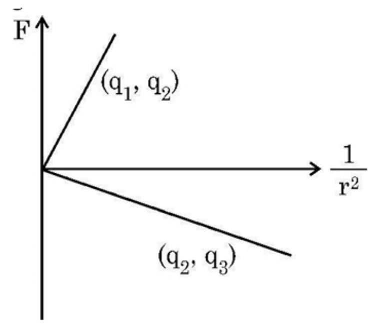
QUESTION BANK

CLASS – XII

SUBJECT -PHYSICS (042)

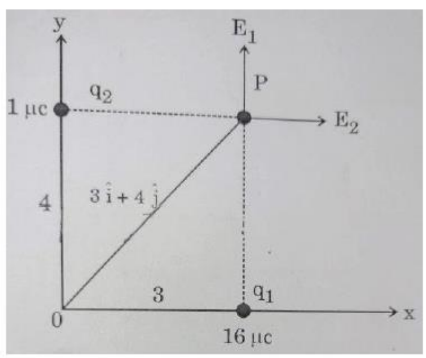
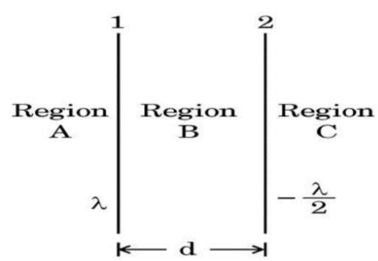
NOTE: Appropriate option for MCQ and Suggestive value points are provided with each question for answer formulation.

CHAPTER -1 ELECTRIC CHARGES AND FIELD

Q. N.	**SECTION (A) CARRY 1 MARK EACH**	**CBSE-2025**
1	Figure shows variation of Coulomb force F versus $\frac{1}{r^2}$, r being the separation between two pairs of point charges (q_1 and q_2) and (q_2 and q_3). If q_2 is positive and least in magnitude, then the magnitudes q_1, q_2 and q_3 are such that:  (a) $q_2<q_3<q_1$ (b) $q_3<q_1<q_2$ (c) $q_1<q_2<q_3$ (d) $q_2<q_1<q_3$ **APPROPRIATE OPTION. (a) $q_2<q_3<q_1$**	MAIN
2.	Two charges, each of charge -q are placed on vertices A and B of an equilateral triangle ABC. If M is the mid -point of AB the net electric field at C will point along: (a)CA (b)CB (c)MC (d) CM. **APPROPRIATE OPTION. (d) CM**.	MAIN
3.	Two identical point charges are placed at the two vertices A and B of an equilateral triangle of side *l*. The magnitude of the electric field at the third vertex P is E. If a hollow conducting sphere of radius (*l*/4) is placed at P, the magnitude of the electric field at point P now becomes (a) >E (b) E (c) E/2 (d) zero. **APPROPRIATE OPTION. (d) zero.**	MAIN

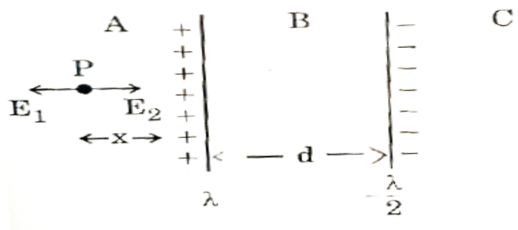
4.	Consider two identical dipoles D_1 and D_2. Charges -q and q of dipole D_1 are located at (0, 0) and (a, 0) and that of dipole D_2 at (0, a) and (0, 2a) in x-y plane, respectively. The net dipole moment of the system is (a) $qa(\hat{i} + \hat{j})$ (b) $-qa(\hat{i} + \hat{j})$ (c) $qa(\hat{i} - \hat{j})$ (d) $-qa(\hat{i} - \hat{j})$. **APPROPRIATE OPTION. (a) $qa(\hat{i} + \hat{j})$**	MAIN
5.	A body acquires charge $8{\cdot}0 \times 10^{-12}$ C. The mass of the body: (a) increases by $4{\cdot}5 \times 10^{-7}$ kg (b) decreases by $1{\cdot}0 \times 10^{-6}$ kg (c) decreases by $4{\cdot}55 \times 10^{-23}$ kg (d) increases by $9{\cdot}1 \times 10^{-23}$ kg. **APPROPRIATE OPTION.**	MAIN
6.	An electric dipole of dipole moment $1{\cdot}0 \times 10^{-12}$ Cm lies along x-axis. An electric field of magnitude $2{\cdot}0 \times 10^4$ NC^{-1} is switched on at an instant in the region. The unit vector along the electric field is $\frac{\sqrt{3}}{2}\hat{\imath}+\frac{1}{2}\hat{\jmath}$ The magnitude of the torque acting on the dipole at that instant is: (a) $0{\cdot}5 \times 10^{-6}$ Nm (b) $1{\cdot}0 \times 10^{-8}$ Nm (c) $2{\cdot}0 \times 10^{-8}$ Nm (d) $4{\cdot}0 \times 10^{-8}$ Nm **APPROPRIATE OPTION. (b) $1{\cdot}0 \times 10^{-8}$ Nm**	MAIN
7.	Two-point charges Q and -q are held r distance apart in free space. A uniform electric field is applied in the region perpendicular to the line joining the two charges. Which one of the following angles will the direction of the net force acting on charge q make with the line joining Q and -q? (a) $\tan^{-1}\frac{4\pi\epsilon_0 Er^2}{Q}$ (b) $\cot^{-1}\frac{4\pi\epsilon_0 Er^2}{Q}$ (c) $\tan^{-1}\frac{QE}{4\pi\epsilon_0 Er^2}$ (d) $\cot^{-1}\frac{QE}{4\pi\epsilon_0 Er^2}$ **APPROPRIATE OPTION.** (a) $\tan^{-1}\frac{4\pi\epsilon_0 Er^2}{Q}$	MAIN
8.	A particle of mass m and charge q moving with velocity $v\hat{\imath}$ is subjected to a uniform electric field $E\hat{\jmath}$. The particle will initially have a tendency to move in a circle of radius: (a) (mv/qE) in x-y plane (b) $\frac{mv^2}{qE^2}$ in x-z plane (c) $\frac{mv^2}{qE}$ in x-y plane (d) $\frac{mv}{qE^2}$ in y-z plane **APPROPRIATE OPTION. (c)**	MAIN

9.	When a negative charge (-Q) is brought near one face of a metal cube, the: (a) cube becomes positively charged (b) cube becomes negatively charged (c) face near the charge becomes positively charged and the opposite face becomes negatively charged (d) face near the charge becomes negatively charged and the opposite face becomes positively charged **APPROPRIATE OPTION. (c)**	COMP
10.	The electric flux through a Gaussian spherical surface enclosing a point charge q is ϕ. If the charge is replaced by an electric dipole, magnitude of its dipole moment being 2qa, the flux through the surface will be: (a) 2 ϕ (b) ϕ (c) ϕ /2 (d) Zero. **APPROPRIATE OPTION. (d) Zero.**	BLIND
11.	A small metallic sphere S of charge +q is placed exactly at a point midway between two-point charges A (+Q) and B (+Q) where Q >> q. If the sphere is slightly displaced towards charge A and released, then: (a) it will move further towards A (b) it will move towards B (c) it will oscillate about its original position (d) it will not move at all. **APPROPRIATE OPTION. (c)**	COMP
12.	A charge Q is enclosed by a spherical Gaussian surface of radius R. If the radius is doubled, then the total electric flux through the surface: (a) becomes four times (b) remains the same (c) becomes half (d) becomes twice. **APPROPRIATE OPTION. (b) remains the same**	COMP
13.	Which of the following statements about electric field E is incorrect? (a) The magnitude of the electric field due to a point charge is proportional to $\frac{1}{r^2}$, where r is the distance of the point from the charge. (b) The magnitude of the electric field is zero at all points in a region where the potential is zero. (c) Electric field is a vector quantity. (d) The magnitude of the electric field at a point is a measure of the force experienced by a unit charge at that point. **APPROPRIATE OPTION. (b)**	BLIND COMP

14.	A charge of -1 μC on a body represents: (a) loss of 6.25×10^{12} electrons by the body. (b) gain of 6.25×10^{12} electrons by the body. (c) gain of 1.6×10^{13} electrons by the body. (d) loss of 1.6×10^{13} electrons by the body. **APPROPRIATE OPTION. (b)**	BLIND
15.	**Assertion (A):** Electrostatic force is a conservative force. **Reason (R):** In an electrostatic field, the work done between two points per unit positive charge depends on the path followed. **APPROPRIATE OPTION. (c)**	COMP
	SECTION (B) CARRY 2 MARK EACH	
16.	Two-point charges q_1 (= 16μ C) and q_2 (= 1 μC) are placed at points $\vec{r_1}$= (3 m)$\hat{\imath}$ and $\vec{r_2}$= (4 m)$\hat{\jmath}$. Find the net electric field $\vec{E}$ at point $\vec{r}$= (3 m)$\hat{\imath}$ + (4 m)$\hat{\jmath}$. **SUGGESTIVE VALUE POINTS** Finding net electric field at point $\vec{r}$ 2 (ii) $\vec{E} = \frac{Kq}{r^2}\hat{r}$ $\vec{E}_1 = \frac{9\times10^9\times16\times10^{-6}}{(4)^2}\hat{j}$ $= 9\times10^3\ \hat{j}$ $\vec{E}_2 = \frac{9\times10^9\times1\times10^{-6}}{(3)^2}\hat{i}$ $= 10^3\ \hat{i}$ $\vec{E}_{net} = (\hat{i}+9\hat{j})10^3\ N/C$ 	MAIN
	SECTION (C) CARRY 3 MARK EACH	
17.	Two infinitely long straight wires 1 and 2 are placed d distance apart, parallel to each other, as shown in the figure. They are uniformly charged having charge densities λ and -λ/2 respectively. Locate the position of the point from wire 1 at which the net electric field is zero and identify the region in which it lies. 	MAIN

SUGGESTIVE VALUE POINTS

Location of point at which net electric field is zero	2½
Identification of Region	½



Electric field due to wire 1 and wire 2 at point P

$$E_1 = \frac{\lambda}{2\pi\varepsilon_0 x}$$

$$E_2 = \frac{\lambda/2}{2\pi\varepsilon_0 (x+d)}$$

At P, Net electric field is zero

$$E_1 = E_2$$

$$\frac{\lambda}{2\pi\varepsilon_0 x} = \frac{\lambda}{2\times 2\pi\varepsilon_0 (x+d)}$$

$$x = -2d$$

Negative sign indicates that point lies in the region C.

At a distance 2d from wire 1 electric field is zero.

18. An electric field E given by: $\vec{E} = 100\hat{\imath} N/C$ for x>0 — MAIN

$\vec{E} = -100\hat{\imath} N/C$ for x<0 exists in a region.

A right circular cylinder of length 10 cm and radius 2 cm, is placed in the region such that its axis coincides with x-axis and its two faces are at x =- 5 cm and x = 5 cm.

Calculate: (a) the net outward flux through the cylinder, and (b) the net charge inside the cylinder.

SUGGESTIVE VALUE POINTS

Calculating	
(a) Net outward flux through the cylinder	2
(b) Net charge inside the cylinder	1

$$\phi_L = \overline{\vec{E}.\overrightarrow{\Delta S}}$$

$$= 100(-\hat{i}).\Delta S(-\hat{i})$$

$$= 100\times\pi\left(2\times 10^{-2}\right)^2$$

$$= 4\pi\times 10^{-2}\ \mathrm{Nm^2/C}$$

$$\phi_R = 100(\hat{i}).\Delta S(\hat{i})$$

$$= 100\times\pi\left(2\times 10^{-2}\right)^2$$

$$= 4\pi\times 10^{-2}\ \mathrm{Nm^2/C}$$

	$\phi_{total} = \phi_L + \phi_R$ $= 8\pi \times 10^{-2}\ Nm^2/C$ $= 25.12 \times 10^{-2}\ Nm^2/C$ Charge $q = \varepsilon_0\, \phi_{total}$ $= 25.12 \times 10^{-2} \times 8.85 \times 10^{-12}$ $= 0.22 \times 10^{-11}\ C$	
19.	(i) Define electric flux. Is it a scalar or a vector quantity? (ii)A point charge q is kept at a distance of d /2 directly above the centre of a square of side d. Use Gauss' law to obtain the expression for the electric flux through the square. (iii) If the point charge is now moved to a point at a distance 'd' from the centre of the square and the side of the square is doubled, explain how the electric flux through the square will be affected. **SUGGESTIVE VALUE POINTS** • Defining electric flux ½ • Stating scalar or vector quantity ½ • Obtaining expression for the electric flux through the square 1 • Effect on electric flux through the square 1 Flux through one face (square) $= \dfrac{q_{en}}{6\varepsilon_0}$ If a charge is now moved to the point of a distance d from the center of square and side of the square is doubled, then electric flux through square remains unchanged because electric flux through a closed surface depends only on the amount of charge contained inside the closed surface and is independent of the size of the Gaussian surface.	COMP
	SECTION (E) **LONG ANSWER CARRY 5 MARKS**	
20.	**(i)** Two point charges $5\ \mu C$ and $-1\ \mu C$ are placed at points $(-3\text{ cm}, 0, 0)$ and $(3\text{ cm}, 0, 0)$ respectively. An external electric field $\vec{E} = \frac{A}{r^2}\hat{r}$ where $A = 3 \times 10^5\ Vm$ is switched on in the region. Calculate the change in electrostatic energy of the system due to the electric field. **(ii)** A system of two conductors is placed in air and they have net charge of $+80\ \mu C$ and $-80\ \mu C$ which causes a potential difference of $16\ V$ between them. (1) Find the capacitance of the system. (2) If the air between the capacitor is replaced by a dielectric medium of dielectric	MAIN

constant 3, what will be the potential difference between the two conductors?

(3) If the charges on two conductors are changed to $+160\ \mu C$ and $-160\ \mu C$, will the capacitance of the system change? Give reason for your answer.

SUGGESTIVE VALUE POINTS

i) Calculating the change in electrostatic energy of the system	2
ii) (1) Finding the capacitance.	1
(2) Finding the potential difference.	1
(3) Answering and Reason	½ + ½

(i) $\vec{E} = \dfrac{3\times10^5}{r^2}\hat{r}$ (Given) $dV = -\vec{E}.d\vec{r}$

$V = 3\times10^5 / r$

Electrostatic energy of the system in the absence of the field

$$U_i = \frac{Kq_1q_2}{r_{12}}$$

Electrostatic energy in the presence of the field

$$U_f = \frac{Kq_1q_2}{r_{12}} + q_1V(\vec{r}_1) + q_2V(\vec{r}_2)$$

$$\Delta U = U_f - U_i = q_1V(\vec{r}_1) + q_2V(\vec{r}_2)$$

$$\Delta U = \frac{5\times10^{-6}\times3\times10^5}{3\times10^{-2}} - \frac{1\times10^{-6}\times3\times10^5}{3\times10^{-2}}$$

$$= 40\ J$$

ii) 1) $C = \dfrac{Q}{V} = \dfrac{80}{16} = 5\mu F$

2) $C' = KC$

$= 3\times5\mu F = 15\ \mu F$

$V' = \dfrac{Q}{C'} = \dfrac{80\mu C}{15\mu F} = 5.33V$

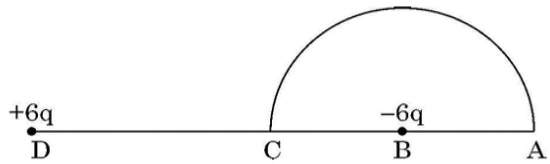
3) No,

The capacitance of the system depends on its geometry.

