

# PHYSICS

## PAPER – 1

### (THEORY)

(Maximum Marks: 70)

(Time allowed: Three hours)

(Candidates are allowed additional 15 minutes for *only* reading the paper.

They must NOT start writing during this time.)

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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.

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### 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) In **Figure 1** below, a charge  $Q$  is fixed. Another charge  $q$  is moved along a circular arc MN of radius  $r$  around it, from the point M to the point N such that the length of the arc MN =  $l$ . The work done in this process is:

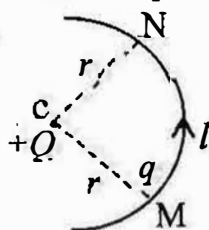


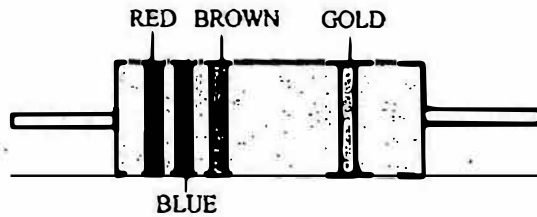
Figure 1

- (a) zero  
(b)  $\frac{1}{4\pi\epsilon_0} \cdot \frac{Qq}{r^2} l$   
(c)  $\frac{Qq}{2\epsilon_0 r^2} l$   
(d)  $\frac{Qq}{2\pi\epsilon_0 r^2}$

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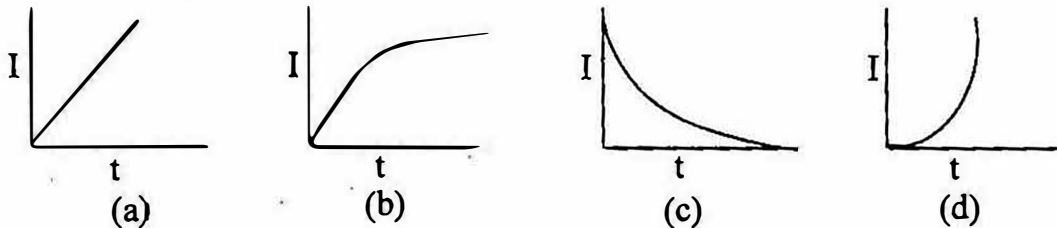
This Paper consists of 8 printed pages.

- (ii) A carbon resistor has coloured bands as shown in **Figure 2** below. The resistance of the resistor is:



**Figure 2.**

- (a)  $26\Omega \pm 10\%$   
(b)  $26\Omega \pm 5\%$   
(c)  $260\Omega \pm 5\%$   
(d)  $260\Omega \pm 10\%$
- (iii) A solenoid L and a resistor R are connected in series to a battery, through a switch. When the switch is put on, current I flowing through it varies with time t as shown in which of the graphs given below:

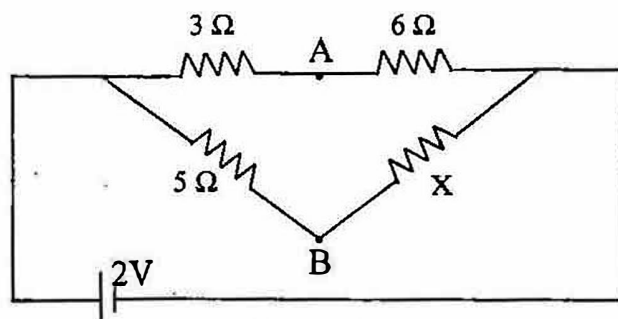


- (iv) Two thin lenses having optical powers of  $-10D$  and  $+6D$  are placed in contact with each other. The focal length of the combination is:
- (a)  $+0.25\text{ cm}$   
(b)  $-0.25\text{ cm}$   
(c)  $+0.25\text{ m}$   
(d)  $-0.25\text{ m}$
- (v) Total energy of an electron in the **ground state** of hydrogen atom is  $-13.6\text{ eV}$ . Its total energy, when hydrogen atom is in the **first excited state**, is:
- (a)  $+13.6\text{ eV}$   
(b)  $+3.4\text{ eV}$   
(c)  $-3.4\text{ eV}$   
(d)  $-54.4\text{ eV}$

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

[15]

- (i) A charged oil drop weighing  $1.6 \times 10^{-15} \text{ N}$  is found to remain suspended in a uniform electric field of intensity  $2 \times 10^3 \text{ NC}^{-1}$ . Find the **charge** on the drop.
- (ii) For a metallic conductor, what is the relation between **current density** ( $J$ ), **conductivity** ( $\sigma$ ) and **electric field intensity**  $E$ ?
- (iii) In **Figure 3** given below, find the value of resistance  $x$  for which points A and B are at the same potential:



