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) Intensity of electric field at a point at a perpendicular distance 'r' from an infinite line charge, having linear charge density 'λ' is given by:

(a) $E = \left(\frac{1}{4\pi \epsilon_0}\right)\frac{\lambda}{r}$

(b) $E = \left(\frac{1}{4\pi \epsilon_0}\right)\frac{2\lambda}{r}$

(c) $E = \left(\frac{1}{4\pi \epsilon_0}\right)\frac{\lambda}{r^2}$

(d) $E = \left(\frac{1}{4\pi \epsilon_0}\right)\frac{2\lambda}{r^2}$

(ii) If R_1 and R_2 are filament resistances of a 200 W and a 100 W bulb respectively, designed to operate on the same voltage, then:

(a) $R_1 = R_2$

(b) $R_2 = 2R_1$

(c) $R_2 = 4R_1$

(d) $R_1 = 4R_2$

(iii) A metallic wire having length of 2 m and weight of 4×10^{-3} N is found to remain at rest in a uniform and transverse magnetic field of 2×10^{-4} T. Current flowing through the wire is:

(a) 10 A

(b) 5 A

(c) 2 A

(d) 1 A

(iv) When a beam of white light is passed through sodium vapours and then through a spectrometer, spectrum so obtained has two dark lines present in the yellow region. This spectrum is called:

(a) band spectrum

(b) continuous spectrum

(c) absorption spectrum of sodium

(d) emission spectrum of sodium

(v) If l_3 and l_2 represent angular momenta of an orbiting electron in III and II **Bohr** orbits respectively, then $l_3:l_2$ is:

(a) 3:2

(b) 9:4

(c) 2:3

(d) 4:9

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

(i) A parallel plate air capacitor has a capacitance of 5μF. It becomes 50μF when a dielectric medium occupies the entire space between its two plates. What is the dielectric constant of the medium?

(ii) Find the emf of the battery shown in ***Figure 1***:

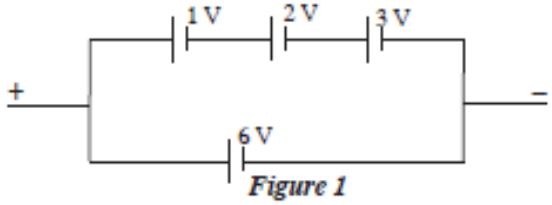

Figure 1

(iii) Two substances A and B have their relative permeabilities slightly greater and slightly less than 1 respectively. What do you conclude about A and B as far as their magnetic materials are concerned?

(iv) When does a moving charged particle **not** experience any force while moving through a uniform magnetic field?

(v) What is the turns ratio i.e. **transformer ratio, $n_s:n_p$**, in an ideal transformer which increases ac voltage from 220 V to 33000 V?

(vi) What is meant by **coherent sources of light?**

(vii) A ray of light is incident on a transparent medium at **polarizing angle**. What is the angle between the reflected ray and the refracted ray?

(viii) Name the physical **principle** on which the working of **optical fibres** is based.

(ix) What is meant by **shortsightedness**?

(x) How does focal length of a convex lens change with **increase** in **wavelength** of incident light?

(xi) With reference to photo-electric effect, what is meant by **threshold wavelength?**

(xii) Half life of a certain radioactive element is 3·465 days. Find its *disintegration constant.*

(xiii) Binding energy per nucleon for helium nucleus $\left({}_{2}^{4}\mathrm{He}\right)$ is 7·0 MeV. Find the value of **mass defect** for helium nucleus.

(xiv) Write *one* balanced reaction representing **nuclear fusion.**

(xv) Draw the truth table of a NOR gate.