21. **(i)** Consider three metal spherical shells A, B and C, each of radius R. Each shell is having a concentric metal ball of radius R/10. The spherical shells A, B and C are given charges +6q, –4q, and 14q respectively. Their inner metal balls are also given charges –2q, +8q and –10q respectively. Compare the magnitude of the electric fields due to shells A, B and C at a distance 3R from their centres. MAIN

(ii) A charge –6 µC is placed at the centre B of a semicircle of radius 5 cm, as shown in the figure. An equal and opposite charge is placed at point D at a distance of 10 cm from B. A charge +5 µC is moved from point ‘C’ to point ‘A’ along the circumference.

Calculate the work done on the charge.



SUGGESTIVE VALUE POINTS

i) Comparing the magnitude of the Electric fields 2

ii) Calculating the work done on the charge 3

Total charge for A = Total charge for B = Total charge for C = +4q

Since Q = 4q and r = 3R

$$E = \frac{k(4q)}{9R^2} = \frac{4kq}{9R^2}$$

$$\therefore\ E_A = E_B = E_c$$

$$\text{ii) } V_c = \left[\frac{k \times 6 \times 10^{-6}}{5 \times 10^{-2}} - \frac{k \times 6 \times 10^{-6}}{5 \times 10^{-2}}\right]$$

$$= 0$$

$$V_A = \left[\frac{k \times 6 \times 10^{-6}}{15 \times 10^{-2}} - \frac{k \times 6 \times 10^{-6}}{5 \times 10^{-2}}\right]$$

$$= \frac{k \times 6 \times 10^{-6}}{10^{-2}}\left[\frac{1-3}{15}\right]$$

$$= -\frac{9 \times 10^9 \times 6 \times 10^{-6} \times 2}{15 \times 10^{-2}}$$

$$= -7.2 \times 10^5\ V$$

$$W = q[V_A - V_c]$$

$$= 5 \times 10^{-6}[-7.2 \times 10^5 - 0]$$

$$W = -3.6\ J$$

22. (i) What is difference between an open surface and a closed surface? Draw elementary surface vector ds for a spherical surface S. MAIN

(ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why?

(iii) A small spherical shell S_1 has point charges $q_1 = -3\ \mu C$, $q_2 = -2\ \mu C$ and $q_3 = 9\ \mu C$ inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q.

SUGGESTIVE VALUE POINTS

<table>
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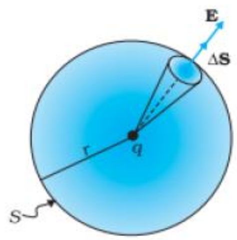
(i) Difference between an open surface and a closed surface	½
Diagram of elementary surface vector $\vec{ds}$	1
(ii) Definition of electric flux	1
Significance of Gaussian Surface	½
Reason	½
(iii) Finding charge Q	1½

(i) Open Surface – A surface which does not enclose a volume.
Closed Surface – A surface which does enclose a volume.



(ii) Electric flux is defined as the number of electric field lines crossing an area normally.

Significance of Gaussian Surface: -

It helps in finding the electric field in a simpler way.

Reason: -

Because any electric field line from the charge which enters the surface at one point will exit at another, resulting in a net zero flux.

(iii) Total charge enclosed by $S_1 = (-3-2+9)\ \mu C = 4\ \mu C$
Total charge enclosed by $S_2 = Q + 4\ \mu C$

$\phi_{s_2} = 4\phi_{s_1}$

$$\frac{Q + 4\mu C}{\varepsilon_o} = 4\left(\frac{4\mu C}{\varepsilon_o}\right)$$

$Q = 12\ \mu C$
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<td>23.</td>
<td>(a) (i)Two-point charges + q and -q are held at (a, 0) and (- a, 0) in x-y plane. Obtain an expression for the net electric field due to the charges at a point (0, y).
Hence, find electric field at a far-off point (y >> a).
(ii) Three-point charges of 2 nC, 1 nC, and + 5 nC are kept at the vertices A, B and C of an equilateral triangle of side 0·2 m. Find the total amount of work done in shifting the charges from A to A_1, B to B_1 and C to C_1. Here A_1, B_1 and C_1 are the midpoints of sides AB, BC and CA, respectively.</td>
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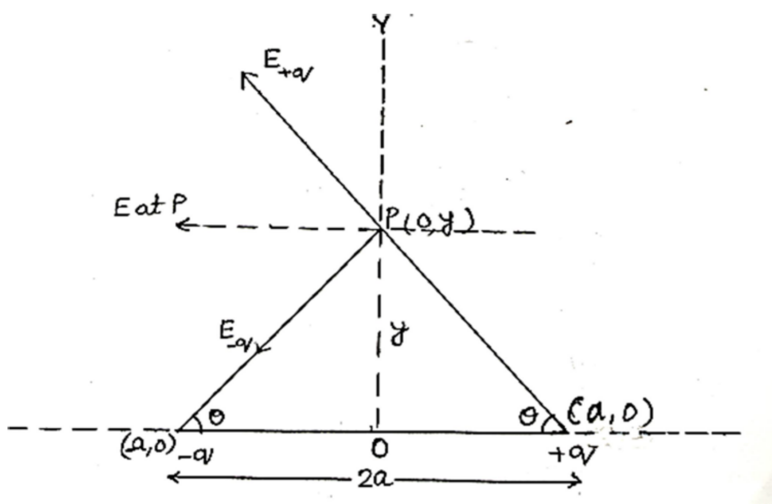
(a) (i) SUGGESTIVE VALUE POINTS

(i) Finding electric field at a far off point (y>>a)	3
(ii) Calculation of work done in shifting the charges	2



Magnitude of electric field due to the two charges +q and -q are given by

$$E_{+q} = \frac{q}{4\pi\varepsilon_o}\frac{1}{y^2+a^2}$$

$$E_{-q} = \frac{q}{4\pi\varepsilon_o}\frac{1}{y^2+a^2}$$

Components normal to the dipole axis cancel out.

The components along the dipole axis add up.

The total electric field is opposite to the dipole moment will be given by-

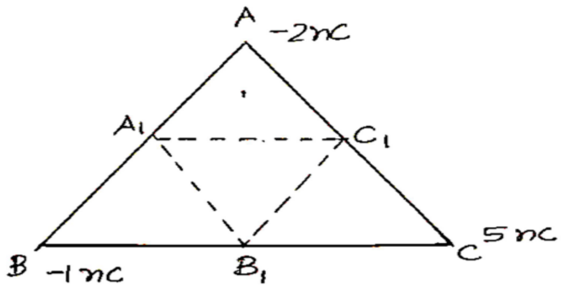
$$\vec{E} = -\,(E_{+q}+E_{-q})\cos\theta\,\hat{p}$$

$$= -\,\frac{2qa}{4\pi\varepsilon_o(y^2+a^2)^{3/2}}\hat{p}$$ ($\hat{p}$ is a unit vector along dipole moment)

At large distance (y>>a)

$$\vec{E}=\frac{-2qa}{4\pi\varepsilon_o y^3}\hat{p}$$

(ii) **SUGGESTIVE VALUE POINTS**



Initial electrostatic potential energy of the system

$$U_1=\frac{1}{4\pi\varepsilon_o}\left(\frac{q_A q_B}{AB}+\frac{q_C q_A}{AC}+\frac{q_C q_B}{BC}\right)$$

$$=\frac{9\times10^9}{0.2}\left[(-2\times-1)+(-2\times5)+(-1\times5)\right]\times10^{-18}$$

$$U_1=-5.85\times10^{-7}J$$

$$U_2=\frac{1}{4\pi\varepsilon_o}\left(\frac{q_{A_1}q_{B_1}}{A_1B_1}+\frac{q_{C_1}q_{A_1}}{A_1C_1}+\frac{q_{c_1}q_{B_1}}{B_1C_1}\right)$$

$$U_2=-11.7\times10^{-7}J$$

$$W=U_2-U_1=-5.85\times10^{-7}J$$

OR

(b)

(i) Show that Gauss's theorem is consistent with Coulomb's law. Using it, derive an expression for the electric field due to a uniformly charged thin spherical shell of radius r at a point at a distance y from the centre of the shell such that (I) y > r, and (II) y < r.

(ii) A point charge of + 2 nC is kept at the origin of a three-dimensional coordinate system. Find the type and magnitude of the charge which should be kept at (0, 0, – 6m) so that the potential due to the system becomes zero at (0, 0, 2m).

(b) (i) **SUGGESTIVE VALUE POINTS**

(i)

- Showing consistency of Gauss's theorem with Coulomb's law 1
- Derivation for electric field due to uniformly charged thin spherical shell at (I) $y > r$ (II) $y < r$ 2

(ii) Finding type and magnitude of charge 2

- Gauss's theorem is based on the inverse square dependence on distance contained in the coulomb's law.

Alternatively-

According to Gauss's theorem

$$\oint \vec{E}.d\vec{s} = \frac{q}{\varepsilon_o}$$

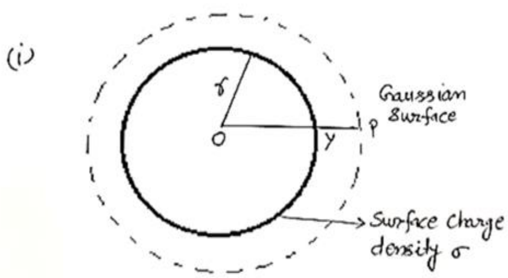
$$E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$$

According to Coulomb's law, force on charge q_o in this field

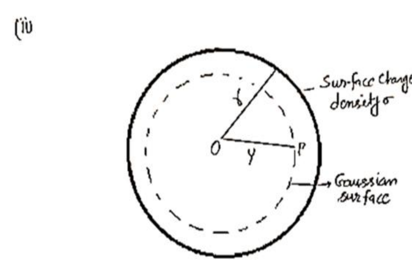
$$F = \frac{1}{4\pi\varepsilon_o}\frac{qq_o}{r^2}$$

Therefore, Gauss's law is consistent with Coulomb's law

(I) For $y > r$



(II) For $y < r$



Electric flux through Gaussian surface $E \times 4\pi y^2$

The charge enclosed by the surface $\sigma \times 4\pi r^2$

Using Gauss theorem

$$E(4\pi y^2) = \frac{\sigma 4\pi r^2}{\varepsilon_\circ}$$

$$\vec{E} = \frac{q}{4\pi\varepsilon_0 y^2}\hat{r}$$

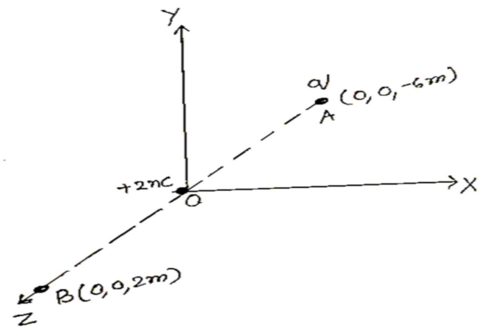
The charge enclosed by Gaussian surface = 0

Using Gauss theorem

Electric flux $= E(4\pi y^2) = 0$

i.e. $E = 0 \quad (y < r)$

(ii)



Let the charge is kept at A be q

Potential at point B due to charge at the origin O and charge (q) at A

$$V = V_1 + V_2$$

$$V = \frac{1}{4\pi\varepsilon_0}\left[\frac{2\times10^{-9}}{2} + \frac{q}{6+2}\right]$$

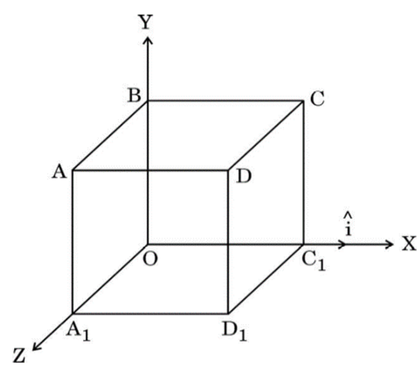
$$\frac{1}{4\pi\varepsilon_0}\left[10^{-9} + \frac{q}{8}\right] = 0$$

$$q = -8\times10^{-9}\,C$$

24. (i) Obtain an expression for the electric field of dipole moment due to a dipole at a point on its equatorial plane and specify its direction. Hence, find the value of electric field: (I) at the centre of the dipole (r = 0), and (II) at a point r >> a, where 2a is the length of the dipole.

(ii) An electric field $\vec{E} = (10x + 5)\hat{i}$ N/C exists in a region in which a cube of side L is kept as shown in the figure. Here x and L are in metres. Calculate the net flux through the cube.

MAIN

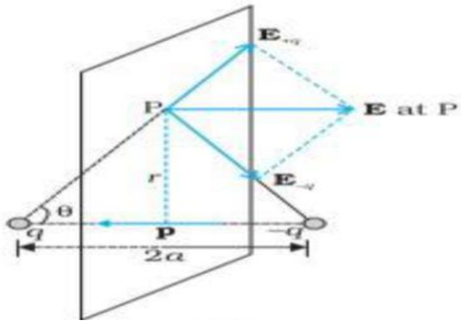


(i)	Obtaining expression for electric field due to a dipole on its equatorial plane	2
	Finding electric field:	
	(I) At centre of the dipole	½
	(II) At a point r >> a	½
(ii)	Calculating net electric flux through cube	2

(i)

SUGGESTIVE VALUE POINTS

(i)



The magnitudes of the electric field due to two charges +q and -q are

$$E_{+q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{\left(r^2+a^2\right)}$$

$$E_{-q} = \frac{q}{4\pi\varepsilon_0}\frac{1}{\left(r^2+a^2\right)}$$

The total electric field

$$\vec{E} = -\left(E_{+q}+E_{-q}\right)\cos\theta\,\hat{p}$$

$$\vec{E} = -\frac{\vec{p}}{4\pi\varepsilon_0\left(r^2+a^2\right)^{3/2}}$$

Direction of electric field is opposite to dipole moment ($\vec{p}$)

(I) At centre of dipole, r = 0

$$\vec{E} = -\frac{-\vec{p}}{4\pi\varepsilon_0 a^3}$$

(II) At a point r>>a

$$\vec{E} = -\frac{-\vec{p}}{4\pi\varepsilon_0 r^3}$$

(ii) $\vec{E} = (10x+5)\hat{i}$ N/C

$$\phi_L = \int \vec{E}.\vec{ds}$$

$$= -E_L(L^2)$$

$$= -5L^2$$

$$\phi_R = E_R(L^2)$$

$$= (10L+5)L^2$$

$$\phi_{net} = \phi_L + \phi_R$$

$$= -5L^2 + (10L+5)L^2$$

$$= 10L^3 \;\; \text{Nm}^2/\text{C}$$

25. (i) Write Coulomb's law of electrostatics in vector form. Apply it to determine the electric field at a point due to a system of point charges. — COMP

(ii) ABC is an equilateral triangle of side l. Two-point charges +2 μC each, are located at points B and C. Find the sign and magnitude of the point charge q to be kept at the midpoint M of the side BC, so that the net electric field at point A becomes zero.

