

# 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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*All questions are compulsory.*

*This question paper is divided in 4 Sections A, B, C and D as follows.*

#### **Section A**

*Question number 1 is of twelve marks. All parts of this question are compulsory.*

#### **Section B**

*Question numbers 2 to 12 carry 2 marks each with two questions having internal choice.*

#### **Section C**

*Question numbers 13 to 19 carry 3 marks each with two questions having internal choice.*

#### **Section D**

*Question numbers 20 to 22 are long-answer type questions and carry 5 marks each. Each question has an internal choice.*

*The intended marks for questions are given in brackets [ ].*

*All working, including rough work, should be done on the same sheet as and adjacent to the rest of the answer.*

*Answers to sub parts of the same question must be given in one place only. A list of useful physical constants is given at the end of this paper.*

*A simple scientific calculator without a programmable memory may be used for calculations.*

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### **Section A**

*Answer all questions.*

#### **Question 1**

(A) Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below: [5×1]

(i) Ohm's law in **vector** form is:

(a)  $V = I.R$

(b)  $\vec{J} = \sigma \vec{E}$

(c)  $\vec{J} = \rho \vec{E}$

(d)  $\vec{E} = \sigma \vec{J}$

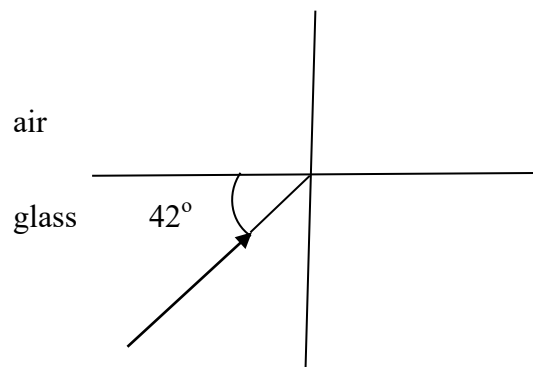
- (ii) Current flowing through a long solenoid is varied. Then, magnetic flux density of the magnetic field inside it varies:
- (a) inversely with I
  - (b) inversely with  $I^2$
  - (c) directly with I
  - (d) directly with  $I^2$
- (iii) A convex lens, made of glass, is immersed in water. As a result, its focal length will:
- (a) increase
  - (b) decrease
  - (c) double
  - (d) remain same
- (iv) de Broglie wavelength of a moving particle is  $\lambda$ . Its momentum is given by:
- (a)  $\frac{h\lambda}{c}$
  - (b)  $\frac{h}{\lambda}$
  - (c)  $\frac{hc}{\lambda}$
  - (d) Zero
- (v) Half Life of a certain radioactive substance is 69.3 days. Its disintegration constant is:
- (a)  $0.010 \text{ day}^{-1}$
  - (b)  $0.100 \text{ day}^{-1}$
  - (c)  $0.001 \text{ day}^{-1}$
  - (d)  $1.00 \text{ day}^{-1}$

(B) Answer the following questions briefly and to the point:

[7×1]

- (i) How will the **sensitivity** of a potentiometer change with increase in current flowing through its wire?
- (ii) Which of the two; an ammeter or a voltmeter, has a greater resistance?
- (iii) Why is soft iron preferred to steel in making the **core** of a transformer?
- (iv) When would a moving charged particle travel undeviated in a uniform magnetic field?

- (v) Complete the ray diagram shown in **Figure 1**, given that the critical angle for air-glass pair is  $i_c=42^\circ$ .



**Figure 1**

- (vi) State the Law of Malus.  
 (vii) Name *any one* material used as a moderator in a nuclear reactor.

### Section B

Answer *all* questions.

#### Question 2

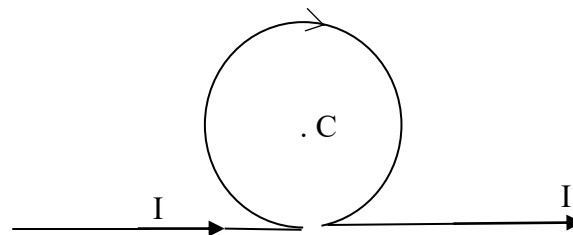
[2]

Define **drift velocity** and **relaxation time**, with reference to the free electron theory of conductors.

