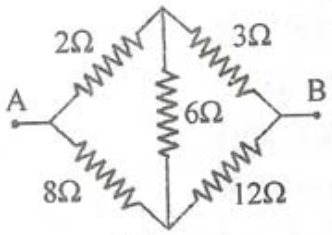

Figure 1

The effective resistance i.e. equivalent resistance between the points A and B is:

(a) 4 Ω

(b) 5 Ω

(c) 15 Ω

(d) 20 Ω

(iii) The **Biot Savart's** Law in **vector** form is:

(a) $\overrightarrow{\delta B} = \frac{\mu_o}{4\pi} \frac{dl\left(\vec{I} \times \vec{r}\right)}{r^3}$

(b) $\overrightarrow{\delta B} = \frac{\mu_o}{4\pi} \frac{I\left(\overrightarrow{dl} \times \vec{r}\right)}{r^3}$

(c) $\overrightarrow{\delta B} = \frac{\mu_o}{4\pi} \frac{I\left(\vec{r} \times \overrightarrow{dl}\right)}{r^3}$

(d) $\overrightarrow{\delta B} = \frac{\mu_o}{4\pi} \frac{I\left(\overrightarrow{dl} \times \vec{r}\right)}{r^2}$

(iv) In an astronomical telescope of refracting type:

(a) Eyepiece has greater focal length.

(b) Objective has greater focal length.

(c) Objective and eyepiece have equal focal length.

(d) Eyepiece has greater aperature than the objective.

(v) The particles which cannot be accelerated by a **cyclotron** or a **Van de Graff** generator are:

(a) Alpha particles

(b) Beta particles

(c) Neutrons

(d) Protons

B. Answer **all** questions given below briefly and to the point: **[15]**

(i) A large hollow metallic sphere has a positive charge of $35{\cdot}4\,\mu C$ at its centre. Find how much **electric flux** emanates from the sphere.

(ii) A current 'I' flows through a metallic wire of radius 'r' and the free electrons in it drift with a velocity v_d. Calculate the drift velocity of the free electrons through the wire of the **same material**, having double the radius , when **same** current flows through it.

(iii) Name **any one** instrument which works on the principle of **tangent law** in magnetism.

(iv) State the SI unit of **magnetic dipole moment.**

(v) Alternating current flowing through a certain electrical device leads over the potential difference across it by 90°. State whether this device is a **resistor, capacitor** or an **inductor.**

(vi) What is the shape of the wavefront diverging from a **point source of light?**

(vii) The critical angle for a given transparent medium and air is i_c . A ray of light travelling in air is incident on this transparent medium at an angle of incidence equal to the polarising angle i_p . What is the relation between the two angles i_c and i_p ?

(viii) Find the **focal length** and **nature** of a lens whose optical power is – 5D.

(ix) What is **Modulation**? Explain in brief.

(x) What are the **dark lines** seen in the **solar spectrum** called?

(xi) What is the relation between **wavelength** and **momentum** of moving particles?

(xii) Name the series of lines in the hydrogen spectrum which lies in the **ultra-violet** region.

(xiii) Fill in the blank in the given nuclear reaction:

$$\text{\_\_\_\_\_} + {}^{27}_{13}\text{Al} \rightarrow {}^{25}_{12}\text{Mg} + {}^{4}_{2}\text{He}$$

(xiv) Give an example where energy is converted into matter.

(xv) To convert a pure semiconductor into ***n***-type semiconductor, what type of impurity is added to it?

PART II (50 Marks)

Answer **six** *questions in this part, choosing* **two** *questions*

from ***each*** *of the Sections* ***A, B*** *and* ***C.***

SECTION A

Answer any **two** *questions.*

Question 2

(a) (i) Write an expression (**derivation not required**) for intensity of electric field in: **[3]**

(1) Axial position.

(2) Broad side position of an electric dipole, in terms of its length (2a) dipole moment (p) and distance (r).

(ii) What is the ratio of these two intensities i.e. $E_1 : E_2$, for a **short** electric dipole?