SUGGESTIVE VALUE POINTS

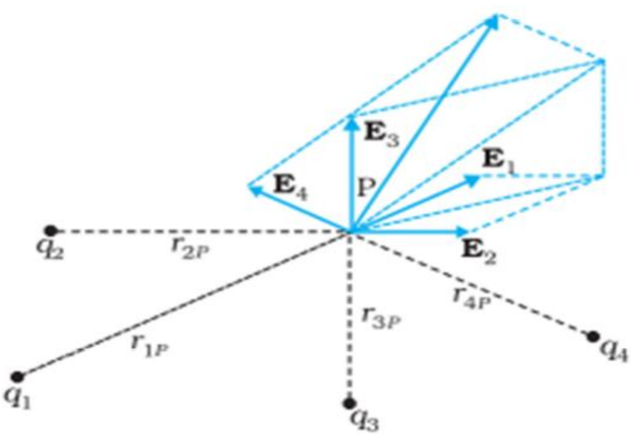
(i) Writing coulomb's law in vector form	1
Determining the electric field due to a system of point charges	2
(ii) Finding sign and magnitude of q	2

(i) $\vec{F}_{21} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{21}^2}\hat{r}_{21}$

Alternative: $\vec{F}_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r_{12}^2}\hat{r}_{12}$

OR $\vec{F} = \frac{1}{4\pi\varepsilon_0}\frac{q_1 q_2}{r^2}\hat{r}$

For determining electric field due to a system of point charges



$\vec{E}_1 = \frac{1}{4\pi\varepsilon_0}\frac{q_1}{r_{1p}^2}\hat{r}_{1p}$

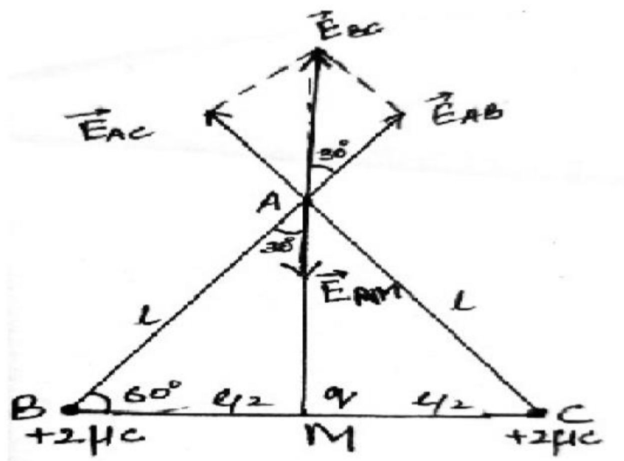
$$\vec{E}_2 = \frac{1}{4\pi\varepsilon_0}\frac{q_2}{r_{2p}^2}\hat{r}_{2p}$$

and so on

By superposition principle

$$\vec{E} = \vec{E}_1 + \vec{E}_2 + \ldots\ldots\ldots\ldots + \vec{E}_n$$

(ii)



From the figure

$$\left|\vec{E}_{AB}\right| = \frac{1}{4\pi\varepsilon_0}.\frac{q}{r^2}$$

$$= \frac{1}{4\pi\varepsilon_0}.\frac{2\times10^{-6}}{l^2}$$

$$\left|\vec{E}_{AC}\right| = \frac{1}{4\pi\varepsilon_0}.\frac{2\times10^{-6}}{l^2}$$

$$\because \quad \left|\vec{E}_{AB}\right| = \left|\vec{E}_{AC}\right|$$

$\therefore$ Resultant of $\vec{E}_{AB}$ & $\vec{E}_{AC}$

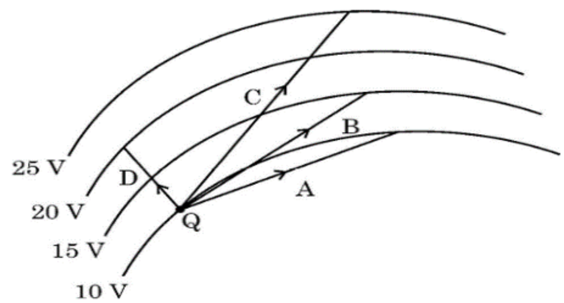
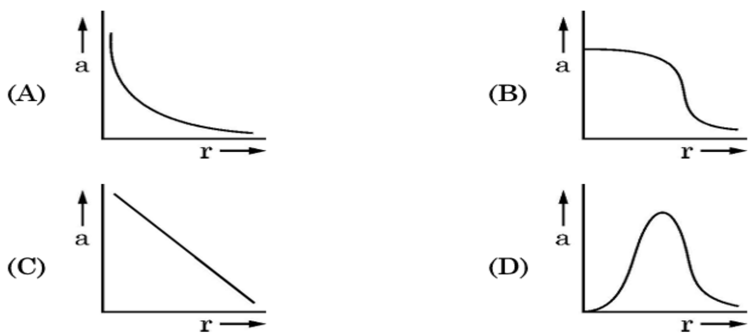
$$\vec{E}_{BC} = \vec{E}_{AB} + \vec{E}_{AC}$$

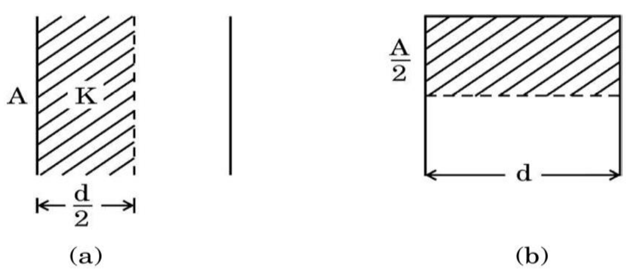
$$\left|\vec{E}_{BC}\right| = 2E_{AB}\cos 30^\circ$$

$$\left|\vec{E}_{BC}\right| = \frac{1}{4\pi\varepsilon_0}.\frac{2\times10^{-6}}{l^2}\frac{\sqrt{3}}{2}$$

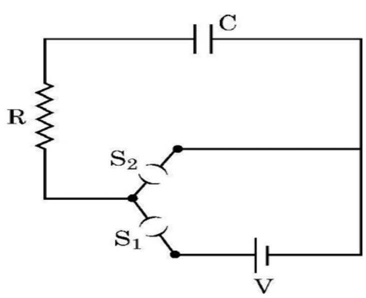
$$\left|\vec{E}_{AM}\right| = \frac{1}{4\pi\varepsilon_0}.\frac{q}{\left(\frac{l\sqrt{3}}{2}\right)^2}$$

CHAPTER -2 ELECTROSTATIC POTENTIAL AND CAPACITANCE

Q.N.	**SECTION (A) CARRY 1 MARK EACH**	**CBSE-2025**
1.	In the figure curved line represent equipotential surfaces. A charge Q is moved along different paths A, B, C and D. The work done the charge will be maximum along the path:  (a)A (b) B (c) C (d) D **APPROPRIATE OPTION. c**	MAIN
2.	A charge Q is fixed in position. Another charge q is brought near Q and released from rest. Which of the following graph is the correct representation of the acceleration of the charge q as a function of its distance r from the charge Q?  **APPROPRIATE OPTION. (A)**	MAIN
3.	A metal sheet is inserted between the plates of a parallel plate capacitor of capacitance C. If the sheet partly occupies the space between the plates, the capacitance: (a) remains C (b) becomes greater than C (c) becomes less than C (d) becomes zero. **APPROPRIATE OPTION. (b) becomes greater than C**	MAIN
4.	The electric field at a point in a region is given by $\vec{E} = \alpha \frac{\vec{r}}{\lvert\vec{r}\rvert^3}$ where α is a constant and r is the distance of the point from the origin. The magnitude of potential of the point is:	MAIN

	(a)α/r (b)αr^2/2 (c) $\frac{\alpha}{2r^2}$ (d)$\frac{-\alpha}{r}$. **APPROPRIATE OPTION.** (a)α/r	
5.	Four-point charges Q each, are held at the four corners of a square of side l. The amount of work done in bringing a charge Q from infinity to the centre of the square will be: (A) $\frac{Q^2}{\pi \varepsilon_0 l}$ (B) $\frac{\sqrt{2} Q^2}{\pi \varepsilon_0 l}$ (C) $\frac{Q^2}{2\pi \varepsilon_0 l}$ (D) Zero **APPROPRIATE OPTION. (B)**	MAIN
6.	The electric field (E) and electric potential (V) at a point inside a charged hollow metallic sphere are respectively: (a) E = 0, V = 0 (b) E = 0, V = V_0 (a constant) (c) E 0, V 0 (d) E = E_0 (a constant), V = 0. **APPROPRIATE OPTION. (b) E = 0, V = V_0 (a constant)**	MAIN
	SECTION (C) EACH QUESTION CARRY 3 MARKS	
7.	A parallel plate capacitor has plate area A and plate separation d. Half of the space between the plates is filled with a material of dielectric constant K in two ways as shown in the figure.  Find the values of the capacitance of the capacitors in the two cases**.** **SUGGESTIVE VALUE POINTS**	MAIN

	Finding the values of capacitance in two cases 1 ½ + 1 ½ a) $\frac{1}{C} = \frac{1}{K\left(\frac{\varepsilon_0 A}{d/2}\right)} + \frac{1}{\frac{\varepsilon_0 A}{d/2}}$ $\frac{1}{C} = \frac{d}{2K\varepsilon_0 A} + \frac{d}{2\varepsilon_0 A}$ $= \left(\frac{1}{K}+1\right)\frac{d}{2\varepsilon_0 A}$ $C = \left(\frac{2K}{K+1}\right)\frac{\varepsilon_0 A}{d}$ b) $C = \frac{\varepsilon_0 AK}{2d} + \frac{\varepsilon_0 A}{2d}$ $= \left(\frac{K+1}{2}\right)\frac{\varepsilon_0 A}{d}$	
8.	Two small solid metal balls A and B of radii R and 2R having charge densities 2σ and 3σ respectively are kept far apart. Find the charge densities on A and B after they are connected by a conducting wire. **SUGGESTIVE VALUE POINTS** (a) Finding charge densities on A and B 3 For ball A $q_1 = 2\sigma \times 4\pi R^2$ $= 8\pi R^2\sigma$ For ball B $q_2 = 3\sigma \times 4\pi(2R)^2$ $= 48\pi R^2\sigma$ Total charge (Q) $= q_1 + q_2$ $= 56\pi R^2\sigma$ When balls A and B are connected by a wire, their potentials will be equal Let q be the charge on ball A and (Q – q) be the charge on the ball B after connecting wire. $\frac{Kq}{R} = \frac{K(Q-q)}{2R}$ $2q = Q - q$ $q = \frac{Q}{3}$ $= \frac{56\pi R^2\sigma}{3}$	MAIN

9.	Two-point charges of -5 μC and 2μC are located in free space at (-4 cm, 0) and (6 cm, 0) respectively. (a) Calculate the amount of work done to separate the two charges at infinite distance. (b) If this system of charges was initially kept in an electric field $E = \frac{A}{r^2}$, where A =8 × 10^4 m^2N/ C, calculate the electrostatic potential energy of the system. **SUGGESTIVE VALUE POINTS** (a) Calculating work done to separate two charges 1 (b) Calculating electrostatic potential energy 2 (a) $U = \frac{kq_1q_2}{r}$ $= \frac{9\times10^9 \times(-5\times10^{-6})\times(2\times10^{-6})}{10\times10^{-2}}$ $= -0.9\,J$ W = U(infinity) – U(r) = 0.9J (b) $E = \frac{-dV}{dr}$ $dV = \frac{-A}{r^2}dr$ $V = \frac{A}{r}$ $U = q_1 V_1 + q_2 V_2 + \frac{kq_1q_2}{r}$ $= (-5\times10^{-6})\left(\frac{8\times10^4}{4\times10^{-2}}\right) + (2\times10^{-6})\left(\frac{8\times10^4}{6\times10^{-2}}\right) - 0.9$ $= -10 + 2.67 - 0.9$ $= -8.24\,J$	MAIN
	SECTION (D) **CASE STUDY CARRY 4 MARKS**	
10.	A circuit consisting of a capacitor of capacitance C, a resistor of resistance R and ideal battery of emf V as shown in the figure is known as RC series circuit.  As soon as circuit is completed by closing key S_1 (keeping S_2 open) charges begin to flow	MAIN

between the capacitor plates and the battery terminals. The charges on the capacitor increases and consequently the potential difference ($V_c=q/C$) across the capacitor also increases with time. When this potential difference equals the potential difference across the battery, the capacitor is fully charged ($Q=VC$). During this process of charging, the charge q on the capacitor changes with time as $q=Q\,[1-e^{-t/RC}]$

The charging current can be obtained by deafferenting it and using $\frac{d}{dx}e^{mx}=me^{mx}$

Consider the case when R=20kΩ, C=500μF and V=10 Volt.

(i) The final charge on the capacitor, when key S_1 is closed and S_2 is open, is:

(a) 5μC (b)5mC (c)25mC (d)0.1C

(ii) For sufficient time the key S_1 is closed and S_2 is open. Now key S_2 is closed and S_1 is open. What is the final charge on the capacitor?

(a) 5μC (b)5mC (c)2.5mC (d)zero

(iii) The dimensional formula for RC is:

(a) $[ML^2T^{-3}A^{-2}]$ (b) $[M^0L^0T^{-1}A^0]$

(c) $[M^{-1}L^{-2}T^4A^2]$ (d) $[M^0L^0T^1A^0]$

(iv) The key S_1 is closed and S_2 is open. The value of current in resister after 5 seconds, is:

(a) $\frac{1}{2\sqrt{e}}$ mA (b) $\sqrt{e}mA$ (c) $\frac{1}{\sqrt{e}}$ mA (d) $\frac{1}{2e}$ mA

OR

(iv) The key S_1 is closed and S_2 is open. The initial value of charging current in the in the resister, is:

(a)5mA (b)0.5mA (c) 2mA (d)1mA

APPROPRIATE OPTIONS

i) (B) 5mC
ii) (A) zero
iii) (D) $[M^0L^0TA^0]$
iv) (A) $\frac{1}{2\sqrt{e}}mA$

Note: 1 mark for this part may be given to all the students who have attempted other parts of the question.

OR

(B) 0.5 mA

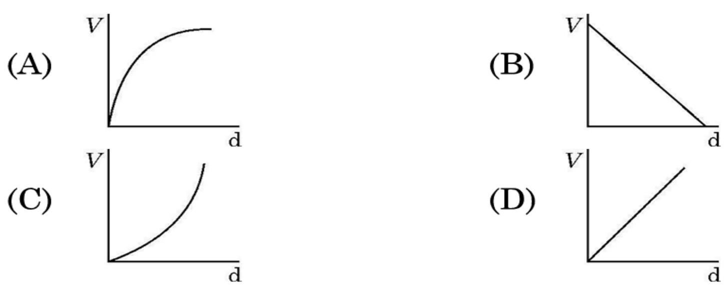
11. A parallel plate capacitor has two parallel plates which are separated by an insulating medium like air, mica, etc. When the plates are connected to the terminals of a battery, they get equal and opposite charges and an electric field is set up in between them. This electric field between the two plates depends upon the potential difference applied, the separation of the plates, and the nature of the medium between the plates. MAIN

(i) The electric field between the plates of a parallel plate capacitor is E. Now the separation between the plates is doubled and simultaneously the applied potential difference between the plates is reduced to half of its initial value. The new value of the electric field between the plates will be:

(a) E (b) 2E (c) E/4 (d) E/9

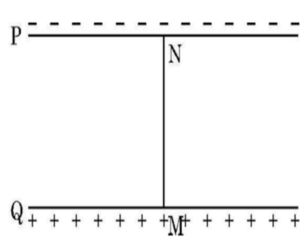
APPROPRIATE OPTIONS. (c)

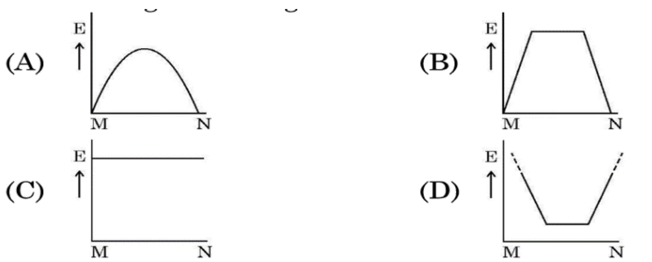
(ii) A constant electric field is to be maintained between the two plates of a capacitor whose separation d changes with time. Which of the graphs correctly depict the potential difference (V) to be applied between the plates as a function of separation between the plates (d) to maintain the constant electric field?