#### Question 3

[2]

A long straight wire is bent as shown in **Figure 2** below. Find the resultant magnetic field „B” at the centre C of the circular path of radius 2 cm if a current I of 5 A is passed through the wire as shown:



**Figure 2**

#### Question 4

[2]

- (i) Explain the meaning of the statement:  
 “Angle of dip at a certain place on earth is  $60^\circ$ .”
- (ii) If the horizontal component of earth’s magnetic field at this place is  $3 \times 10^{-5}$  T, calculate the earth’s **total** magnetic field at that place.

**Question 5** [2]

- (a) Briefly explain the following terms:
- (i) Curie temperature
  - (ii) Self-induction

**OR**

- (b) Name *any two* types of energy losses in a transformer. State how *any one* of them can be minimized.

**Question 6** [2]

- (i) What is **displacement current**?
- (ii) Which electromagnetic radiation is used to study the crystal structure?

**Question 7** [2]

A thin convex lens of focal length 20 cm is kept in contact with a thin concave lens of focal length 15 cm. Find the focal length and the nature of the combination.

**Question 8** [2]

What is meant by **dispersive power**? Write an expression of dispersive power in terms of refractive indices.

**Question 9**

- (a) For *each* of the following, state *one* phenomenon in which: [2]
- (i) particles behave like waves.
  - (ii) waves behave like particles.

**OR**

- (b) Plot a labelled graph of maximum kinetic energy of photo electrons versus frequency of incident radiation. State how you will obtain the value of Planck's constant „h“ from the graph. [2]

**Question 10**

Draw energy level diagram for Hydrogen atom showing at least four lowest energy levels. Show the transitions responsible for emission of **Balmer series**.

**Question 11** [2]

What is meant by '**binding energy per nucleon**' of a nucleus? State its physical significance.

**Question 12** [2]

Name essential components of a communication system. Draw its block diagram.

### Section C

Answer all questions.

#### Question 13

[3]

Using **Gauss' theorem**, obtain an expression for **intensity of electric field 'E'** at a point, which is at a distance „ $r$ “ ( $r > R$ ) from the centre „ $C$ “ of a thin spherical shell (of radius  $R$ ) carrying charge „ $Q$ “.

#### Question 14

[3]

(a) Obtain an expression for **electric potential 'V'** due to a point charge '**Q**' at a distance  $r$ .

**OR**

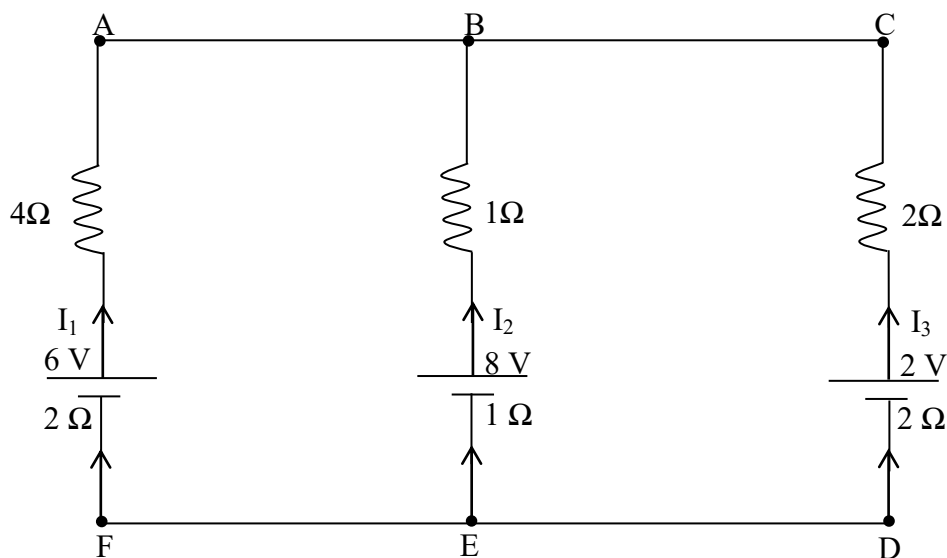
(b) A parallel plate capacitor is charged by a battery; which is then disconnected. A dielectric slab is now introduced between the two plates to occupy the space completely. State the effect on the following:

- the capacitance of the capacitor.
- potential difference between the plates.
- the energy stored in the capacitor.

#### Question 15

[3]

Using **Kirchhoff's laws** of electrical networks, calculate the currents  $I_1$ ,  $I_2$  and  $I_3$  in the circuit shown below (**Figure 3**).