**Figure 3**

- (iv) Write the expression for the **Lorentz force**  $\mathbf{F}$  in vector form.
- (v) A coil has a **self-inductance** of 0.05 Henry. Find magnitude of the emf induced in it when the current flowing through it is changing at the rate  $100 \text{ As}^{-1}$ .
- (vi) To which regions of the **electromagnetic spectrum** do the following wavelengths belong:
  - (a) 250 nm
  - (b) 1500 nm
- (vii) What is the difference between **polarised light** and **unpolarised light**?
- (viii) Name the **principle** on the basis of which **optical fibres** work.
- (ix) Calculate **dispersive power** of a transparent material given:  
$$n_v = 1.56, \quad n_r = 1.54, \quad n_y = 1.55.$$
- (x) What is meant by **short-sightedness**?
- (xi) Two metals A and B have work functions 4eV and 6eV respectively. Which metal has lower **threshold wavelength** for photoelectric effect?
- (xii) Calculate **angular momentum** of an electron in the **third** Bohr orbit of hydrogen atom.
- (xiii) In a nuclear reactor, what is the function of a **moderator**?
- (xiv) In our Nature, where is the **nuclear fusion** reaction taking place continuously?
- (xv) What is the use of a **Zener diode**?

## 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

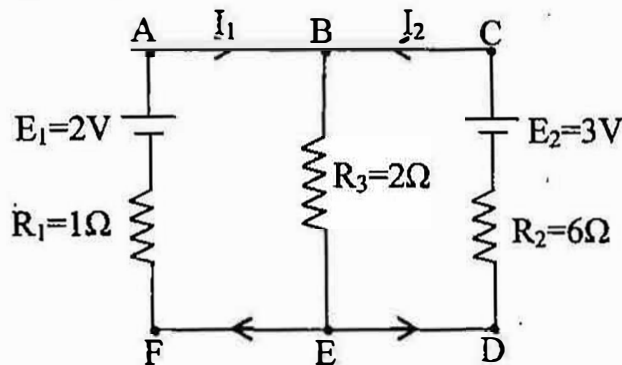
- (a) Two point charges  $Q_1 = 400\mu\text{C}$  and  $Q_2 = 100\mu\text{C}$  are kept fixed, 60 cm apart in vacuum. Find **intensity** of the electric field at **midpoint** of the line joining  $Q_1$  and  $Q_2$ . [3]
- (b) (i) State **Gauss' Law**. [2]
- (ii) In an electric dipole, at which point is the **electric potential** zero?

#### Question 3

- (a) Obtain an expression for **equivalent capacitance** when three capacitors  $C_1$ ,  $C_2$  and  $C_3$  are connected in **series**. [3]
- (b) A metallic wire has a resistance of  $3.0\Omega$  at  $0^\circ\text{C}$  and  $4.8\Omega$  at  $150^\circ\text{C}$ . Find the **temperature coefficient of resistance** of its material. [2]

#### Question 4

- (a) In the circuit shown in **Figure 4** below,  $E_1$  and  $E_2$  are two cells having emfs 2V and 3V respectively, and negligible internal resistances. Applying **Kirchoff's laws** of electrical networks, find the values of currents  $I_1$  and  $I_2$ . [4]



**Figure 4**

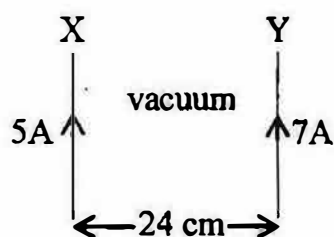
- (b) State how a moving coil galvanometer can be converted into an ammeter. [1]

### Question 5

- (a) Draw a labelled circuit diagram of a **potentiometer** to measure **internal resistance** of a cell. Write the working formula. (*Derivation not required*). [3]
- (b) (i) Define **Curie temperature**. [2]  
(ii) If magnetic susceptibility of a certain magnetic material is 0.0001, find its **relative permeability**.

### Question 6

- (a) (i) Two infinitely long current carrying conductors X and Y are kept parallel to each other, 24 cm apart in vacuum. They carry currents of 5A and 7A respectively, in the **same direction**, as shown in **Figure 5** below. Find the position of a **neutral point**, i.e. a point where resultant magnetic flux density is zero. (*Ignore earth's magnetic field*). [3]



**Figure 5**

- (ii) If current through the conductor Y is **reversed** in direction, will neutral point lie between X and Y, to the left of X or to the right of Y?
- (b) (i) Define **Ampere** in terms of force between two current carrying conductors. [2]  
(ii) What is an **ideal transformer**?