APPROPRIATE OPTIONS. (d)

(iii) In the given figure P, Q are the two parallel plates of a capacitor. Plate Q is at positive potential with respect to plate P. MN is an imaginary line drawn perpendicular to the plates. Which of the graphs shows correctly the variations of the magnitude of electric field strength E along the line MN?





APPROPRIATE OPTIONS. (c)

(iv) Three parallel plates are placed above each other with equal displacement d between neighbouring plates. The electric field between the first pair of the plates is E_1 and the electric field between the second pair of the plates is E_2. The potential difference between the third and the first plate is –

(a) $(\vec{E}_1 + \vec{E}_2).\vec{d}$ (b) $(\vec{E}_1 - \vec{E}_2).\vec{d}$

(c) $(\vec{E}_2 - \vec{E}_1).\vec{d}$ (d) $d(E_1+E_2)/2$

APPROPRIATE OPTIONS. (A)

OR

(iv) A material with a dielectric constant K is placed in a parallel plate capacitor that initially has a capacitance C. The new capacitance will be.

(a)C (c)C/K (c)CK (d) $C(1+K^{-1})$

APPROPRIATE OPTIONS. (C)

LONG ANSWER EACH CARRY 5 MARKS

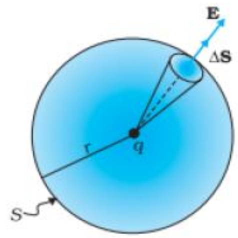
12. (a) (i) A small conducting sphere A of radius r charged to a potential V, is enclosed by a spherical conducting shell B of radius R. If A and B are connected by a thin wire, calculate the final potential on sphere A and shell B. MAIN

(ii) Write two characteristics of equipotential surfaces. A uniform electric field of 50 NC^{-1} is set up in a region along +x axis. If the potential at the origin (0, 0) is 220 V, find the potential at a point (4m, 3m).

SUGGESTIVE VALUE POINTS.

(i) Calculating final potential	
- on sphere A	1
- on shell B	1
(ii) Two characteristics of of equipotential surface	½+½
Finding potential at (4m,3m)	2

	(i) Potential on sphere A = V = $\frac{Q}{4\pi\varepsilon_o r}$ Charge on sphere A = $4\pi\varepsilon_0 r V$ The charge is transferred to shell B. Potential on shell B = $\frac{1}{4\pi\varepsilon_0} \times \frac{4\pi\varepsilon_0 rV}{R}$ Potential on shell B = $\frac{rV}{R}$ Potential on sphere A = Potential on shell B (ii) Characteristics of equipotential surfaces: - (Any two) - Potential at all points on the surface is same. - Equipotential surface is normal to the direction of the electric field. - The work done in moving a charge on an equipotential surface is zero. $V_0 - V = E\,d = 50 \times 4$ $V_0 - V = 200$ V V = 220 V – 200 V V = 20 V	
13.	(i) What is difference between an open surface and a closed surface ? Draw elementary surface vector $d\vec{S}$ for a spherical surface S. (ii) Define electric flux through a surface. Give the significance of a Gaussian surface. A charge outside a Gaussian surface does not contribute to total electric flux through the surface. Why ? (iii) A small spherical shell S_1 has point charges $q_1 = -3\ \mu C$, $q_2 = -2\ \mu C$ and $q_3 = 9\ \mu C$ inside it. This shell is enclosed by another big spherical shell S_2. A point charge Q is placed in between the two surfaces S_1 and S_2. If the electric flux through the surface S_2 is four times the flux through surface S_1, find charge Q. **SUGGESTIVE VALUE POINTS.** (i) Difference between an open surface and a closed surface — ½ Diagram of elementary surface vector $\vec{ds}$ — 1 (ii) Definition of electric flux — 1 Significance of Gaussian Surface — ½ Reason — ½ (iii) Finding charge Q — 1½	MAIN

	(i) Open Surface – A surface which does not enclose a volume. Closed Surface – A surface which does enclose a volume.  (ii) Electric flux is defined as the number of electric field lines crossing an area normally. Significance of Gaussian Surface: - It helps in finding the electric field in a simpler way. Reason: - Because any electric field line from the charge which enters the surface at one point will exit at another, resulting in a net zero flux. (iii) Total charge enclosed by $S_1 = (-3-2+9)\,\mu C = 4\,\mu C$ Total charge enclosed by $S_2 = Q + 4\,\mu C$ $\phi_{s_2} = 4\phi_{s_1}$ $\frac{Q + 4\mu C}{\varepsilon_0} = 4\left(\frac{4\mu C}{\varepsilon_0}\right)$ $Q = 12\,\mu C$	
14.	(a) (i)The electric field in a region is given by $\vec{E}$= 40x$\hat{\imath}$ N/C. Find the amount of work done in taking a unit positive charge from a point (0, 3m) to the point (5m, 0). (ii) A charge Q is distributed over two concentric hollow spheres of radii r and R (> r) such that their surface charge densities are equal. Find: (I) the electric field, (II) and the potential at their common centre. **(a) (i)SUGGESTIVE VALUE POINTS.**	MAIN

(i) Finding the amount of work done	2
(ii) Finding	
(I) The electric field at their common centre	1
(II) The potential at their common centre	2

(a)

(i) $V = -\int \vec{E} \cdot \vec{dr}$

$= -\int 40\, x\, dx$

$= -20\, x^2$

Potential at A (0, 3m), $V_A = 0$

Potential at B (5m, 0), V_B = -500 V

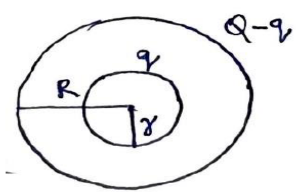
Work done in taking a unit positive charge from a point (0, 3m) to the point (5m, 0)

$W = q(V_B - V_A)$

$= 1(-500 - 0)$

W=-500J

(ii) (I) Electric field at the common centre will be zero as the charge enclosed by the inner sphere is zero.



Alternatively: $q_{en} = 0$

$\phi_E = 0$

$\oint \vec{E}.\vec{ds} = 0$

$E = 0$

(II) $\because$ Surface charge densities are equal

$$\frac{q}{4\pi r^2} = \frac{Q-q}{4\pi R^2}$$

$$q = \frac{Qr^2}{R^2 + r^2}$$

Potential at common centre

$$V = \frac{kq}{r} + \frac{k(Q-q)}{R}$$

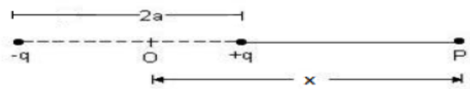
	$V=\frac{k}{r}\frac{Qr^2}{(R^2+r^2)}+\frac{k}{R}\left[Q-\frac{Qr^2}{(R^2+r^2)}\right]$ $V=\frac{kQ(R+r)}{R^2+r^2}$	
15.	(a)(i) A parallel plate capacitor with plate area A and plate separation d has a capacitance C_0. A slab of dielectric constant K having area A and thickness d/4 is inserted in the capacitor, parallel to the plates. Find the new value of its capacitance. (ii) You are provided with a large number of 1µ F identical capacitors and a power supply of 1200 V. The dielectric medium used in each capacitor can withstand up to 200 V only. Find the minimum number of capacitors and their arrangement, required to build a capacitor system of equivalent capacitance of 2µF for use with this supply. **OR** (b)(i) An electric dipole of dipole moment p consists of point charges q and -q, separated by 2a. Derive an expression for electric potential in terms of its dipole moment at a point at a distance x (>> a) from its centre and lying (I) along its axis, and (II) along its bisector line. (ii) An electric dipole of dipole moment $\hat{p}=(0\cdot8\,\hat{\imath}+0\cdot6\hat{\jmath})10^{-29}$ Cm is placed in an electric field $\vec{E}=1\cdot0\;10^7\,\hat{k}$ V/m. Calculate the magnitude of the torque acting on it and the angle it makes with the x-axis, at this instant. **(a) (i) SUGGESTIVE VALUE POINTS** (i) Finding the new value of capacitance — 3 (ii) Finding the number of capacitor — 2 (i) $C_0=\frac{\varepsilon_0 A}{d}$ $C=\frac{\varepsilon_0 A}{(d-t)+\frac{t}{K}}$ $t=d/4$ $C=\frac{\varepsilon_0 A}{\left(d-\frac{d}{4}\right)+\frac{d}{4K}}=\frac{\varepsilon_0 A}{d\left(\frac{3}{4}+\frac{1}{4K}\right)}$ $=C_0\frac{4K}{(3K+1)}$ (ii) Each capacitance can withstand 200V No. of capacitors in each row $=\frac{1200}{200}=6$ Net capacitance of each row= 1/6 µF Number of rows = n $C_{eq}=C_1+C_2+\_\_\_\_\_\_\_+C_n$ $C_{eq}=\frac{1}{6}+\frac{1}{6}+------n$ $2=\frac{n}{6}$ $\therefore n=12$ Total no. of capacitors in the arrangement $=6\times12$ $=72$	MAIN

OR

(b) (i) SUGGESTIVE VALUE POINTS

(i) Deriving the expression of electric potential due to dipole	
I. along its axis	1½
II. along its bisector line	1½
(ii) Calculating the torque	2

I. Along its axis



$$V_- = \frac{-kq}{x+a}$$

$$V_+ = \frac{kq}{x-a}$$

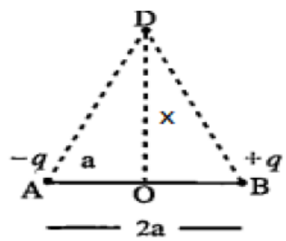
$$V = V_- + V_+$$

$$= kq\left(\frac{-1}{x+a} + \frac{1}{x-a}\right)$$

$$= kq\frac{2a}{(x^2-a^2)} = \frac{kp}{x^2-a^2}$$

$$x \gg a \quad \therefore V = \frac{kp}{x^2}$$

II. Along the bisector line



$$V_- = \frac{kq}{\sqrt{x^2+a^2}}$$

$$V_+ = \frac{-kq}{\sqrt{x^2+a^2}}$$

$$V = V_- + V_+$$

$$= 0$$

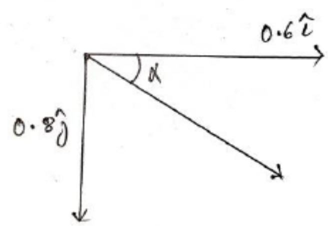
(ii) $\vec{\tau} = \vec{p} \times \vec{E}$

$$= (0.8\hat{i} + 0.6\hat{j}) \times 10^{-29} \times (1 \times 10^7)\hat{k}$$

$$= \left[0.8(-\hat{j}) + 0.6\hat{i}\right] \times 10^{-22}$$

$$\tau = \left[\sqrt{(0.8)^2 + (0.6)^2}\right] \times 10^{-22}$$

$$= 10^{-22}\ Nm$$



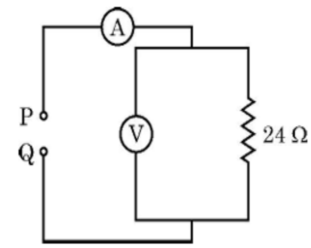
$$\tan\alpha = \frac{|0.8|}{0.6}$$

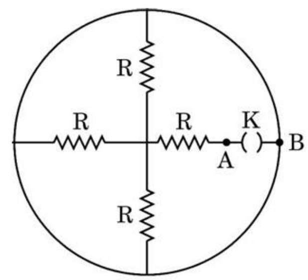
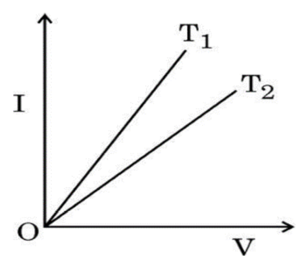
$$\alpha = \tan^{-1}\left(\frac{4}{3}\right)$$

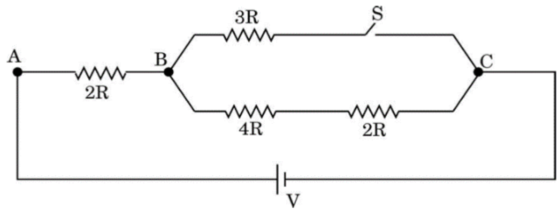
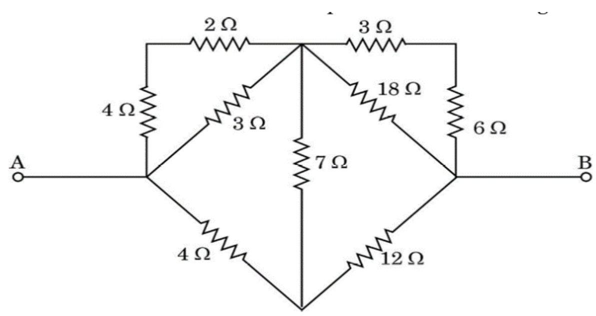
$$\alpha = 53^0$$

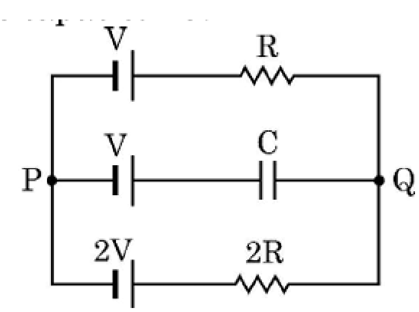
CH 3 CURRENT ELECTRICITY

Q.N.	SECTION (A) CARRY 1 MARK EACH	CBSE 2025
1.	Two wires P and Q are made of the same material. The wire Q has twice the diameter and half the length as that of wire P. If the resistance of wire P is R, the resistance of the wire Q will be (a) R (b) R/2 (c) R/8 (d) 2R. **APPROPRIATE OPTION** (C). R/8	MAIN
2.	The resistance of a wire of length L and radius r is R. Which one of the following would provide a wire of the same material of resistance R/2? (a) Using a wire of same radius and twice the length (b) Using a wire of same radius and half length (c) Using a wire of same length and twice the radius (d) Using a wire of same length and half the radius **APPROPRIATE OPTION.(b)**	MAIN
3.	Two conductors A and B of the same material have their lengths in the ratio 1:2 and radii in the ratio 2:3. If they are connected in parallel across a battery, the ratio $(v_A)/(v_B)$ of the drift velocities of electrons in them will be - (a) 2 (b) ½ (c) 3/2 (d) 8/9 **APPROPRIATE OPTION**. **(a) 2**	MAIN
4.	A student has three resistors, each of resistance R. To obtain a resistance of $\frac{2}{3}R$, she should connect: (a) all the three resistors in series (b) all the three resistors in parallel (c) two resistors in series and this combination in parallel with third resistor (d) two resistors in parallel and this combination in series with third resistor **APPROPRIATE OPTION**. (c)	MAIN
5.	A battery of e.m.f. 12 V and internal resistance 0.5 Ω is connected to a 9.5 Ω resistor through a key. The ratio of potential difference between the two terminals of the battery, when the key is open to that when the key is closed, is:	MAIN

