## PHYSICS

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(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.)

## All questions are compulsory. <br> This question paper is divided into 4 Sections, $A, B, C$ and $D$ as follows: <br> 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.

## Section A

Answer all questions.

## Question 1

(A) Choose the correct alternative (a), (b), (c) or (d) for each of the questions given below:
(i) A point charge ' $q$ ' is kept at each of the vertices of an equilateral triangle having each side ' $a$ '. Total electrostatic potential energy of the system is:
(a) $\left(\frac{1}{4 \pi \varepsilon_{0}}\right) \frac{3 q^{2}}{a^{2}}$
(b) $\left(\frac{1}{4 \pi \varepsilon_{o}}\right) \frac{3 q}{a}$
(c) $\left(\frac{1}{4 \pi \varepsilon_{0}}\right) \frac{3 q^{2}}{a}$
(d) $\left(\frac{1}{4 \pi \varepsilon_{o}}\right) \frac{3 q}{a^{2}}$

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(ii) Curie temperature is the temperature above which:
(a) a ferromagnetic substance behaves like a paramagnetic substance.
(b) a paramagnetic substance behaves like a diamagnetic substance.
(c) a ferromagnetic substance behaves like a diamagnetic substance.
(d) a paramagnetic substance behaves like a ferromagnetic substance.
(iii) In an astronomical telescope of refracting type:
(a) Objective should have small focal length.
(b) Objective should have large focal length.
(c) Eyepiece should have large focal length.
(d) Both objective and eyepiece should have large focal length.
(iv) In photoelectric effect experiment, the slope of the graph of the stopping potential versus frequency gives the value of:
(a) $\frac{h}{e}$
(b) h
(c) $\frac{\mathrm{e}}{\mathrm{h}}$
(d) $\frac{h c}{\mathrm{e}}$
(v) In a nuclear reactor, cadmium rods are used as:
(a) Control rods
(b) Fuel rods
(c) Coolant
(d) Moderator
(B) Answer the following questions briefly and to the point:
(i) State Gauss' theorem.
(ii) A metallic wire having a resistance of $20 \Omega$ is bent in order to form a complete circle. Calculate the resistance between any two dianietrically opposite points on the circle.
(iii) How can a moving coil galvanometer be converted into a voltmeter?
(iv) Write Biot-Savart's law in vector form.
(v) What is the phase difference between any two points lying on the same wavefront?
(vi) Name the physical principle on the basis of which optical fibres work.
(vii) What is Pair production?

## Section B

Answer all questions.
Question 2
(a) A uniform copper wire having a cross sectional area of $1 \mathrm{~mm}^{2}$ carries a current of 5 A . Calculate the drift speed of free electrons in it.
(Free electron number density of copper $=2 \times 10^{28} / \mathrm{m}^{3}$.)

## OR

(b) An electric bulb is rated as $250 \mathrm{~V}, 750 \mathrm{~W}$. Calculate the:
(i) Electric current flowing through it, when it is operated on a 250 V supply.
(ii) Resistance of its filament.

## Question 3

Write an expression for force per unit length between two long current carrying wires, kept parallel to each other, in vacuum and hence define an ampere, the SI unit of current.

## Question 4

(i) Define angle of dip.
(ii) State the relation between magnetic susceptibility $(\mathcal{X})$ and relative permeability ( $\mu_{r}$ ) of a magnetic substance.

## Question 5

(a) Figure $l$ below shows a metallic rod MN of length $l=80 \mathrm{~cm}$, kept in a uniform magnetic field of flux density $B=0.5 \mathrm{~T}$, on two parallel metallic rails $\mathbf{P}$ and Q. Calculate the emf that will be induced between iis two ends, when it is moved towards right with a constant velocity $v$ of $36 \mathrm{~km} / \mathrm{hr}$.

(b) When current flowing through one coil changes from 0 Amp to 15 Amp in 0.2 s , an emf of 750 V is induced in an adjacent coil. Calculate the coefficient of mutual inductance of the two coils.

## Question 6

(i) State any one use of infrared radiations.
(ii) State any one source of ultraviolet radiations.

## Question 7

Where will you keep an object in front of a:
(i) Convex lens in order to get a virtual and magnified image?
(ii) Concave mirror to get a real and diminished image?

## Question 8

Draw a labelled graph of angle of deviation ( $\delta$ ) versus angle of incidence $(i)$ for a prism.

## Question 9

(i) State de Broglie hypothesis.
(ii) What conclusion can be drawn from Davisson and Germer's experiment?

## Question 10

Calculate binding energy of oxygen nucleus $\left({ }_{8}^{16} \mathrm{O}\right)$ from the data given below:

| Mass of a proton | $=$ | 1.007825 u |
| :--- | :--- | ---: |
| Mass of a neutron | $=$ | 1.008665 u |
| Mass of $\left({ }_{8}^{16} \mathrm{O}\right)$ | $=$ | 15.994915 u |

Question 11
For a radioactive substance, write the relation between:
(i) Half life (T) and disintegration constant $(\lambda)$.
(ii) Mean life $(\tau)$ and disintegration constant $(\lambda)$.

## Question 12

With reference to communication systems, what is meant by:
(i) modulation?
(ii) demodulation?