(b) Three capacitors $C_1 = 6\,\mu F$, $C_2 = 12\,\mu F$ and $C_3 = 20\,\mu F$ are connected to a 100 V battery, as shown in ***Figure 2*** below: **[3]**

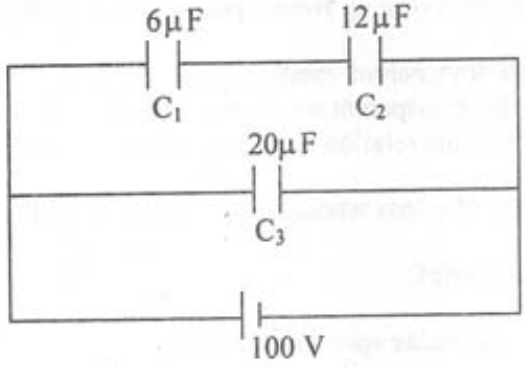

Figure 2

Calculate:

(i) Charge on each plate of capacitor C_1

(ii) Electrostatic potential energy stored in capacitor C_3.

(c) 'n' cells, each of emf 'e' and internal resistance 'r' are joined in series to form a row. 'm' such rows are connected in parallel to form a battery of N = mn cells. This battery is connected to an external resistance 'R'. **[3]**

(i) What is the emf of this battery and how much is its internal resistance?

(ii) Show that current 'I' flowing through the external resistance 'R' is given by:

$$I = \frac{Ne}{mR + nr}$$

Question 3

(a) In the circuit shown in ***Figure 3***, $E_1 = 17$ V, $E_2 = 21$ V, $R_1 = 2\Omega$, $R_2 = 3\Omega$ and $R_3 = 5\Omega$. Using **Kirchoff's laws,** find the currents flowing through the resistors R_1, R_2 and R_3. (Internal resistance of each of the batteries is neglegible.) **[4]**

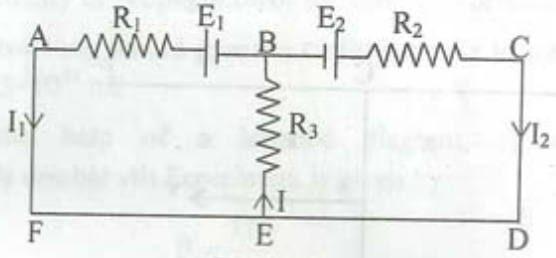

Figure 3

(b) You are provided with one low resistance R_L and one high resistance R_H and two galvanometers. One galvanometer is to be converted to an ammeter and the other to a voltmeter. Show how you will do this with the help of simple, labelled diagrams. **[2]**

(c) (i) Plot a labelled graph to show variation of thermo-emf 'e' versus temperature difference 'θ' between the two junctions of a thermocouple. Mark 'N' as **neutral temperature** and 'I' as **temperature of inversion.** **[3]**

(ii) What is **Peltier effect**?

Question 4

(a) ***Figure 4*** below shows two infinitely long and thin current carrying conductors X and Y kept in vacuum, parallel to each other, at a distance 'a'. **[2]**

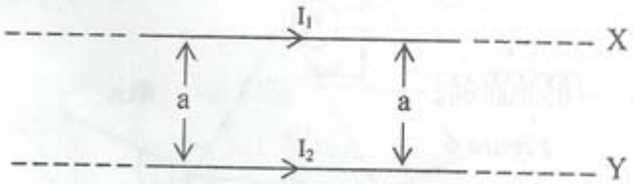

Figure 4

(i) How much force per unit length acts on the conductor Y due to the current flowing through X ? Write your answer in terms of $\left(\frac{\mu_o}{4\pi}\right)$, I_1, I_2, and a.

(Derivation of formula is not required.)

(ii) Define **ampere**, in terms of force between two current carrying conductors.

(b) A metallic rod CD rests on a thick metallic wire PQRS with arms PQ and RS parallel to each other, at a distance l = 40 cm, as shown in ***Figure 5***. A uniform magnetic field B = 0·1T acts perpendicular to the plane of this paper, pointing inwards (i.e. away from the reader). The rod is now made to slide towards right, with a constant velocity of $v = 5.0\ ms^{-1}$. [3]

