

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 ten questions from Part II, choosing four questions from Section A, three questions from Section B and three questions from Section 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) A **short** electric dipole (which consists of two point charges, $+q$ and $-q$) is placed at the centre O and inside a **large** cube (ABCDEFGH) of length L , as shown in **Figure 1**. The electric flux, emanating through the cube is:

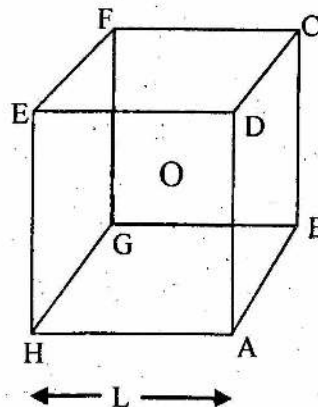


Figure 1

- (a) $q/4\pi\epsilon_0 L$
- (b) zero
- (c) $q/2\pi\epsilon_0 L$
- (d) $q/3\pi\epsilon_0 L$

(ix) The equivalent resistance between points **a** and **f** of the network shown in *Figure 2* is:

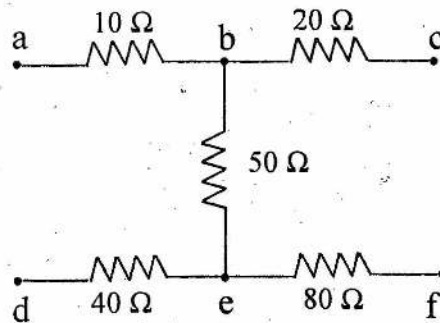


Figure 2

- (a) 24 Ω
- (b) 110 Ω
- (c) 140 Ω
- (d) 200 Ω

(xii) A moving electron enters a uniform and **perpendicular** magnetic field. Inside the magnetic field, the electron travels along:

- (a) a straight line.
- (b) a parabola
- (c) a circle
- (d) a hyperbola

(xiii) A fish which is at a depth of 12 cm in water ($\mu = \frac{4}{3}$) is viewed by an observer on the bank of a lake. Its **apparent depth** as observed by the observer is:

- (a) 3 cm
- (b) 9 cm
- (c) 12 cm
- (d) 16 cm

(xiv) If E_p and E_k represent potential energy and kinetic energy respectively, of an orbital electron, then, according to **Bohr's theory**:

- (a) $E_k = -E_p/2$
- (b) $E_k = -E_p$
- (c) $E_k = -2E_p$
- (d) $E_k = 2E_p$

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

[15]

- (i) What is meant by the term **Quantization of charge**?
- (ii) A resistor **R** is connected to a cell of emf **e** and internal resistance **r**. Potential difference across the resistor **R** is found to be **V**. State the relation between **e**, **V**, **R** and **r**.
- (iii) Three identical cells each of emf **2V** and internal resistance **1Ω** are connected in series to form a battery. The battery is then connected to a parallel combination of two identical resistors, each of resistance **6Ω**. Find the current delivered by the battery.
- (iv) State how **magnetic susceptibility** is **different** for the three types of magnetic materials, i.e. diamagnetic, paramagnetic and ferromagnetic materials.
- (v) An emf of **2V** is induced in a coil when current in it is changed from **0A** to **10A** in **0.40 sec**. Find the **coefficient of self-inductance** of the coil.
- (vi) How are electric vector (\vec{E}), magnetic vector (\vec{B}) and velocity vector (\vec{c}) oriented in an electromagnetic wave?
- (vii) State *any two* methods by which ordinary light can be polarised.
- (viii) A monochromatic ray of light falls on a **regular prism**. What is the relation between angle of incidence and angle of emergence in the case of **minimum deviation**?
- (ix) What type of lens is used to correct **long-sightedness**?
- (x) State any one **advantage** of using a reflecting telescope in place of a refracting telescope.
- (xi) State **Moseley's law**.
- (xii) Wavelengths of the first lines of the **Lyman series**, **Paschen series** and **Balmer series**, in hydrogen spectrum are denoted by λ_L , λ_P , and λ_B , respectively. Arrange these wavelengths in **increasing order**.
- (xiii) What is the **significance of binding energy per nucleon** of a nucleus of a radioactive element?
- (xiv) Write any one **balanced** equation representing **nuclear fission**.
- (xv) What is the difference between **analogue** signal and **digital** signal?

PART II (50 Marks)

Answer ten questions in this part, choosing four questions

from Section A, three questions from Section B and three questions from Section C.

SECTION A

Answer any four questions.