## Section C <br> Answer all questions.

## Question 13

Show that intensity of electric field $\mathbf{E}$ at a point in broadside on position is given by:

$$
\mathrm{E}=\left(\frac{1}{4 \pi \epsilon_{o}}\right) \frac{p}{\left(r^{2}+l^{2}\right)^{3 / 2}}
$$

where the terms have their usual meaning.

## Question 14

A parallel plate capacitor is charged by a battery, which is then disconnected. A dielectric slab having dielectric constant (relative permittivity) K , is now introduced between its two plates in order to occupy the space completely.
State, in terms of K , its effect on the following:
(i) The capacitance of the capacitor.
(ii) The potential difference between its plates.
(iii) The energy stored in the capacitor.

## Question 15

(a) $\quad E_{1}$ and $E_{2}$ are two batteries having emfs of 3 V and 4 V and internal resistances of $2 \Omega$ and $1 \Omega$ respectively. They are connected as shown in Figure 2 below. Using Kirchhoff's Laws of electrical circuits, calculate the currents $\mathrm{I}_{1}$ and $\mathrm{I}_{2}$.


Figure 2

## OR

(b) A potentiometer circuit is shown in Figure 3 below. AB is a uniform metallic wire having length of 2 m and resistance of $8 \Omega$. The batteries $E_{1}$ and $E_{2}$ have emfs of 4 V and 1.5 V and their internal resistances are $1 \Omega$ and $2 \Omega$ respectively.


Figure 3
(i) When the jockey J does not touch the wire AB , calculate:
(a) the current flowing through the potentiometer wire AB .
(b) the potential gradient across the wire AB .
(ii) Now the jockey $J$ is made to touch the wire $A B$ at a point $C$ such that the galvanometer $(G)$ shows no deflection. Calculate the length $A C$.

## Question 16

For two thin lenses kept in contact with each other, show that:

$$
\frac{1}{F}=\frac{1}{f_{1}}+\frac{1}{f_{2}}
$$

where the terms have their usual meaning.

## Question 17

(a) A compound microscope consists of two convex lenses having focal length of 1.5 cm and 5 cm . When an object is kept at a distance of 1.6 cm from the objective, the final image is virtual and lies at a distance of 25 cm from the eyepiece. Caiculate magnifying power of the compound microscope in this set-up.

## OR

(b) In Young's double slit experiment, the screen is kept at a distance of 1.2 m from the plane of the slits. The two slits are separated by 5 mm and illuminated with monochromatic light having wavelength 600 nm . Calculate:
(i) Fringe width i.e. fringe separation of the interference pattern.
(ii) Distance of $10^{\text {th }}$ bright fringe from the centre of the pattern.

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## Question 18

Draw the energy level diagram of hydrogen atom and show the transitions responsible for:
(i) absorption lines of Lyman series.
(ii) emission lines of Balmer series.

## Question 19

(i) State any one difference between energy band diagram of conductors and that of insulators.
(ii) Give a relation between $\alpha$ and $\beta$ for a transistor.
(Derivation is not required.)
(iii) What is the advantage of an LED bulb over the filament electric bulb?

# Section D <br> Answer all questions. 

## Question 20

(a) (i) $\mathrm{A} 400 \Omega$ resistor, a 3 H inductor and a $5 \mu \mathrm{~F}$ capacitor are connected in series to a $220 \mathrm{~V}, 50 \mathrm{~Hz}$ ac source. Calculate the:
(1) Impedance of the circuit.
(2) Current flowing through the circuit.
(ii) Draw a labelled graph showing the variation of impedance $(Z)$ of a series LCR circuit versus frequency ( $f$ ) of the ac supply.

## OR

(b) (i) When an alternating emf $\mathrm{e}=310 \sin (100 \pi \mathrm{t}) \mathrm{V}$ is applied to a series LCR circuit, current flowing through it is $i=5 \sin (100 \pi t+\pi / 3) A$.
(1) What is the phase difference between the current and the emf?
(2) Calculate the average power consumed by the circuit.
(ii) Obtain an expression for the resonant frequency $\left(f_{0}\right)$ of a series LCR circuit.

## Question 21

(a) (i) Derive an expression for refraction at a single (convex) spherical surface, i.e. a relation between $u, v, R, n_{1}$ (rarer medium) and $\mathrm{n}_{2}$ (denser medium), where the terms have their usual meaning.
(ii) Name the phenomenon due to which the sun appears reddish at sunset.
(b) (i) Draw a labelled graph of intensity of diffracted light (I) versus angle $(\theta)$ in the Fraunhofer diffraction experiment for a single slit diffraction.
(ii) State the law of Malus.
(iii) How will you distinguish experimentally between ordinary light and plane polarized light?

Question 22
(a) (i) In a semiconductor diode, what is meant by potential barrier?
(ii) Draw a labelled circuit diagram of a Zener diode as a voltage regulator.
(iii) Show with the help of a diagram, how you will obtain an AND gate using only NAND gates. (Truth table is not required.)

## OR

(b) (i) Draw a labelled circuit diagram of a transistor acting as a common emitter amplifier. What is meant by phase reversal?
(ii) Draw the symbol of a NAND gate and write its truth table.

Useful Constant and Relation:

| $1 u$ | $=931 \mathrm{MeV}$ |
| :--- | :--- | :--- |