	(a) 1.05 (b) 1 (c) 0.95 (d) 1.1 **APPROPRIATE OPTION. (a) 1.05**	
6.	Which pair of readings of ideal voltmeter and ideal ammeter in the given circuit is possible when a suitable power source of 3 Ω internal resistance is connected between P and Q?  (a) 12.0 V, 2.0 A (b) 2.0 V, 0.5 A (c) 6.0 V, 2.0 A (d) 12 V, 0.5 A **APPROPRIATE OPTION. (d) 12 V, 0.5 A**	MAIN
7.	A current flow through a cylindrical conductor of radius R. The current density at a point in the conductor is j = αr (along its axis), here α is a constant and r is distance from the axis of the conductor. The current flowing through the portion of the conductor from r = 0 to r =R/2 is proportional to: (a) R (b) R^2 (c) R^3 (d) R^4 **APPROPRIATE OPTION. (c) R^3**	MAIN
8.	When the switch of the circuit is turned on, the filament of the bulb glows instantaneously because: (a) the electrons coming from the power source move fast through the initially empty filament. (b) the filament may be old having low resistance. (c) electric field is established instantaneously across the filament which pushes the electrons. (d) free electrons in the filament travel with the speed of light. **APPROPRIATE OPTION** (C)	MAIN
9.	Three wires A, B and C of the same material have lengths and area of cross-sections as (2l, A/2), (l, A) and (l/2, 2A), respectively. If the resistances of these wires are RA, RB and RC respectively, then: (a) $R_A > R_B > R_C$ (b) $R_B > R_C > R_A$ (c) $R_C > R_A > R_B$ (d) $R_A > R_C > R_B$	MAIN

	APPROPRIATE OPTION. (A)	
10.	Four resistors, each of resistance R and a key K are connected as shown in the figure. The equivalent resistance between points A and B when key K is open, will be:  (a) 4R (b) ∞ (c) R/4 (d) 4R/3 **APPROPRIATE OPTION. (d) 4R/3**	MAIN
11.	The figure shows the voltage (V) versus the current (I) graphs for a wire at two temperatures T_1 and T_2. One can conclude that:  (a) $T_2 = 2T_1$ (b) $T_1 > T_2$ (c) $T_1 = T_2 / 3$ (d) $T_1 < T_2$ **APPROPRIATE OPTION.** (d) $T_1 < T_2$	MAIN
12.	If R_s and R_p are the equivalent resistances of n resistors, each of value R, in series and parallel combinations respectively, then the value of (Rs -Rp) is: (a) $(\frac{n^2-1}{n^2})R$ (b) $(\frac{n^2+1}{n^2-1})R$ (c) $(\frac{n^2-1}{n})R$ (d) $(\frac{n^2+1}{n^2})R$ **APPROPRIATE OPTION**. (c) $(\frac{n^2-1}{n})R$	MAIN
13.	A wire of resistance R, connected to an ideal battery consumes a power P. If the wire is gradually stretched to double its initial length, and connected across the same battery, the power consumed will be: (a) P/4 (b) P/2 (c) P (d) 2P **APPROPRIATE OPTION. (a) P/4**	MAIN

14.	The ratio of potential difference across AB in the circuit shown for the case (i) when switch S is closed and (ii) when S is open is:  (a) ¼ (b) ½ (c) 1 (d) 2 **APPROPRIATE OPTION. (d) 2**	MAIN
15.	The effective resistance between points A and B in the given circuit is: (a) 6 Ω (b) 8/3 Ω (c) 16/3 Ω (d) 2 Ω  **APPROPRIATE OPTION** . (c) 16/3 Ω	MAIN
16.	The resistance of a wire at 20 °C is 50 Ω. When it is heated to 120 °C, the resistance becomes 51 Ω. The temperature coefficient of resistance of the material of the wire is: (a) 2×10^{-4} °C^{-1} (b) 1×10^{-4} °C^{-1} (c) 5×10^{-4} °C^{-1} (d) 1×10^{-3} °C^{-1} **APPROPRIATE OPTION.** (a) 2×10^{-4} °C^{-1}	BLIND
	SECTION (B) SHORT ANSWER CARRY 2 MARK EACH	
17.	A battery of emf E and internal resistance r is connected to a rheostat. When a current of 2A is drawn from the battery, the potential difference across the rheostat is 5V. The potential difference becomes 4V when a current of 4A is drawn from the battery. Calculate the value of E and r. **SUGGESTIVE VALUE POINTS.**	MAIN

	Calculating the value of E 1 Calculating the value of r 1 $E = V + Ir$ In first case $E = 5 + 2r$ In second case $E = 4 + 4r$ After solving **E=6V r=0.5 ohm**	
18.	Show that $\vec{E} = \rho\vec{j}$ leads to Ohm's law. Write a condition in which Ohm's law is not valid for a material. **SUGGESTIVE VALUE POINTS.** Obtaining Ohm's law from $\vec{E} = \rho\vec{j}$ 1 ½ Writing the condition ½ $\vec{E} = \rho\vec{j}$ $\frac{V}{l} = \rho\frac{I}{A}$ $\frac{V}{I} = \rho\frac{l}{A}$ = constant (Ohm's Law) Condition for non- validity of Ohm's Law High temperature / in semiconductor	MAIN
19..	(a) Two wires of the same material and the same radius have their lengths in the ratio 2: 3. They are connected in parallel to a battery which supplies a current of 15 A. Find the current through the wires. **OR** (b) In the circuit three ideal cells of e.m.f. V, V and 2V are connected to a resistor of resistance R, a capacitor of capacitance C and another resistor of resistance 2R as shown in figure. In the steady state find (i) the potential difference between P and Q and (ii) potential difference across capacitor C.  	MAIN

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(a) **SUGGESTIVE VALUE POINTS.**

OR

Finding current	2

$R_1 = \frac{\rho l_1}{A}$; $R_2 = \frac{\rho l_2}{A}$

$\frac{l_1}{l_2} = \frac{2}{3} \Rightarrow \frac{R_1}{R_2} = \frac{2}{3}$

$I \propto \frac{1}{R}$

$\Rightarrow \frac{I_1}{I_2} = \frac{3}{2}$

$\Rightarrow I_1 = \frac{3}{5} \times 15 = 9A$

$\Rightarrow I_2 = \frac{2}{5} \times 15 = 6A$

(b)

Finding the potential difference	
(i) between P and Q	1
(ii) across capacitor C	1

In steady state,

$2V - V = i(2R + R)$

$i = \frac{V}{3R}$

(i) $V_P - V_Q = -V - iR$

$= -V - \frac{V}{3}$

$V_P - V_Q = -\frac{4V}{3}$

(ii) $V_P - V_Q = -V + V_C$

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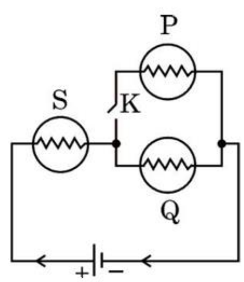
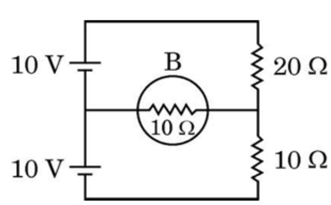
(a) In the given figure, three identical bulbs P, Q and S are connected to a battery.



(i)Compare the brightness of bulbs P and Q with that of bulb S when key K is closed.

(ii) Compare the brightness of the bulbs S and Q when the key K is opened. Justify your answer in both cases.

OR



(b) Two cells of emf 10 V each, two resistors of 20Ω

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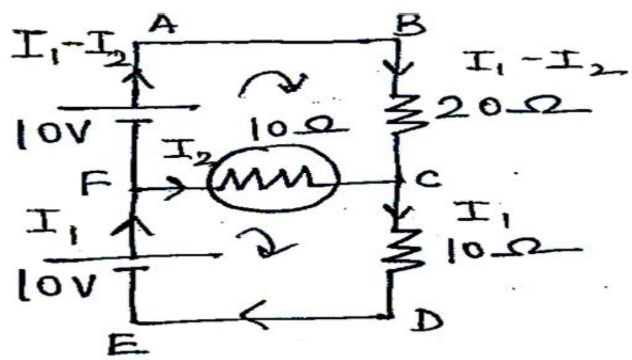
	and 10 Ω and a bulb B of 10Ω resistance are connected together as shown in the figure. Find the current that flows through the bulb. **(a) SUGGESTIVE VALUE POINTS** (i) Comparison of brightness of bulbs P and Q with bulb S ½ Justification ½ (ii) Comparison of brightness of bulb S with Q ½ Justification ½ (**i**) Brightness of the bulb 'S' will be more than bulbs 'P' and 'Q' The current flowing through the bulb 'S' is twice of the current in bulbs 'P' and 'Q'. (ii) Brightness of the bulb 'S' and Q 'Will be same. The current flowing through both bulbs is same. **OR** **(b) SUGGESTIVE VALUE POINTS** Finding the current through the bulb 'B' 2  By applying Kirchhoff's loop rule to closed loops ABCFA and FCDEF $2I_1-3I_2=1$----(1) $I_1+I_2=1$-----(2) On solving, Current through the bulb, $I_2=\frac{1}{5}A$	
21.	The resistance of a wire at 25^0C is 10·0 Ω. When heated to 125^0 C, its resistance becomes 10·5Ω. Find (i) the temperature coefficient of resistance of the wire, and (ii) the resistance of the wire at 425^0C.	MAIN

SUGGESTIVE VALUE POINTS

Finding (i) temperature coefficient of resistance	1 ½
(ii) resistance of wire at 425 °C	½

(i) $R_2 = R_1(1+\alpha(t_2-t_1))$

$10.5 = 10(1+\alpha\times 100)$

$\alpha = 5\times 10^{-4}\,/\,^{o}C$

(ii) $R_{425} = R_{25}(1+\alpha(425-25))$

$= 10(1+5\times 10^{-4}\times 400)$

$= 12\,\Omega$

22. A wire of resistance X ohm is gradually stretched till its length becomes twice its original length. If its new resistance becomes 40 values of X. — MAIN

SUGGESTIVE VALUE POINTS

Finding value of X	2

$R = n^2 x$

$40 = (2)^2 x$

$x = 10\ \Omega$

Alternatively

Volume of wire before and after stretch will remain same

$A_1 l_1 = A_1 l_1$

$A_2 = \frac{Al}{2l}$

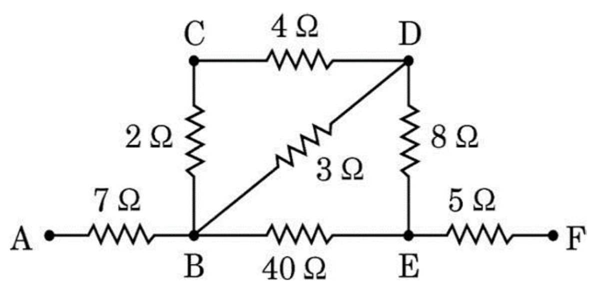
$= \frac{A}{2}$

$R = \rho \frac{l_2}{A_2}$

$40 = 4\rho \frac{2l}{A/2}$

$\therefore\ x = 10\,\Omega$

23. Find the effective resistance of the network of resistors between points A and F as shown in the figure. — MAIN



SUGGESTIVE VALUE POINTS

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Finding effective resistance	2

$R_{BCD} = 2+4 = 6\Omega$

$R_{BD} = \frac{3\times 6}{6+3}$

$= 2\Omega$

$R_{BDE} = 2 + 8$

$= 10\Omega$

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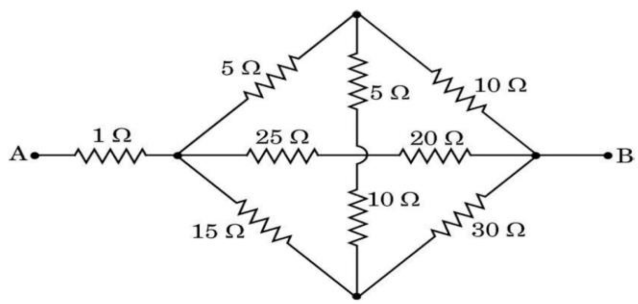
Find the equivalent resistance between points A and B for the network shown in the figure.



SUGGESTIVE VALUE POINTS

Finding equivalent resistance between points A and B	2

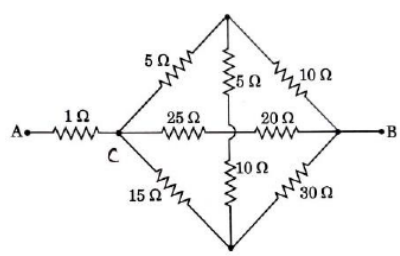
Resistance between points C and B

$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$

$\frac{1}{R} = \frac{1}{15} + \frac{1}{45} + \frac{1}{45}$

$R = 9\ \Omega$

Equivalent resistance between points A and B



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A cell of emf E and internal resistance r is connected to an external variable resistance R. Plot a graph showing the variation of terminal voltage V of the cell as a function of current I, supplied by the cell. Explain how the emf of the cell and its internal resistance can be found from it.

SUGGESTIVE VALUE POINTS

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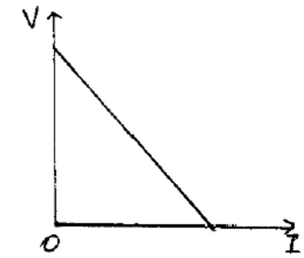
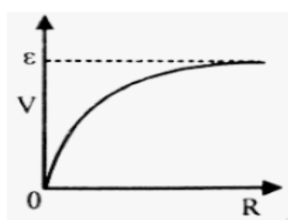
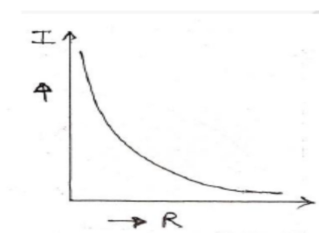
	Plotting the graph 1 Explaining how to find emf and internal resistance of cell ½ + ½ Graph showing the variation of terminal voltage V of the cell as a function of current I.  $V = E - Ir$ E = intercept on y-axis (i.e. V-axis) $r = \|\text{slope of graph}\|$	
26.	A cell of emf E and internal resistance r is connected across a resistor of variable resistance R. Show graphically the variation of (a) the terminal voltage across the cell, (b) the current supplied by the cell, with R as it is increased from 0 to the maximum value. **SUGGESTIVE VALUE POINTS** Showing variation graphically (a)Terminal voltage with resistance R 1 (b)Current supplied by cell with resistance R 1 (a)  (b)  	MAIN
27.	Two wires made of the same material have the same length (l) but different cross-sectional areas A_1 and A_2. They are connected together with a cell of voltage V. Find the ratio of the drift velocities of free electrons in the two wires when they are joined in (i) series, and (ii) parallel. **SUGGESTIVE VALUE POINTS**	MAIN
	SECTION (C) SHORT ANSWER CARRY 3 MARK EACH	
28.	**(a)** Two batteries of emfs 3V & 6V and internal resistances 0.2 Ω & 0.4 Ω are	MAIN

	connected in parallel. This combination is connected to a 4 Ω resistor. Find: (i) the equivalent emf of the combination (ii) the equivalent internal resistance of the combination (iii) the current drawn from the combination. Value points. Finding (i) Equivalent emf of combination 1 (ii) Equivalent internal resistance of combination 1 (iii) Current drawn from combination 1 (i) Because $E_{eq} = \frac{E_1 r_2 + E_2 r_1}{r_1 + r_2}$ $E_{eq} = \frac{3 \times 0.4 + 6 \times 0.2}{0.6} = 4 \text{ V}$ (ii) $r_{eq} = \frac{r_1 r_2}{r_1 + r_2}$ $r_{eq} = \frac{0.2 \times 0.4}{0.2 + 0.4} = 0.133\Omega$ (iii) $I = \frac{E}{R + r_{eq}}$ $I = \frac{4}{4 + 0.13} = \frac{4}{4.13} A$ $I = 0.9A$ **OR** (b) (i) A conductor of length *l* is connected across an ideal cell of emf E. Keeping the cell connected, the length of the conductor is increased to 2*l* by gradually stretching it. If R and R' are initial and final values of resistance and v_d and v'_d are initial and final values of drift velocity, find the relation between (i) R' and R and (ii) v'_d and v_d. (ii) When electrons drift in a conductor from lower to higher potential, does it mean that all the 'free electrons' of the conductor are moving in the same direction? **SUGGESTIVE VALUE POINT**	