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) An electric dipole of dipole moment $\vec{p}$ is placed in a uniform electric field $\vec{E}$ with its axis inclined to the field. Write an expression for the torque $\vec{\tau}$ experienced by the dipole in **vector** form. Show **diagrammatically** how the dipole should be kept in the electric field so that the **torque** acting on it is:

(i) maximum [3]

(ii) zero

(b) You are provided with 8 μ F capacitors. Show with the help of a diagram how you will arrange **minimum** number of them to get a resultant capacitance of 20 μ F. [3]

(c) (i) Define **temperature coefficient** of resistance of the material of a conductor. [3]

(ii) When the cold junction of a thermocouple is maintained at 0°C, the thermo emf 'e', generated by this thermocouple is given by the relation:

$$e = [16{\cdot}8\,\theta + \frac{1}{2}(-0{\cdot}048)\,\theta^2] \times 10^{-6},$$

where θ is the temperature of the hot junction in °C. Find the **neutral temperature** of this thermocouple.

Question 3

(a) Draw a **labelled** circuit diagram of a **potentiometer** to compare emfs of two cells. Write the working formula *(Derivation not required)*. [3]

(b) How much resistance should be connected to 15 Ω resistor shown in the circuit in ***Figure 2*** below so that the points M and N are at the same potential: [3]

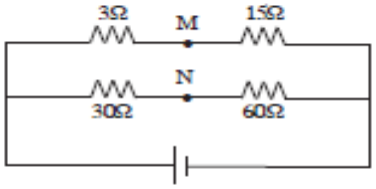

Figure 2

(c) (i) With reference to **free electron theory of conductivity**, explain the terms: [3]

(1) Drift speed

(2) Relaxation time

(ii) What is the **colour code** of a carbon resistor having a resistance of 470Ω and a tolerance of 5%?

Question 4

(a) (i) State **Tangent Law** in magnetism. [2]

(ii) At a certain temperature, a ferromagnetic material becomes paramagnetic. What is this temperature called?

(b) (i) State **Biot Savart law**. [3]

(ii) Find magnetic flux density at a point on the axis of a long solenoid having 5000 turns/m when it is carrying a current of 2 A.

(c) An alternating emf of 110V is applied to a circuit containing a resistance R of 80 Ω and an inductor L in series. The current is found to lag behind the supply voltage by an angle $\theta = \tan^{-1}(3/4)$. Find the: [4]

(i) Inductive reactance

(ii) Impedance of the circuit

(iii) Current flowing in the circuit

(iv) If the inductor has a coefficient of self inductance of 0·1 H, what is the frequency of the applied emf ?

SECTION B

Answer any **two** *questions*

Question 5

(a) Name the part of the **electromagnetic spectrum** which is: [2]

(i) Suitable for radar systems used in aircraft navigation.

(ii) Produced by bombarding a metal target with high speed electrons.

(b) In **Young's double slit experiment**, using monochromatic light, fringes are obtained on a screen placed at some distance from the slits. If the screen is moved by 5×10^{-2} m towards the slits, the change in the fringe width is 3×10^{-5} m. If the distance between the two slits is 10^{-3} m, calculate wavelength of the light used. [3]

(c) (i) State **Brewster's law** of polarization of light. [3]

(ii) How will you identify **with the help of an experiment** whether a given beam of light is of polarized light or of unpolarized light?

Question 6

(a) A narrow beam of monochromatic light, PQ, is incident normally on one face of an equiangular glass prism of refractive index 1·45. When the prism is immersed in a certain liquid, the ray makes a grazing emergence along the other face (See ***Figure 3***). Find the **refractive index** of this liquid. [2]

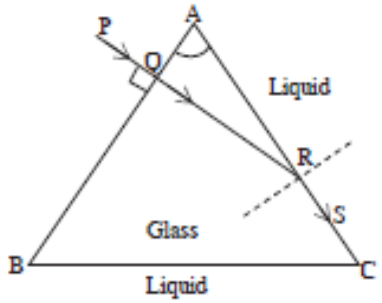

Figure 3

(b) When two thin lenses of focal lengths f_1 and f_2 are kept coaxially and in contact, prove that their **combined focal length** *"f"* is given by: [3]