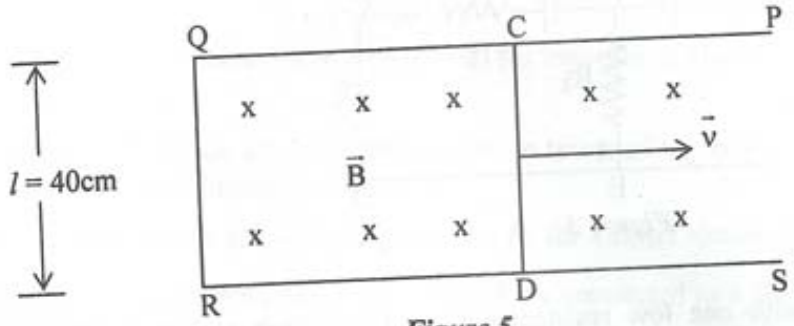

Figure 5

(i) How much emf is induced between the two ends of the rod CD ?

(ii) What is the direction in which the induced current flows?

(c) (i) ***Figure 6*** below shows a series **RCL** circuit connected to an ac source which generates an alternating emf of frequency 50 Hz. The readings of the voltmeters V_1 and V_2 are 80 V and 60 V respectively. [4]

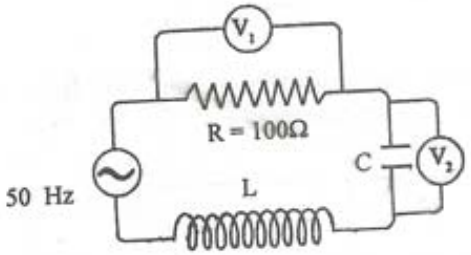

Figure 6

Find:

(1) the current in the circuit.

(2) the capacitance C of the capacitor.

(ii) At resonance, what is the relation between impedance of a series LCR circuit and its resistance R?

SECTION B

Answer any **two** *questions*

Question 5

(a) (i) In an electromagnetic wave, how are electric vector ($\vec{E}$), magnetic vector ($\vec{B}$) and velocity of propagation of the wave ($\vec{c}$) oriented? **[2]**

(ii) How long would **gamma radiation** take to travel from sun to earth, a distance of $1{\cdot}5\times10^{11}$ m?

(b) With the help of a labelled diagram, show that fringe separation β in **Young's double slit** experiment is given by: **[4]**

$$\beta = \frac{\lambda D}{d}$$

where the terms have their usual meaning.

(c) (i) What is the difference between **polarised** light and **unpolarised** light based on the direction of electric vector ($\vec{E}$)? **[2]**

(ii) What will be the effect on the **width** of the **central bright fringe** in the diffraction pattern of a single slit if:

(1) Monochromatic light of smaller wavelength is used.

(2) Slit is made narrower.

Question 6

(a) At what angle, a ray of light should be incident on the first face AB of a regular glass prism ABC so that the emergent ray grazes the adjacent face AC? **[3]**
See ***Figure 7*** below. (Refractive Index of glass = 1·6)

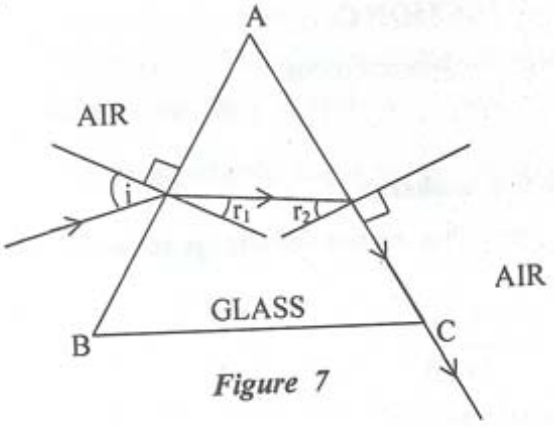

Figure 7

(b) A convex lens '**L**' and a plane mirror '**M**' are arranged as shown in ***Figure 8*** below. Position of object pin '**O**' is adjusted in such a way that the inverted image '**I**' formed by the lens mirror combination, coincides with the object pin '**O**'. Explain how and when this happens. [2]