<table>
<tr><td></td><td>(i) Finding the relation
(i) between R' and R 1
(ii) between v_d' and v_d 1
(ii) To identify whether all free electrons are moving in the same direction. 1

(i) $l' = 2l$
$Al = A'l'$ = volume of the wire
$Al = A'(2l)$
$\frac{A}{2} = A'$
$R = \frac{\rho l}{A}$
$R' = \frac{\rho l'}{A'}$
$R' = \frac{\rho(2l)}{A/2}$
$\frac{R'}{R} = 4$
Alternatively
$R' = n^2R$
n= 2
$R' = 4R$
(ii) $v_d = \frac{eE}{m}\tau$
$v_d = \frac{eV}{ml}\tau$
$v_d' = \frac{eV}{ml'}\tau$
$\frac{v_d'}{v_d} = \frac{l}{l'} = \frac{1}{2}$
(ii) No</td><td></td></tr>
<tr><td>29.</td><td>(a) Define resistivity of a conductor. Discuss its dependence on temperature of the conductor and draw a plot of resistivity of copper as a function of temperature.
(b) (i) “A low voltage battery from which high current is required must have low internal resistance.” Justify.
(ii) “A high voltage battery must have a large internal resistance.” Justify.
SUGGESTIVE VALUE POINT
(a) Defining resistivity 1
Discussing its dependence on temperature ½
Plotting graph of resistivity with temperature for copper ½
(b) (i) Justification ½
(ii) Justification ½</td><td>MAIN</td></tr>
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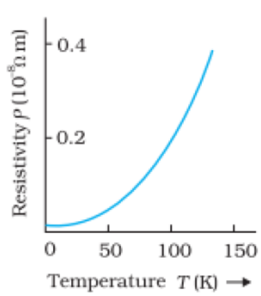
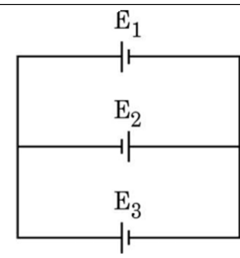
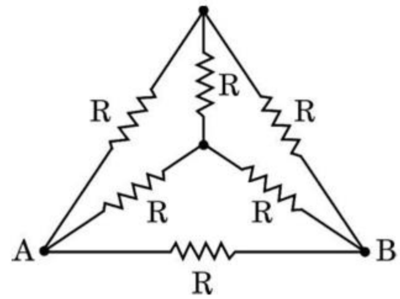
	(a) Resistivity is the resistance of a material of unit length having unit area of cross-section. On increasing the temperature of a conductor, the resistivity increases.  (b) (i) A low internal resistance allows large current to be drawn even at a low voltage. (ii) To limit the current.	
	SECTION (D) CASE STUDY CARRY 4 MARK EACH	
30.	In a metallic conductor, an electron, moving due to thermal motion, suffers collisions with the heavy fixed ions but after collision, it will emerge out with the same speed but in random directions. If we consider all the electrons, their average velocity will be zero. When an electric field is applied, electrons move with an average velocity, known as drift velocity (v_d). The average time between successive collisions is known as relaxation time (τ). The magnitude of drift velocity per unit electric field is called mobility (μ). An expression for current through the conductor can be obtained in terms of drift velocity, number of electrons per unit volume (n), electronic charge (- e), and the cross-sectional area (A) of the conductor. This expression leads to an expression between current density (J) and the electric field (E). Hence, an expression for resistivity (ρ)) of a metal is obtained. This expression helps us to understand increase in resistivity of a metal with increase in its temperature, in terms of change in the relaxation time (τ) and change in the number density of electrons (n). (i) Consider two cylindrical conductors A and B, made of the same metal connected in series to a battery. The length and the radius of B are twice that of A. If μ_A and μ_B are the mobility of electrons in A and B respectively, then $\frac{\mu_A}{\mu_B}$ is: (A) ½ (B) ¼ (C) 1 (D) 2 **APPROPRIATE OPTION .(C) 1**	MAIN

	(ii) A wire of length 0·5 m and cross-sectional area $1·0 \times 10^{-7}$ m2 is connected to a battery of 2 V that maintains a current of 1·5A in it. The conductivity of the material of the wire (in Ω^{-1} m^{-1}) is: (A) $2·5 \times 10^4$ (B) $3·0 \times 10^5$ (C) $3·75 \times 10^6$ (D) $5·0 \times 10^7$ **APPROPRIATE OPTION (C) $3·75 \times 10^6$** (iii) The temperature coefficient of resistance of nichrome is $1·70 \times 10^{-4}$ /C. In order to increase resistance of a nichrome wire by 8·5%, the temperature of the wire should be increased by: (A) 250^0C (B) 500^0C (C) 850^0C (D) 1000^0C **APPROPRIATE OPTION (B) 500^0C** (iv) (a) Consider the contribution of the following two factors I and II in resistivity of a metal: I. Relaxation time of electrons II. Number of electrons per unit volume The resistivity of a metal increases with increase in its temperature because: (A) I decrease and II increases. (B) I increase and II is almost constant. (C) Both I and II increase. (D) I decrease and II is almost constant. **APPROPRIATE OPTION. (D) I decrease and II is almost constant.** **OR** (b) A steady current flow in a copper wire of non-uniform cross-section. Consider the following three physical quantities: I. Electric field II. Current density III. Drift speed Then at the different points along the wire: (A) II and III change, but I is constant. (B) I and II change, but III is constant. (C) I and III change, but II is constant. (D) All I, II and III change. **APPROPRIATE OPTION. (D) All I, II and III change.**	
	SECTION (E) LONG ANSWER CARRY 5 MARK EACH	

31. (a) (i) Three batteries E_1, E_2 and E_3 of emfs and internal resistances (4 V, 2Ω), (2 V, 4 Ω) and (6 V, 2 Ω) respectively are connected as shown in the figure. Find the values of the currents passing through batteries E_1, E_2 and E_3. MAIN

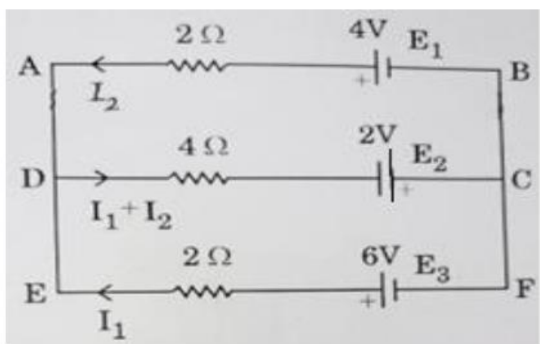


(ii) The ends of six wires, each of resistance R (= 10 Ω) are joined as shown in the figure. The points A and B of the arrangement are connected in a circuit. Find the value of the effective resistance offered by it to the circuit.



(i)**SUGGESTIVE VALUE POINT**

(i)	Finding current through batteries E_1, E_2 and E_3	3
(ii)	Finding effective resistance	2



In closed loop ABCD, using Kirchhoff's loop law

$4I_1 + 6I_2 = 6$ ....(1)

Similarly In closed loop CDFE

$6I_1 + 4I_2 = 8$ ....(2)

Solving eqn. (1) and (2)

$$I_2 = \frac{1}{5}A$$

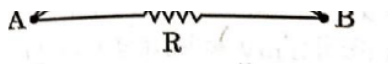
$$I_1 = \frac{6}{5}A$$

$$I_1 + I_2 = \frac{7}{5}A$$

ii) $$\frac{1}{R_{eq}} = \frac{1}{R} + \frac{1}{R}$$

$$R_{eq} = \frac{R}{2}$$

Given R = 10Ω, Therefore R_{eq} = 5Ω



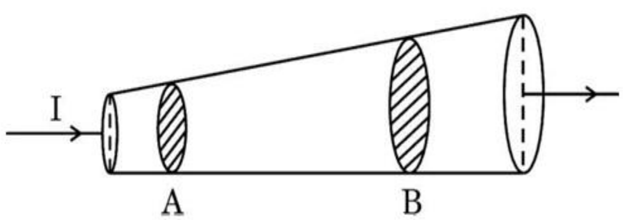
Resistances R_{AC}, R_{CB} , R_{AD} , and R_{DB} form a balanced Wheatstone bridge
Hence current through R_{CD} is zero and will not contribute to equivalent resistance.
The equivalent resistance of bridge is R, is in parallel with R_{AB}
Series combinations of R_{AC} & R_{CB} and R_{AD} & R_{DB} is in parallel with R_{AB}

OR

(b) (i) Current I (= 1A) is passing through a copper rod (n = 8·5 10^{28} m^3) of varying cross-sections as shown in the figure. The areas of cross-section at points A and B along its length are 1·0 x10^{-7} m^2 and 2·0 x10^{-7} m^2 respectively. Calculate:

(I) the ratio of electric fields at points A and B.

(II) the drift velocity of free electrons at point B.



SUGGESTIVE VALUE POINT

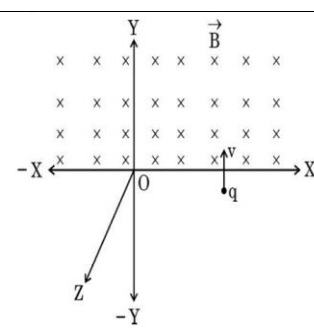
(i)	Calculating		
	(I)	ratio of electric fields at points A & B	1 ½
	(II)	drift velocity of free electrons at point B	1 ½
(ii)	Finding net electric field at point $\vec{r}$		2

(I) $$\vec{j} = \sigma \vec{E}$$

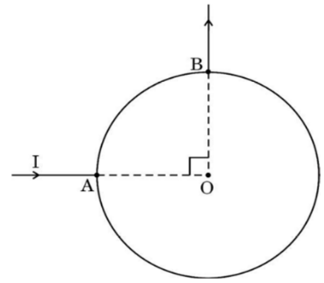
$$\frac{j_A}{j_B} = \frac{E_A}{E_B} = \frac{I/A_A}{I/A_B} = \frac{A_B}{A_A} = \frac{2}{1}$$

(II) $$v_d = \frac{I}{neA} = \frac{1}{8.5\times10^{28}\times1.6\times10^{-19}\times2\times10^{-7}} = 3.6\times10^{-4}\ m/s$$

CHAPTER -4 MOVING CHARGES AND MAGNETISM

Q.N.	SECTION (A) CARRY 1 MARK EACH	CBSE 2025
1.	A 1 cm segment of a wire lying along x-axis carries current of 0.5 A along +x direction. A magnetic field B = (0.4 mT) $\hat{j}$ + (0.6 mT) $\hat{k}$ is switched on, in the region. The force acting on the segment is: (a) $(2\hat{j} + 3\hat{k})$ mN (b) $(-3\hat{j} + 2\hat{k})$ μN (c) $(6\hat{j} + 4\hat{k})$ mN (d) $(-4\hat{j} + 6\hat{k})$ μN **APPROPRIATE OPTION (b) $(-3\hat{j} + 2\hat{k})$ μN**	MAIN
2.	A 1 cm straight segment of a conductor carrying 1 A current in x direction lies symmetrically at origin of Cartesian coordinate system. The magnetic field due to this segment at point (1m, 1m, 0) is: (a) $1.0 \times 10^{-9}\hat{k}T$ (b) $-1.0 \times 10^{-9}\hat{k}T$ (c) $\frac{5}{\sqrt{2}} \times 10^{-10}\hat{k}T$ (d) $-\frac{5}{\sqrt{2}} \times 10^{-10}\hat{k}T$ **APPROPRIATE OPTION. (C)**	MAIN
3.	The magnetic field due to a small magnetic dipole of dipole moment 'M' at a distance 'r' from the centre along the axis of the dipole is given by: (a) $\frac{\mu_0}{4\pi}\frac{2M}{r^3}$ (b) $\frac{\mu_0}{4\pi}\frac{M}{r^3}$ (c) $\frac{\mu_0}{4\pi}\frac{2M}{2r^3}$ (d) $\frac{\mu_0}{4\pi}\frac{2M}{2r^2}$ **APPROPRIATE OPTION. (A)**	MAIN
4.	A particle having charge +q enters a uniform magnetic field as shown in the figure. The particle will describe:  (a) a circular path in XZ plane (b) a semicircular path in XY plane (c) a helical path with its axis parallel to Y-axis (d) a semicircular path in YZ plane **APPROPRIATE OPTION. (B)**	MAIN

5.	A particle with charge q moving with velocity $\vec{v}=v_0\hat{\imath}$ enters a region with magnetic field $B_1\hat{j} + B_2\hat{k}$. The magnitude of force experienced by the particle is: (a) $qv_0(B_1 + B_2)$ (b) $q\sqrt{v_0(B_1 + B_2)}$ (c) $qv_0\sqrt{(B_1^2 + B_2^2)}$ (d) $q\sqrt{v_0(B_1^2 + B_2^2)}$ **APPROPRIATE OPTION .(C)**	MAIN
6.	A particle of mass m and charge q moves along y-axis in a region in which a uniform magnetic field is pointing along x-axis. The Lorentz force acting on the charge will point along: (a) x-axis (b) y-axis (c) z-axis (d) negative z-axis **APPROPRIATE OPTION. (D)**	MAIN
7.	A charged particle gains a speed of 10^6 m/s, when accelerated from rest through a potential difference 10 kV. It enters a region of magnetic field of 0·4 T such that $\vec{v} \perp \vec{B}$. The radius of circular path described by it is: (a) 2·5 cm (b) 5 cm (c) 8 cm (d) 10 cm **APPROPRIATE OPTION. (B)**	MAIN
8.	A current of $(\frac{10}{\pi})$A is maintained in a circular loop of radius 14 cm. The value of dipole moment associated with the loop is: (a) 0·019 Am^2 (b) 0·14 Am^2 (c) 0·196 Am^2 (d) 0·615 Am^2 **APPROPRIATE OPTION. (C)**	MAIN
9.	A galvanometer can be converted into an ammeter of desired range by connecting a: (a) small resistance in series (b) large resistance in series (b) small resistance in parallel (d) large resistance in parallel. **APPROPRIATE OPTION. (A)**	MAIN
10.	A proton and an α particle enter with the same velocity $\vec{v}$ in a uniform magnetic field $\vec{B}$ such that $\vec{v} \perp \vec{B}$. The ratio of the radii of their paths is: (a) 2 (b) ½ (c) 4 (d) ¼	MAIN

	APPROPRIATE OPTION. (B)	
11.	A straight conductor is carrying a current of 2 A in +x direction along it. A uniform magnetic field $\vec{B} = (0.6\hat{j} + 0.8\hat{k})$ T is switched on, in the region. The force acting on 10 cm length of the conductor is: (a) $(0{\cdot}12\hat{j} - 0{\cdot}16\hat{k})$ N (b) $(-0{\cdot}16\hat{j} + 0{\cdot}12\hat{k})$ N (c) $(-0{\cdot}12\hat{j} + 0{\cdot}16\hat{k})$ N (d) $(0{\cdot}16\hat{j} - 0{\cdot}12\hat{k})$ N **APPROPRIATE OPTION. (B)**	MAIN
12.	In a circular loop of radius R, current I enter at point A and exits at point B, as shown in the figure. The value of the magnetic field at the centre O of the loop is: (a) $\frac{\mu_0 I}{R}$ (b) $\frac{\mu_0 I}{2R}$ (c) $\frac{\mu_0 I}{4R}$ (d) zero  **APPROPRIATE OPTION (B)**	MAIN

Questions number 20 to 21 are Assertion (A) and Reason (R) type questions. Two statements are given one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer from the codes (a), (b), (c) and (d) as given below.