### Question 7

- (a) A coil having **self-inductance** of 0.7H and resistance of  $165\Omega$  is connected to an a.c. source of 275V, 50Hz. If  $\pi = \frac{22}{7}$ , [3]  
Calculate:  
(i) Reactance of the coil  
(ii) Impedance of the coil  
(iii) Current flowing through the coil
- (b) Draw a labelled graph showing variation of **impedance** of a series LCR circuit with frequency of the a.c. supply. [2]

## SECTION B

Answer any *three* questions.

### Question 8

- (a) Derive **Snell's law** of refraction using **Huygen's wave theory**. [3]
- (b) Monochromatic light of wavelength 650nm falls normally on a slit of width  $1.3 \times 10^{-4}$  cm and the resulting **Fraunhofer diffraction** is obtained on a screen. Find the **angular width** of the central maxima. [2]

### Question 9

- (a) In **Young's double slit experiment**, show that: [4]
- $$\beta = \frac{\lambda D}{a},$$
- where the terms have their usual meaning.
- (b) A ray of ordinary light is travelling in air. It is incident on air glass pair at a **polarising angle** of  $56^\circ$ . Find the angle of **refraction** in glass. [1]

### Question 10

- (a) Find the **angle of incidence** at which a ray of monochromatic light should be incident on the **first surface AB** of a **regular** glass prism ABC so that the emergent ray **grazes** the adjacent surface AC. (Refractive Index of glass = 1.56). [3]
- (b) State how focal length of a glass lens (Refractive Index 1.5) changes when it is completely immersed in: [2]
- (i) Water (Refractive Index 1.33)
- (ii) A liquid (Refractive Index 1.65)

### Question 11

- (a) A convex lens of a focal length 5 cm is used as a **simple microscope**. Where should an object be placed so that the image formed by it lies at the least distance of distinct vision ( $D=25\text{cm}$ )? [2]
- (b) Draw a labelled ray diagram showing the formation of an image by a **refracting telescope** when the final image lies at infinity. [3]

## SECTION C

Answer any *three* questions.

### Question 12

- (a) Monochromatic light of wavelength 198 nm is incident on the surface of a metallic cathode whose work function is 2.5 eV. How much potential difference must be applied between the cathode and the anode of a photocell to **just stop** the photo current from flowing? [3]
- (b) (i) What is **de Broglie** hypothesis? [2]  
(ii) What conclusion can be drawn from **Davisson and Germer's** experiment?

### Question 13

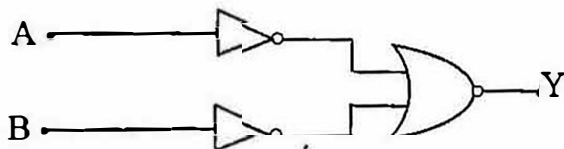
- (a) (i) How are various lines of **Lyman series** formed? Explain on the basis of **Bohr's** theory. [3]  
(ii) Calculate the **shortest** wavelength of electromagnetic radiation present in **Balmer** series of hydrogen spectrum.
- (b) State the effect of the following changes on the X-rays emitted by Coolidge X-ray tube: [2]  
(i) High voltage between cathode and anode is increased.  
(ii) Filament temperature is increased.

### Question 14

- (a) **Half life** of a certain **radioactive material** is 8 hours. [3]  
(i) Find **disintegration constant** of this material.  
(ii) If one starts with 600g of this substance, how much of it will **disintegrate** in one day?
- (b) Sketch a graph showing the variation of **binding energy per nucleon** of a nucleus with its **mass number**. [2]

### Question 15

- (a) Draw a circuit diagram for the **common emitter transistor amplifier**. What is meant by **phase reversal**? [3]
- (b) Write the **truth table** of the following circuit. Name the **gate** represented by this circuit. [2]



**Useful Constants and Relations:**

1.	Charge of a proton	(e)	$= 1.6 \times 10^{-19} \text{C}$
2.	Planck's constant	(h)	$= 6.6 \times 10^{-34} \text{Js}$
3.	Mass of an electron	(m)	$= 9.1 \times 10^{-31} \text{kg}$
4.	Permittivity of vacuum	( $\epsilon_0$ )	$= 8.85 \times 10^{-12} \text{Fm}^{-1}$
5.		$\left( \frac{1}{4\pi\epsilon_0} \right)$	$= 9 \times 10^9 \text{mF}^{-1}$
6.	Permeability of vacuum	( $\mu_0$ )	$= 4\pi \times 10^{-7} \text{Hm}^{-1}$
7.		$\left( \frac{\mu_0}{4\pi} \right)$	$= 10^{-7} \text{Hm}^{-1}$
8.	Rydberg's constant	(R)	$= 1.097 \times 10^7 \text{m}^{-1}$
9.	Speed of light in vacuum	(c)	$= 3 \times 10^8 \text{ms}^{-1}$