Question 2

- (a) Derive an expression for intensity of electric field at a point in **broadside position** or on an **equatorial line** of an electric dipole. [4]
- (b) Two point charges of 10C each are kept at a distance of 3m in vacuum. Calculate their electrostatic potential energy. [1]

Question 3

- (a) Four capacitors, C_1 , C_2 , C_3 and C_4 are connected as shown in **Figure 3** below. Calculate **equivalent capacitance** of the circuit between points X and Y. [3]

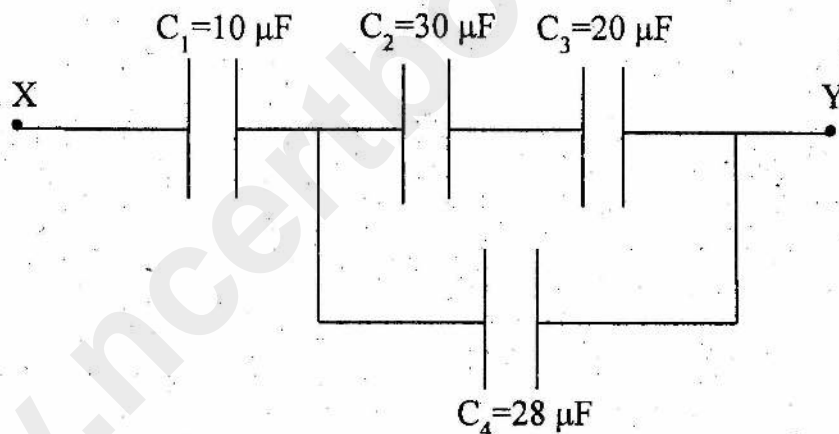


Figure 3

- (b) Draw labelled graphs to show how **electrical resistance** varies with **temperature** for: [2]
- (i) a metallic wire.
- (ii) a piece of carbon.

Question 4

- (a) Two resistors $R_1 = 400 \Omega$ and $R_2 = 20 \Omega$ are connected in **parallel** to a battery. If heating power developed in R_1 is 25 W, find the heating power developed in R_2 . [2]
- (b) With the help of a labelled diagram, show that the **balancing condition** of a **Wheatstone bridge** is: [3]

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \quad \text{where the terms have their usual meaning.}$$

Question 5

- (a) A 10m long uniform metallic wire having a resistance of 20Ω is used as a potentiometer wire. This wire is connected in series with another resistance of 480Ω and a battery of emf 5V having negligible internal resistance. If an unknown emf e is balanced across 6m of the potentiometer wire, calculate: [3]
- (i) the potential gradient across the potentiometer wire.
 - (ii) the value of the unknown emf e .
- (b) (i) Explain the term *hysteresis*. [2]
- (ii) Name **three elements** of the earth's magnetic field which help in defining **earth's magnetic field** completely.

Question 6

- (a) Obtain an expression for **magnetic flux density** B at the centre of a circular coil of radius R , having N turns and carrying a current I . [3]
- (b) A coil of self inductance 2.5H and resistance 20Ω is connected to a battery of emf 120V having internal resistance of 5Ω . Find: [2]
- (i) The **time constant** of the circuit.
 - (ii) The current in the circuit in **steady state**.

Question 7

- (a) **Figure 4** below shows a capacitor C , an inductor L and a resistor R , connected in series to an a.c. supply of **220 V**. [4]

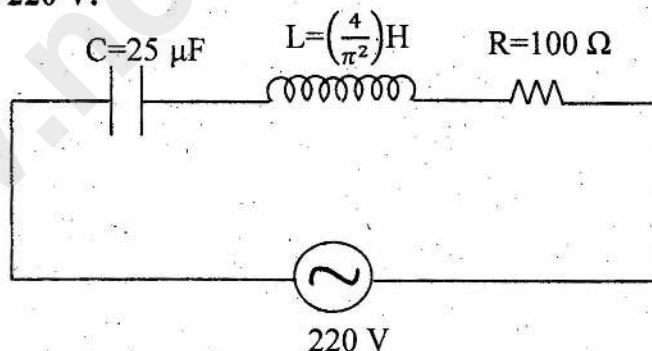


Figure 4

Calculate:

- (i) The **resonant frequency** of the given CLR circuit.
 - (ii) Current flowing through the circuit.
 - (iii) Average power consumed by the circuit.
- (b) In a series LCR circuit, what is the **phase difference** between V_L and V_C where V_L is the potential difference across the inductor and V_C is the potential difference across the capacitor? [1]

SECTION B

Answer any **three** questions.

