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) 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) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{\lambda}{r}$

(b) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{2\lambda}{r}$

(c) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{\lambda}{r^2}$

(d) $E = \left(\frac{1}{4\pi \in_0}\right)\frac{2\lambda}{r^2}$

This Paper consists of 8 printed pages.

(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***:

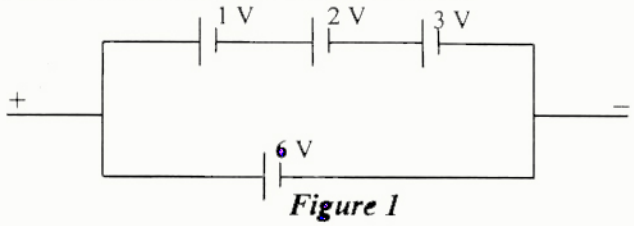

Figure 1

(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 μF capacitors. Show with the help of a diagram how you will arrange **minimum** number of them to get a resultant capacitance of 20 μF. [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 0^0C, 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 ^{0}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]

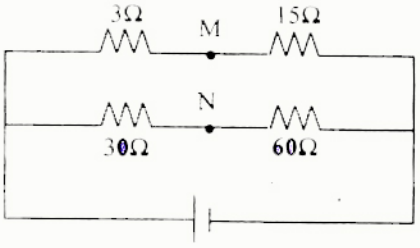

Figure 2

(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]

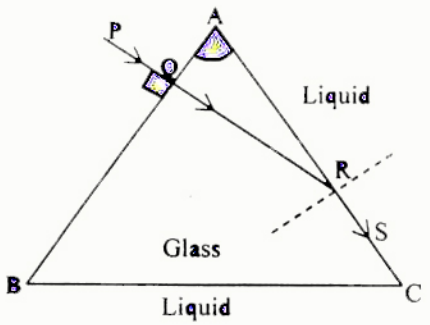

Figure 3

(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]

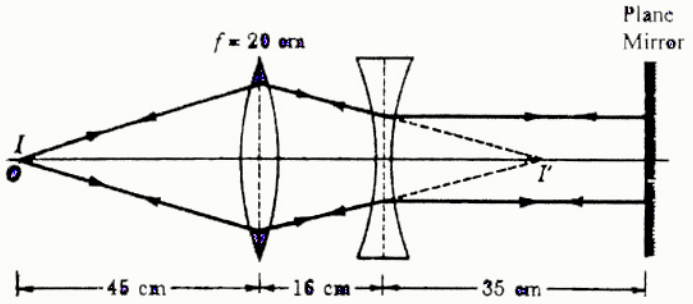

Figure 4

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]

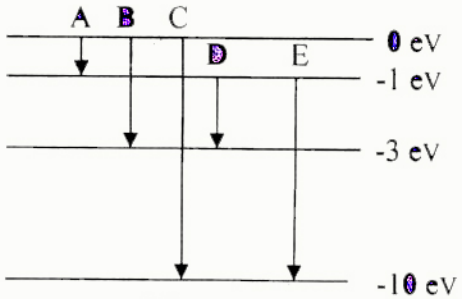

Figure 5

(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]

Useful Constants and Relations:

1.	Speed of Light in vacuum	(c)	$= 3{\cdot}0 \times 10^{8}$ m/s
2.	Charge of a proton	(e)	$= 1{\cdot}6 \times 10^{-19}$C
3.	Planck's constant	(h)	$= 6{\cdot}6 \times 10^{-34}$ Js
4.	Permeability of vacuum	(μ_0)	$= 4\pi \times 10^{-7}$ Hm^{-1}
5.	Electron Volt	(1eV)	$= 1{\cdot}6 \times 10^{-19}$ J
6.	Unified Atomic Mass Unit	(1u)	= 931 MeV
7.		(π)	= 3·14
8.		($ln2$)	= 0·693