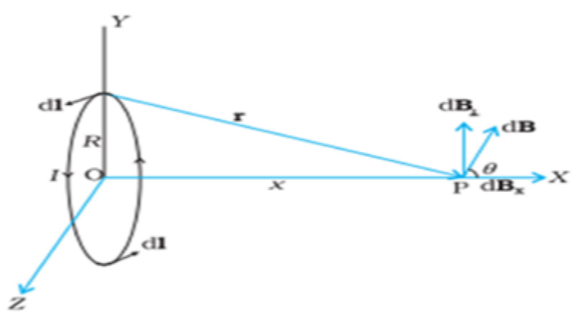
(a) Both Assertion (A) and Reason (R) are true and Reason (R) is the correct explanation of the Assertion (A).

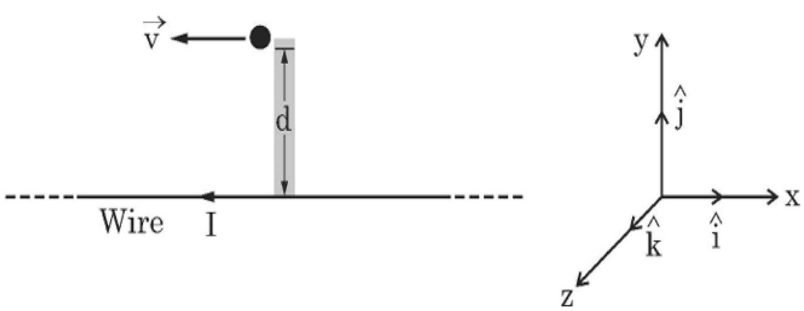
(b) Both Assertion (A) and Reason (R) are true, but Reason (R) is not the correct explanation of the Assertion (A).

(c) Assertion (A) is true, but Reason (R) is false.

(d) Assertion (A) is false and Reason (R) is also false.

13.	**Assertion (A):** The deflection in a galvanometer is directly proportional to the current passing through it. **Reason (R):** The coil of a galvanometer is suspended in a uniform radial magnetic field. **APPROPRIATE OPTION** (A)	MAIN
14.	**Assertion (A):** A charged particle is moving with velocity v in x-y plane, making	MAIN

	an angle θ ($0 < \theta < \frac{\pi}{2}$) with x-axis. If a uniform magnetic field $\vec{B}$ is applied in the region, along y-axis, the particle will move in a helical path with its axis parallel to x-axis. **Reason (R):** The direction of the magnetic force acting on a charged particle moving in a magnetic field is along the velocity of the particle. **APPROPRIATE OPTION. (D)**	
	SECTION (B) SHORT ANSWER TYPE CARRY 2 MARK EACH	
15.	A circular coil of wire having 200 turns, each of radius 4·0 cm is placed in a horizontal plane. It carries a current of 0·40 A in clockwise direction. Find the magnitude and direction of the magnetic field at the centre of the coil. **SUGGESTIVE VALUE POINT** Finding magnitude and direction of magnetic field — 2 $B = \frac{\mu_0 NI}{2r}$ $= \frac{4\pi \times 10^{-7} \times 200 \times 0.40}{2 \times 4 \times 10^{-2}}$ $= 1.256 \times 10^{-3}\ T$ Direction is perpendicularly inward into the horizontal plane.	MAIN
	SECTION (C) SHORT ANSWER TYPE CARRY 3 MARK EACH	
16.	Using Biot-Savart law, derive expression for the magnetic field ($\vec{B}$) due to a circular current carrying loop at a point on its axis and hence at its centre. **SUGGESTIVE VALUE POINT** Derivation for Magnetic field on the axis — 2 ½ Magnetic field at the centre — ½ 	MAIN

	From Biot Savart' s Law $\left\|d\vec{B}\right\| = \frac{\mu_o}{4\pi}\frac{I\left\|d\vec{l}\times\vec{r}\right\|}{r^3}$ Now $r^2 = x^2 + R^2$ Because $\left\|d\vec{l}\times\vec{r}\right\| = rdl$ $\therefore dB = \frac{\mu_o}{4\pi}\frac{idl}{(x^2+R^2)}$ $d\vec{B}$ has two components. All the components perpendicular to x- axis are summed over and we obtain a null result. Only x- components contribute. The net contribution along x- direction $dB_x = dB\cos\theta$ $\cos\theta = \frac{R}{(R^2+x^2)^{\frac{1}{2}}}$ Thus : $dB_x = \frac{\mu_o i}{4\pi}dl\frac{R}{(R^2+x^2)^{\frac{3}{2}}}$ Summing dB_x over the entire loop $\oint dl = 2\pi R$ $\vec{B} = B_x\hat{i} = \frac{\mu_o iR^2}{2(x^2+R^2)^{\frac{3}{2}}}\hat{i}$ Magnetic field at the centre of the loo Here x= 0 $\therefore \vec{B} = \frac{\mu_o i}{2R}\hat{i}$	
17.	A particle of charge q is moving with a velocity $\vec{v}$ at a distance 'd' from a long straight wire carrying a current 'I' as shown in figure. At this instant, it is subjected to a uniform electric field $\vec{E}$ such that the particle keeps moving undeviated. In terms of unit vectors $\hat{\imath}, \hat{\jmath}$ *and* $\hat{k}$,find  (a) the magnetic field, (b) the magnetic force (c) the electric field, acting on the charge **SUGGESTIVE VALUE POINT**	MAIN

	Finding a) The magnetic field $\vec{B}$ — 1 b) The magnetic force $\vec{F}_m$ — 1 c) The electric field $\vec{E}$ — 1	

a) $\vec{B}=\frac{\mu_o I}{2\pi d}(-\hat{K})$

b) $\vec{F}_B=q(\vec{v}\times\vec{B})=\frac{qv\mu_o I}{2\pi d}(-\hat{j})$

c) $q\vec{F}_e=-\vec{F}_B$ (For undeviation of charge particle)

$\therefore\ \vec{F}_e=\frac{qv\mu_o I}{2\pi d}(\hat{j})$

$\vec{F}_e=q\vec{E}$

$\therefore\ \vec{E}=\frac{\mu_o vI}{2\pi d}\hat{j}$

---

18. In a region of a uniform electric field $\vec{E}$, a negatively charged particle is moving with a constant velocity $v=-v_0\hat{\imath}$ near a long straight conductor coinciding with XX' axis and carrying current I towards –X axis. The particle remains at a distance d from the conductor. — MAIN

(i) Draw diagram showing direction of electric and magnetic fields.

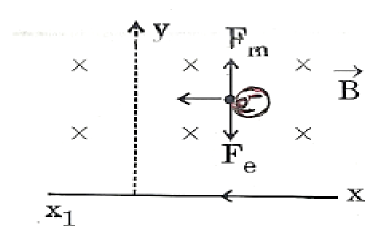
(ii) What are the various forces acting on the charged particle?

(iii) Find the value of v_o in terms of E, d and I.

SUGGESTIVE VALUE POINT

(i) Diagram showing direction of electric and magnetic fields	1
(ii) Naming forces acting on the charged particle	1
(iii) Finding the value of υ_0	1

(i)



(iii) $ev_oB=eE$

$$v_o \times \left[\frac{\mu_o I}{2\pi d}\right]=E$$

$$v_o=\frac{(2\pi d)E}{\mu_o I}$$

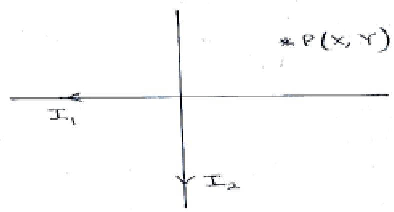
(ii) Electric force
Magnetic force

---

19. Two infinitely long conductors kept along XX' and YY' axes are carrying current I_1 and I_2 along –X axis and –Y axis respectively. Find the magnitude and direction — MAIN of the net magnetic field produced at point P (X, Y).

SUGGESTIVE VALUE POINT

Finding the magnitude and direction of the net magnetic field	2+1



Magnetic field due to conductor carrying current I_1 $(\vec{B}_1) = \frac{\mu_0 I_1}{2\pi Y}(-\hat{k})$

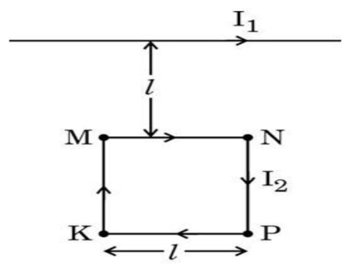
Magnetic field due to conductor Carrying current I_2 $(\vec{B}_2) = \frac{\mu_0 I_2}{2\pi X}(\hat{k})$

$\vec{B}_P = \vec{B}_1 + \vec{B}_2$

$\vec{B}_P = \frac{\mu_0}{2\pi}\left[\frac{I_2}{X} - \frac{I_1}{Y}\right]\hat{k}$

Direction will be along the Z-axis.

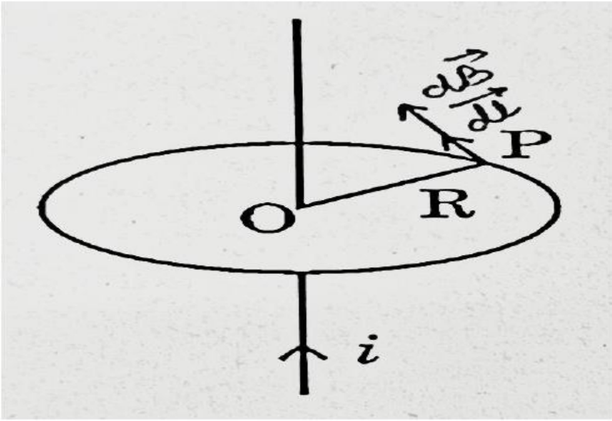
20. A square lo l 2 to a long straight wire in the same plane and the wire carries a steady current I1 as shown in the figure. Obtain the magnitude of magnetic force exerted by the wire on the loop. — MAIN



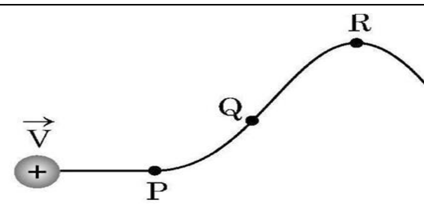
SUGGESTIVE VALUE POINT

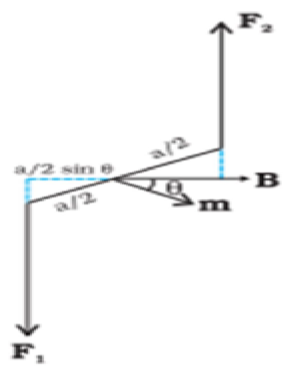
(a) Conditions for, no force experienced by charged particle in magnetic field	1
(b) Obtaining the magnitude of magnetic force exerted by wire on the loop	2

	(a) • If charged particle is at rest v = 0 • If B is parallel or antiparallel to v **(b)** Magnitude of force acting between two current carrying conductor $F = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{r}L$ Force on segment MN of loop $F_{MN} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{l}\times l$ (Towards the wire) Force on segment KP of loop $F_{KP} = \frac{\mu_0}{4\pi}\frac{2I_1I_2}{2l}\times l$ (Away from the wire) No force due to segment MK and NP Net force on the loop $F = F_{MN} - F_{KP}$ $F = \frac{\mu_0}{4\pi}I_1I_2$	
21.	An electron of mass m and charge -e is revolving anticlockwise around the nucleus of an atom. (a) Obtain the expression for the magnetic dipole moment (μ) of the atom. (b) If $\vec{L}$ is the angular momentum of electron, show that $$\vec{\mu} = -(\frac{e}{2m})\vec{L}$$ **SUGGESTIVE VALUE POIN** <table><tr><td>a) Obtaining expression for magnetic dipole moment</td><td>1½</td></tr><tr><td>b) To Show $\vec{\mu} = -\left(\frac{e}{2m}\right)\vec{L}$</td><td>1½</td></tr></table> a) $\mu = IA$ $= \frac{e}{T}\times A$ **T** $= \frac{e}{\frac{2\pi r}{v}}\times \pi r^2$ $= \frac{1}{2}evr$	MAIN

	b) L = mvr $\mu = \frac{evr \times m}{2 \times m}$ $= \left(\frac{e}{2m}\right)L$ Direction of $\vec{\mu}$ is opposite to that of $\vec{L}$ $\vec{\mu} = -\left(\frac{e}{2m}\right)\vec{L}$	
22.	(a) Use Ampere's law to derive the expression for the magnetic field due to a long straight current carrying wire of infinite length. (b) Why is Ampere's law used for the derivation in (a) above and not Biot-Savart's law? Explain. **SUGGESTIVE VALUE POINT** (a) Deriving expression of magnetic field for long straight wire 2 (b) Explanation 1 (a)  Consider an amperian loop of radius R around the wire carrying current I. $\oint \vec{B}.\vec{dl} = \mu_o i$ $B \times 2\pi r = \mu_o i$ $B = \frac{\mu_o i}{2\pi r}$ (b) The expression for magnetic field due to a long straight current carrying infinite wire can be obtained easily using Ampere's circuital law whereas Biot- Savart's law requires lengthy calculation.	MAIN

	SECTION (D) CASE STUDY CARRY 4 MARK EACH	
23.	**Read the following paragraphs and answer the questions that follow.** A galvanometer is an instrument used to show the direction and strength of the current passing through it. In a galvanometer, a coil placed in a magnetic field experiences a torque and hence gets deflected when a current passes through it. The name is derived from the surname of Italian scientist L. Galvani, who in 1791 discovered that electric current makes a dead frog's leg jerk. A spring attached with the coil provides a counter torque. In equilibrium, the deflecting torque is balanced by the restoring torque of the spring and we have: $NBAI = k\phi$ where N is the total number of turns in the coil A is the area of cross-section of each turn B is the radial magnetic field k is the torsional constant of the spring ϕ is the angular deflection of the coil As the current (Ig), which produces full scale deflection in the galvanometer is very small, the galvanometer cannot as such be used to measure current in electric circuits. A small resistance, called shunt, of a suitable value is connected with the galvanometer to convert it into an ammeter of desired range. By using a higher resistance, a galvanometer can also be converted into a voltmeter. (i) The value of the current sensitivity of a galvanometer is given by: (A) $\frac{k}{NBA}$ (B) $\frac{NBA}{k}$ (C) $\frac{kBA}{N}$ (D) $\frac{kNB}{A}$ **APPROPRIATE OPTION. (B)** (ii) A galvanometer of resistance 6 shows full scale deflection for a current of 0·2 A. The value of shunt to be used with this galvanometer to convert it into an ammeter of range (0 -5 A) is: (A) 0·25 (B) 0·30 (C) 0·50 (D) 6·0 **APPROPRIATE OPTION. (A)**	MAIN