Question 8

- (a) On the basis of **Huygen's Wave theory of light**, show that angle of reflection is equal to angle of incidence. You must draw a labelled diagram for this derivation. [4]
- (b) State any one difference between **interference of light** and **diffraction of light**. [1]

Question 9

- (a) Laser light of wavelength 630 nm is incident on a pair of slits which are separated by 1.8mm. If the screen is kept 80 cm away from the two slits, calculate: [3]
- (i) fringe separation i.e. fringe width.
- (ii) distance of 10th bright fringe from the centre of the interference pattern.
- (b) Show graphically the intensity distribution in **Fraunhofer's single slit diffraction experiment**. Label the axes. [2]

Question 10

- (a) A point object **O** is placed at a distance of 15cm from a convex lens **L** of focal length 10cm as shown in **Figure 5** below. On the other side of the lens, a convex mirror **M** is placed such that its distance from the lens is equal to the focal length of the lens. The final image formed by this combination is observed to **coincide** with the object **O**. Find the **focal length** of the **convex mirror**. [3]

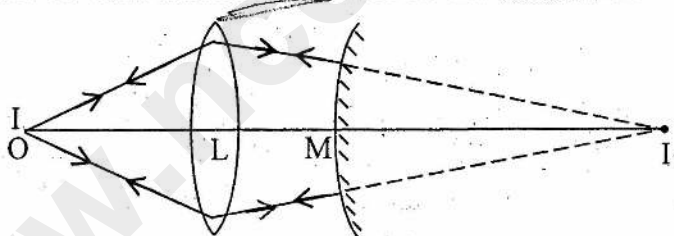


Figure 5

- (b) What is **chromatic aberration**? How can it be minimised or eliminated? [2]

Question 11

- (a) Draw a labelled ray diagram of an image formed by a **compound microscope**, when the final image lies at the **least distance of distinct vision (D)**. [3]
- (b) With regard to an **astronomical telescope of refracting type**, state how you will increase its: [2]
- (i) magnifying power
- (ii) resolving power

SECTION C

Answer any **three** questions.

Question 12

- (a) In an experiment of **photoelectric effect**, the graph of maximum kinetic energy E_K of the emitted photoelectrons versus the frequency ν of the incident light is a straight line **AB** as shown in **Figure 6** below: [3]

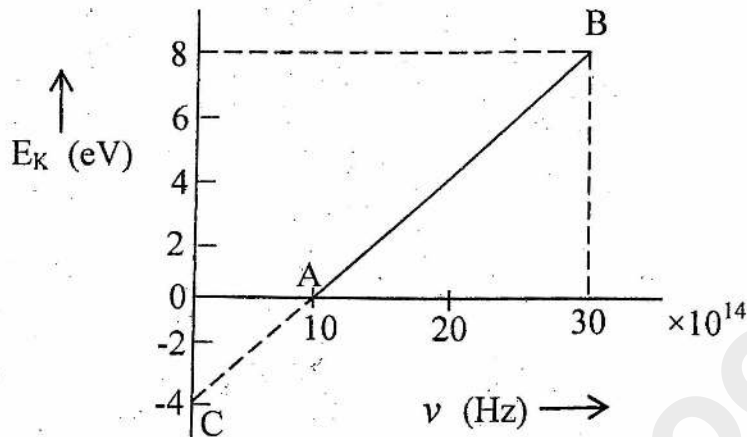


Figure 6

Find:

- (i) Threshold frequency of the metal.
(ii) Work function of the metal.
(iii) Stopping potential for the photoelectrons emitted by the light of frequency $\nu = 30 \times 10^{14}$ Hz.
- (b) (i) State how **de-Broglie wavelength** (λ) of moving particles varies with their linear momentum (p). [2]
(ii) State any one phenomenon in which moving particles exhibit wave nature.

Question 13

- (a) On the basis of **Bohr's** theory, derive an expression for the **radius** of the n^{th} orbit of an electron of hydrogen atom. [3]
- (b) Using the constants given on page 8 of this Paper, find the **minimum wavelength** of the emitted X rays, when an **X ray tube** is operated at 50 kV. [2]

Question 14

- (a) (i) Define **half-life** of a radioactive substance. [3]
- (ii) Using the equation $N = N_0 e^{-\lambda t}$, obtain the relation between **half-life (T)** and **decay constant (λ)** of a radioactive substance.
- (b) With the help of a suitable **example** and an **equation**, explain the term **pair production**. [2]

Question 15

- (a) Draw a labelled diagram of a **full wave rectifier**. Show how output voltage varies with time, if input voltage is a **sinusoidal** voltage. [3]
- (b) What is a NAND gate? Write its truth table. [2]

Useful Constants and Relations:

1.	Speed of Light in vacuum	(c)	$= 3.0 \times 10^8 \text{ ms}^{-1}$
2.	Charge of a proton	(e)	$= 1.6 \times 10^{-19} \text{ C}$
3.	Planck's constant	(h)	$= 6.6 \times 10^{-34} \text{ Js}$
4.	Constant for Coulomb's law	$\left(\frac{1}{4\pi\epsilon_0} \right)$	$= 9 \times 10^9 \text{ mF}^{-1}$
5.	Electron Volt	(1eV)	$= 1.6 \times 10^{-19} \text{ J}$