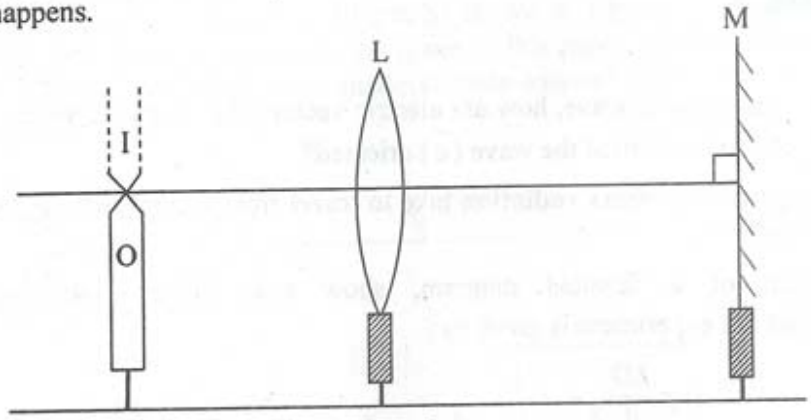

Figure 8

(c) Starting with an expression for refraction at a **single spherical surface**, obtain an expression for **lens maker's formula**. [3]

Question 7

(a) Show that the **axial chromatic aberration** $(f_r - f_v)$ for a convex lens is equal to the product of its mean focal length (f) and dispersive power (ω) of its material i.e. Prove: [3]

$$f_r - f_v = \omega f.$$

(b) Draw a labelled diagram of an image formed by a **compound microscope**, with the image at **least distance of distinct vision**. Write any one expression for its magnifying power. [3]

(c) What is meant by **long-sightedness?** How can this defect be corrected? [2]

SECTION C

Answer any **two** *questions.*

Question 8

(a) (i) What is meant by '**Quantization of charge**'? [3]

(ii) In Thomson's experiment, prove that the ratio of **charge to the mass** (e/m) of an electron is given by:

$$\frac{e}{m} = \frac{1}{2V}\cdot\frac{E^2}{B^2}$$

where the terms have their usual meaning.

(b) In a photo-electric cell, a retarding potential of 0·5V is required to block the movement of electrons from the cathode when monochromatic light of wavelength 400 nm is incident on its surface. Find the **work function** of the material of the cathode. [3]

(c) Name a **phenomenon** or an **experiment** which proves: [2]

(i) Particle nature of electro magnetic radiations.

(ii) Wave nature of particles.

(Description of the phenomenon / experiment is **not** required.)

Question 9

(a) (i) State the postulate of **Bohr's theory** regarding: [3]

(1) Angular momentum of an electron.

(2) Emission of a photon.

(ii) Total energy of an electron orbiting around the nucleus of an atom is always negative. What is the significance of this?

(b) (i) Draw a labelled graph showing variation of relative intensity of X-rays versus their wavelength λ. Mark λ_{min} on the graph. [3]

(ii) State how the value of λ_{min} can be varied.

(c) **Half life** of a certain radioactive substance is 6 hours. If you had 3·2 kg of this substance in the beginning, how much of it will disintegrate in one day? [2]

Question 10

(a) (i) What is the significance of **binding energy per nucleon** of a nucleus? [3]

(ii) In a certain star, three alpha particles undergo **fusion** in a single reaction to form $^{12}_{6}C$ nucleus. Calculate the energy released in this reaction in MeV.

Given : $m(^{4}_{2}He) = 4.002604$ u and $m(^{12}_{6}C) = 12.000000$ u.

(b) Show by drawing labelled diagrams, the nature of output voltages in case of: [3]

(i) A half wave rectifier.

(ii) A full wave rectifier.

(iii) An Amplifier.

(In each case, input is an ac voltage)

Circuit diagrams of these devices are not required.

(c) Identify the logic gate whose truth table is given below and draw its symbol:

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Useful Constants and Relations:

1.	Speed of Light in vacuum	(c)	$= 3{\cdot}00 \times 10^{8}\ ms^{-1}$
2.	Planck's constant	(h)	$= 6{\cdot}63 \times 10^{-34}\ Js$
3.	Charge of a proton	(e)	$= 1{\cdot}60 \times 10^{-19} C$
4.	Permittivity of vacuum	(ϵ_o)	$= 8{\cdot}85 \times 10^{-12}\ Fm^{-1}$
5.	Permeability of vacuum	(μ_o)	$= 4\pi \times 10^{-7}\ Hm^{-1}$
6.	Unified atomic mass unit	1u	= 931 MeV
7.		1nm	$= 10^{-9} m$