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

(c) The ***Figure 4*** below shows the positions of a point object O, two lenses, a plane mirror and the final image I which coincides with the object. The focal length of the convex lens is 20 cm. Calculate the focal length of the **concave** lens. [3]

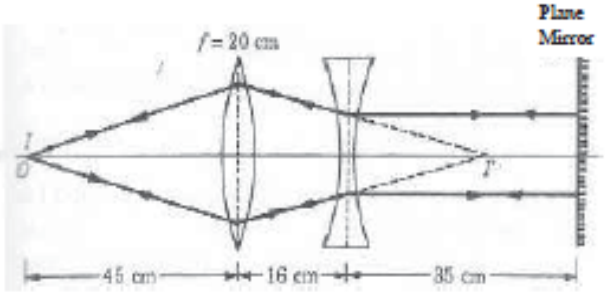

Figure 4

Question 7

(a) (i) What is meant by **dispersive power** of a transparent material? **[4]**

(ii) Show that, two thin lenses kept in contact, form an **achromatic doublet** if they satisfy the condition:

$$\frac{\omega}{f}+\frac{\omega'}{f'}=0$$

where the terms have their usual meaning.

(b) (i) **Define magnifying power of a microscope** in terms of **visual angles**. **[2]**

(ii) What is the advantage of a **compound microscope** over a simple microscope?

(c) An astronomical telescope uses two lenses of powers 10 dioptre and 1 dioptre. If the final image of a distant object is formed at infinity, calculate the length of the telescope. **[2]**

SECTION C

Answer any **two** *questions.*

Question 8

(a) Answer the following questions with reference to **Millikan's oil drop experiment**: **[3]**

(i) What is an atomiser?

(ii) What is the use of an X-ray tube?

(iii) What is the unique property shown by the charge of an oil drop?

(b) (i) Write **Einstein's photo electric equation**. **[3]**

(ii) If the frequency of the incident radiation is increased from 4×10^{15} Hz to 8×10^{15} Hz, by how much will the **stopping potential** for a given photosensitive surface go up?

(c) (i) What are **matter** waves? **[2]**

(ii) Show with the help of a labelled graph how their wavelength (λ) varies with their linear momentum (p).

Question 9

(a) The energy levels of an atom of a certain element are shown in the given ***Figure 5***. Which one of the transitions A, B, C, D or E will result in the emission of photons of electromagnetic radiation of wavelength 618·75 nm? Support your answer with mathematical calculations. **[3]**

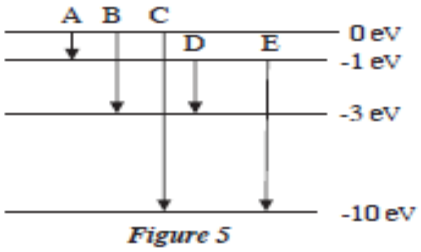

Figure 5

(b) Voltage applied between cathode and anode of an X-ray tube is 18 kV. Calculate the **minimum** wavelength of the X-rays produced. **[2]**

(c) In a **nuclear reactor**, what is the function of: **[3]**

(i) The moderator

(ii) The control rods

(iii) The coolant

Question 10

(a) (i) The atomic mass of Uranium $^{238}_{92}U$ is 238·0508 u, while that of Thorium $^{234}_{90}Th$ is 234·0436 u, and that of Helium $^{4}_{2}He$ is 4·0026 u. Alpha decay converts $^{238}_{92}U$ into $^{234}_{90}Th$ as shown below: [3]

$$^{238}_{92}U \rightarrow {}^{234}_{90}Th + {}^{4}_{2}He + \text{energy}$$

Determine the energy released in this reaction.

(ii) What is a *neutrino*?

(b) In **semi conductor physics**, what is meant by: [3]

(i) a rectifier

(ii) an amplifier

(iii) an oscillator

(c) With the help of a diagram, show how you can use several NAND gates to obtain an OR gate. [2]