**Figure 3**

#### Question 16

[3]

(a) Obtain an expression for refraction at a single convex spherical surface separating the two media having refractive indices „ $n_1$ “ (rarer medium) and „ $n_2$ “ (denser medium) i.e. a relation between  $u$ ,  $v$ ,  $n_1$ ,  $n_2$  and  $R$ .

**OR**

(b) Derive  $R = 2f$  for a spherical mirror, where the symbols have their usual meaning.

**Question 17** [3]

When a ray of ordinary light is incident on the surface of separation of two media at **polarizing angle**, show with the help of a **labelled diagram** that reflected ray and the refracted ray are mutually perpendicular to each other.

**Question 18** [3]

For **radioactive disintegration** of a radioactive substance, show that

$$N = N_0 e^{-\lambda t}$$

where the terms have their usual meaning.

**Question 19** [3]

With reference to a semiconductor diode, define the terms '**depletion region**' and '**potential barrier**'. How will the width of depletion region change during reverse biasing?

### Section D

*Answer all questions.*

**Question 20** [5]

- (a) An 8 H inductor, a 2  $\mu$ F capacitor and a 100  $\Omega$  resistor are connected in **series** to an A.C. supply of 220 V and 50 Hz. Calculate:
- Impedance of the circuit.
  - Current flowing through the circuit.
  - Phase difference between the current and the supply voltage.
  - Average power consumed by the circuit.

**OR**

- (b) An A.C. generator generating an emf „E“ given by  $E = 311 \sin(10 t)$  is connected to a 44  $\Omega$  resistor. Calculate:
- rms value of A.C. flowing through the resistor.
  - frequency of the current.
  - mean value of emf generated by the generator in time interval 0.06s to 0.08s.

**Question 21** [5]

- (a) Draw a labelled ray diagram of an image formed by a **compound microscope** with final image formed at the least distance of distinct vision (D). **Derive** an expression for its magnifying power (in terms of  $V_o$ ,  $U_o$ ,  $f_c$  and D).

**OR**

- (b) Draw a neat and labelled diagram of an experimental setup of **Young's double slit experiment** to study the interference of light and show that:

$$\beta = \frac{\lambda D}{d}$$

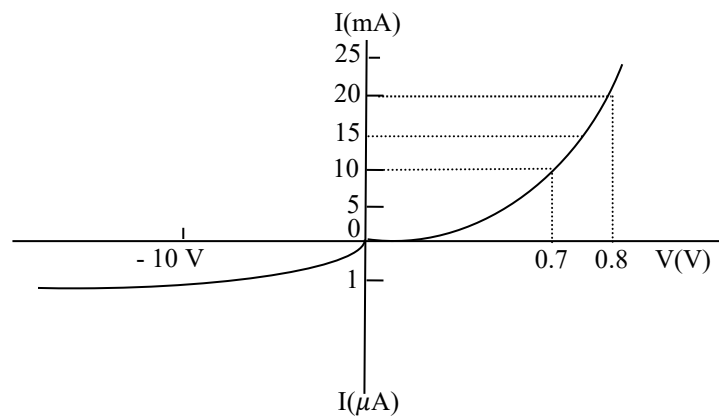
where the terms have their usual meaning. Show intensity variation in the interference

pattern graphically.

**Question 22**

[5]

- (a) (i) For a transistor in a **common emitter** mode, draw labelled graph to show:
- (1) Input characteristic curve.
  - (2) Output characteristic curve.
  - (3) Transfer characteristic curve.
- (Circuit diagram of the arrangement is **not** required.)
- (ii) The characteristic curve of a silicon diode is shown in **Figure 5** below:



**Figure 5**

Calculate the resistance of the diode at:

- (1)  $I = 15 \text{ mA}$  and
- (2)  $V = -10 \text{ V}$

**OR**

- (b) (i) Show how you will obtain an **AND** gate using only **NOR** gates. Draw the **truth table** for this arrangement of gates.
- (ii) For a **common emitter transistor amplifier**, the audio signal voltage across the collector resistance ( $r_c$ ) of  $2 \text{ k}\Omega$  is  $2 \text{ V}$ . If the current amplification factor ( $\beta$ ) of the transistor is  $100$ , calculate the input signal voltage ( $V_{BE}$ ) and base current ( $I_B$ ) for base resistance of  $1 \text{ k}\Omega$ .

**Useful Constants and Relations:**

1.	Permeability of vacuum	( $\mu_o$ )	$= 4\pi \times 10^{-7} \text{ H m}^{-1}$
2.		$\ln 2$	$= 0.693$