PHYSICS PAPER 1 (THEORY)

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) $\epsilon_w = 81\epsilon_o$

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

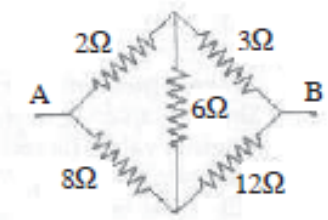

Figure 1

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

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

(c) $\overrightarrow{\delta B} = \frac{\mu_0}{4\pi} \frac{I(\vec{r} \times \vec{dl})}{r^3}$

(d) $\overrightarrow{\delta B} = \frac{\mu_0}{4\pi} \frac{I(\vec{dl} \times \vec{r})}{r^2}$

(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 35·4 μC 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:

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

(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 batttery, [3] as shown in *Figure 2* below:

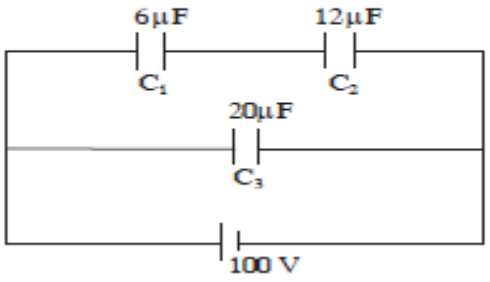

Figure 2

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. [3] 'm' such rows are connected in parallel to form a battery of N = mn cells. This battery is connected to an external resistance 'R'.

(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 negligible.) [4]

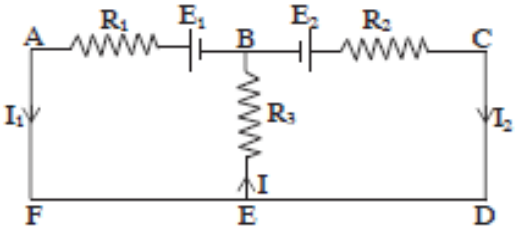

Figure 3

(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]

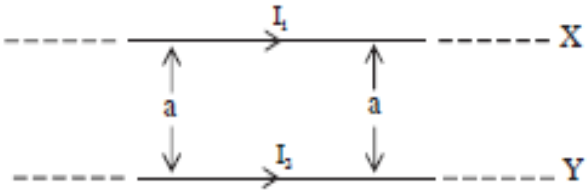

Figure 4

(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 $\left(\frac{\mu_0}{4\pi}\right)$, I_1, I_2, and a.

(Derivation of formula is not required.)

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

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)

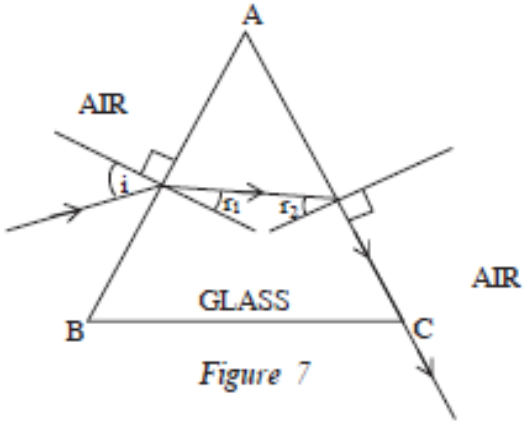

Figure 7

(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]

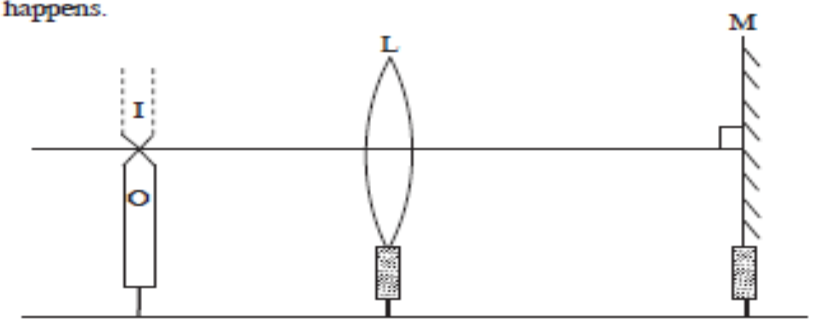

Figure 8

(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: [2]

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