	(iii) The value of resistance of the ammeter in case (ii) will be: (A) 0·20 Ω (B) 0·24 Ω (C) 6·0 Ω (D) 6·25Ω **APPROPRIATE OPTION. (B)** (iv) (a) A galvanometer is converted into a voltmeter of range (0 -V) by connecting with it, a resistance R_1. If R_1 is replaced by R_2, the range becomes (0 - 2 V). The resistance of the galvanometer is: (A) (R_2- 2R_1) (B) (R_2- R_1) (C) (R_1 + R_2) (D) (R_1 -2R_2) **APPROPRIATE OPTION. (A)** **OR** (b) A current of 5 mA flows through a galvanometer. Its coil has 100 turns, each of area of cross-section 18 cm^2 and is suspended in a magnetic field 0·20 T. The deflecting torque acting on the coil will be: (A) 3·6 x10^{3} Nm (B) 1·8x 10^{4} Nm (C) 2·4 x10^{3} Nm (D) 1·2x 10^{4} Nm **APPROPRIATE OPTION. (B)**	1
	SECTION (E) LONG ANSWER TYPE CARRY 5 MARK EACH	
24.	(i) A proton moving with velocity V in a non-uniform magnetic field traces a path as shown in the figure.  The path followed by the proton is always in the plane of the paper. What is the direction of the magnetic field in the region near points P, Q and R? What can you say about relative magnitude of magnetic fields at these points? (ii) A current carrying circular loop of area A produces a magnetic field B at its centre. Show that the magnetic moment of the loop is **2 BA / μ_0 √(A/π)**. **SUGGESTIVE VALUE POINT** i) Finding the direction of magnetic field near points P,Q and R ½ + ½ + ½ Conclusion about the relative magnitude of magnetic field. ½ + ½ + ½ ii) Showing the given expression of magnetic moment. 2	MAIN

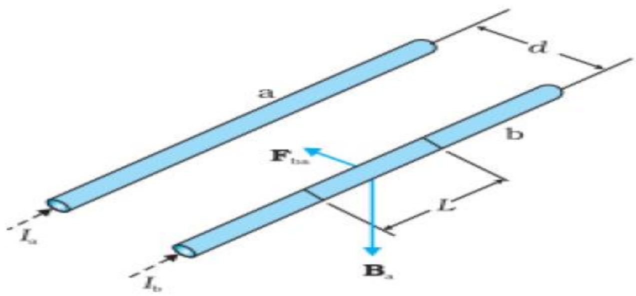
	i) Near point P Magnetic field is acting into the plane of the paper as Force is acting upwards. Near point Q Magnetic field is into the plane of paper as force is acting upwards. Near point R Magnetic field is acting out of the plane of the paper as $\vec{F}$ is acting downwards. Relative Magnitude of the Magnetic field. As B $\alpha \frac{1}{r}$ Therefore, Near point P, magnitude of B is small. Near point Q, B is relatively smaller than point P. Near point R, B is relatively larger than point P. ($B_Q < B_P < B_R$) ii) Let r be the radius of the circular coil and I is the current in the coil then $B = \frac{\mu_0 I}{2r}$ or $I = \frac{2Br}{\mu_0}$ $A = \pi r^2$ $r = \sqrt{\frac{A}{\pi}}$ $M = IA$ $= \frac{2Br}{\mu_0} A$ $= \frac{2BA}{\mu_0}\sqrt{\frac{A}{\pi}}$	
25.	(i) Derive an expression for the torque acting on a rectangular current loop suspended in a uniform magnetic field. (ii) A charged particle is moving in a circular path with velocity V in a uniform magnetic field B. It is made to pass through a sheet of lead and as a consequence, it loses one half of its kinetic energy without change in its direction. How will (1) the radius of its path (2) its time period of revolution change? **SUGGESTIVE VALUE POINT** i) Deriving the expression for the torque ii) 1) Finding the change in radius. 2) Finding the change in time perio  	MAIN

	$\vec{F}_1$ *and* $\vec{F}_2$ are the forces acting on two arms of the rectangular coil having sides a and b. $\lvert\vec{F}_1\rvert = \lvert\vec{F}_2\rvert = I\,b\,B$ (b = length of the arm) Forces constitute a couple. The magnitude of Torque on the loop is – $\tau = F_1 \frac{a}{2}\sin\theta + F_2 \frac{a}{2}\sin\theta$ $= I\,a\,b\,B\sin\theta$ $= IA\,B\sin\theta$ $\vec{\tau} = I\vec{A}\times\vec{B}$ ii) 1) $r = \frac{mv}{qB} = \frac{\sqrt{2mK}}{qB}$ $r \;\alpha\; \sqrt{K}$ $\frac{r'}{r} = \frac{\sqrt{K/2}}{\sqrt{K}} = \frac{1}{\sqrt{2}}$ $r' = \frac{r}{\sqrt{2}}$ 2) $T = \frac{2\pi m}{qB}$ Time period does not depend on Kinetic Energy ∴ Time period will not change.	
26.	(a) (i) "What is the source of force acting on a current-carrying conductor placed in a magnetic field? Obtain the expression for force acting between two long straight parallel conductors carrying steady currents and hence define 'ampere'." **(ii)** A point charge q is moving with velocity v in a uniform magnetic field B. Find the work done by the magnetic force on the charge. **(iii)** Explain the necessary conditions in which the trajectory of a charged particle is helical in a uniform magnetic field. **OR** **(b) (i)** A current carrying loop can be considered as a magnetic dipole placed along its axis. Explain. **(ii)** Obtain the relation for magnetic dipole moment $\vec{M}$ of current carrying coil. Give the direction of $\vec{M}$ **(iii)** A current carrying coil is placed in an external uniform magnetic field. The coil is free to turn in the magnetic field. What is the net force acting on the coil? Obtain the orientation of the coil in stable equilibrium. Show that in this orientation the flux of the total field (field produced by the loop + external field) through the coil is maximum.	MAIN

(a) SUGGESTIVE VALUE POINT

(i) Source of force	½
Obtaining expression for force	1½
Definition of 'ampere'	1
(ii) Finding work done by the magnetic force	1
(iii) Necessary conditions	1

(i) The source of force is the interaction between the field produced by the current carrying conductor and the external field in which it is placed.



Two long parallel conductors a & b, separated by a distance d, carrying currents I_a and I_b, respectively.

The magnetic field due to a,

$$B_a = \frac{\mu_0 I_a}{2\pi d}$$

The force F_{ba}, is the force on a segment L of 'b' due to 'a'.

$$F_{ba} = I_b L B_a$$

$$= \frac{\mu_0 I_a I_b}{2\pi d} L$$

Definition –

The 'ampere' is that value of steady current which, when maintained in each of the two very long, straight, parallel conductors of negligible cross-section, and placed one metre apart in vacuum, would produce on each of these conductors a force equal to 2×10^{-7} newton per metre of length.

(ii) Work done by the magnetic force on the charge is zero as force is perpendicular to $\vec{v}$.

(iii) The velocity ($\vec{v}$) is at an arbitrary angle θ w.r.t the magnetic field ($\vec{B}$).

OR

(b) SUGGESTIVE VALUE POINT

(i) Explanation	1
(ii) Obtaining relation for $\vec{M}$, and direction of $\vec{M}$.	1+1
(iii) Net force on coil	1
Obtaining orientation	½
Showing flux is maximum	½

(i) The two faces of a current carrying loop behave like two poles of a magnet therefore can be considered as a magnetic dipole placed along its axis.

(ii) Magnetic moment (M) α Current (I)

α Area (A)

$$\therefore \vec{M} = I\vec{A}$$

Direction is same as the area vector.

(iii) Net force acting on the coil is zero.

The potential energy (U_B) of a current carrying loop in an external magnetic field $= -\vec{M}.\vec{B}$

For the coil to be in stable equilibrium U_B should be minimum so $\theta = 0°$.

Therefore, magnetic flux (ϕ) due to the total field $= (B_{coil} + B_{ext})A$, which is its maximum value.

27. (a) (i) With the help of a labelled diagram, explain the principle of working of a moving coil galvanometer. Write the purpose of using (i) radial magnetic field, and (ii) soft iron core, in it. MAIN

(ii) Define current sensitivity of a galvanometer. 'Increase the current sensitivity may not necessarily increase the voltage sensitivity'. Give reasons.:

OR

(b)(I) (i) write Ampere's circuital law in mathematical form and explain the terms used.

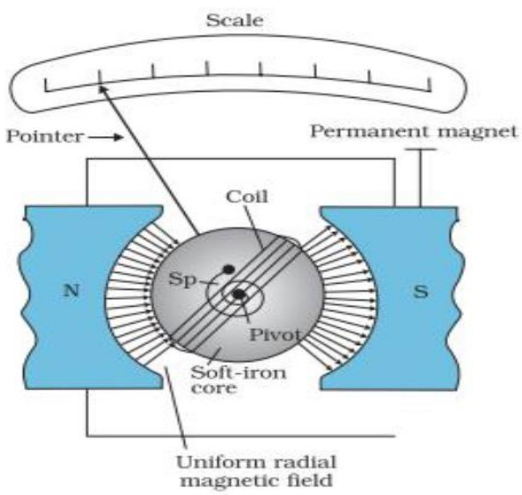
(ii) As the current carrying solenoid is made longer, the magnetic field produced outside it approaches zero. Why?

(iii) A flexible loop of irregular shape carrying current when located in an external magnetic field, changes to a circular shape. Give reason.

(II) A galvanometer of resistance G is converted into a voltmeter to measure up to V volts, by connecting a resistance R_1 series with the coil. If R_1 is replaced by R_2, then it can only measure up to V/2 volt. Find the value of the resistance R_3 (in terms of R $_1$ and R $_2$) needed to convert it into a voltmeter that can read up to 2 V.

(a) (i) SUGGESTIVE VALUE POINT

(i) Labelled diagram	1
Working principle of moving coil galvanometer	1
Use of (i) Radial magnetic field	½
(ii) Soft iron core	½
(ii) Defining current sensitivity	1
Reason	1



Principle: A current carrying coil placed in uniform magnetic field experiences a torque.

(i) Radial magnetic field makes the scale linear

Alternatively: Radial magnetic field provides maximum Torque.

(ii) Use of soft iron core is to increase the strength of magnetic field/ increase sensitivity of the galvanometer.

(ii) **Current sensitivity** is defined as deflection per unit current.

Alternatively:

$$I_s = \frac{\Phi}{I} = \frac{NAB}{k}$$

Voltage sensitivity $V_s = \frac{\Phi}{V} = \left(\frac{NAB}{k}\right)\frac{I}{V} = \left(\frac{NAB}{k}\right)\frac{I}{R}$

Increase in number of turns, increases the current sensitivity and resistance of the galvanometer in the same proportion of current sensitivity therefore Voltage sensitivity remains unchanged.

OR

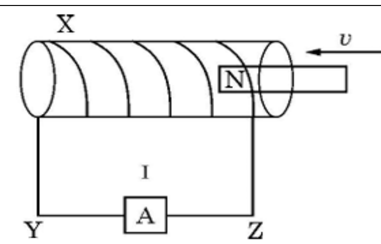
	(b) (i) SUGGESTIVE VALUE POINT (i) (I) Writing Ampere circuital law & explaining the terms. 1 (II) Reason for magnetic field outside long solenoid approaching zero 1 (III) Reason for irregular shaped loop changing to circular loop in uniform magnetic field 1 (ii) Finding the value of Resistance R_3 2 (i) **(I)** $\oint \vec{B}.\vec{dl} = \mu_0 I_e$ I_e= Total current through the surface B= Magnetic field dl = length of small element **(II)** As length of solenoid increases, it appears like a long cylindrical metal sheet so field outside approaches zero. **(III)** For a given perimeter, a circle encloses greater area than any other shape, which maximizes the flux. (ii) $R_1 = \frac{V}{I_g} - G \quad \Rightarrow \frac{V}{I_g} = R_1 + G$ -----(1) $R_2 = \frac{V}{2I_g} - G \quad \Rightarrow \frac{V}{2I_g} = R_2 + G$ -----(2) Solving (1) & (2) $G = R_1 - 2R_2$ $R_3 = \frac{2V}{I_g} - G$ -----(3) Solving using eq (1) & (3) $R_3 = 3R_1 - 2R_2$	

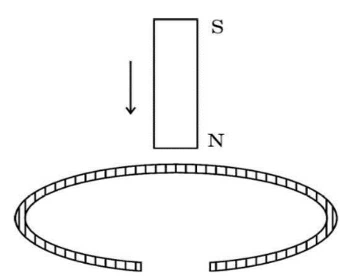
CHAPTER -5 MAGNETISM AND MATTER

Q.N.	SECTION (A) CARRY 1 MARK EACH	CBSE 2025
1.	A diamagnetic substance is brought, one by one, near the north pole and the south pole of a bar magnet. It is: (a) repelled by north pole and attracted by south pole. (b) attracted by north pole and repelled by south pole. (c) attracted by north pole as well as by south pole. (d) repelled by north pole as well as by south pole. **APPROPRIATE OPTION. (D)**	MAIN
2.	A material is pushed out when placed in a uniform magnetic field. The material is: (a) non-magnetic (b) diamagnetic (c) paramagnetic (d) ferromagnetic **APPROPRIATE OPTION. (B)**	MAIN
3.	A bar magnet is initially at right angles to a uniform magnetic field. The magnet is rotated till the torque acting on it becomes one-half of its initial value. The angle through which the bar magnet is rotated is: (a) 30^0 (b) 45^0 (C) 60^0 (d) 75 **APPROPRIATE OPTION.**	MAIN
4.	Which one out of the following materials is not paramagnetic? (a) Aluminum (b) Sodium Chloride (c) Calcium (d) Copper Chloride **APPROPRIATE OPTION. (B)**	MAIN
5.	The materials having negative magnetic susceptibility are: (a) diamagnetic (b) paramagnetic (c) ferromagnetic (d) non-magnetic **APPROPRIATE OPTION. (A)**	MAIN
6.	Which of the following substances has magnetic permeability less than that of free space? (a) Sodium (b) Iron (c) aluminum (d) Copper **APPROPRIATE OPTION. (D)**	MAIN

7.	A piece of a diamagnetic material, free to move when placed in a uniform magnetic field: (a) moves along the field (b) moves opposite to the field (c) moves perpendicular to the field (d) does not move at all. **APPROPRIATE OPTION. (D)**	MAIN
	SECTION C EACH CARRY 3 MARKS	
8.	The magnetic moment (5J/T) of a bar magnet points along a uniform magnetic field 0·4 T. (a) Calculate (i) the potential energy of the bar magnet, and (ii) the work done in turning the magnet by 180^0. (b) In which case is the potential energy of the magnet minimum? **SUGGESTIVE VALUE POINTS** (a) Calculating (i) Potential energy — 1 (ii) Work done in turning the magnet by 180° — 1 ½ (b) Identification of minimum potential energy alignment — ½ (a) (i) $U = -MB\cos\theta = -5\times0.4\times1 = -2\ J$ (ii) $W = MB(Cos\,\theta_2 - Cos\,\theta_1) = -5\times0.4(-1-1) = 4\ J$ (b) Potential energy is minimum in case (i)	MAIN

CHAPTER- 6 ELECTROMAGNETIC INDUCTION (EMI)

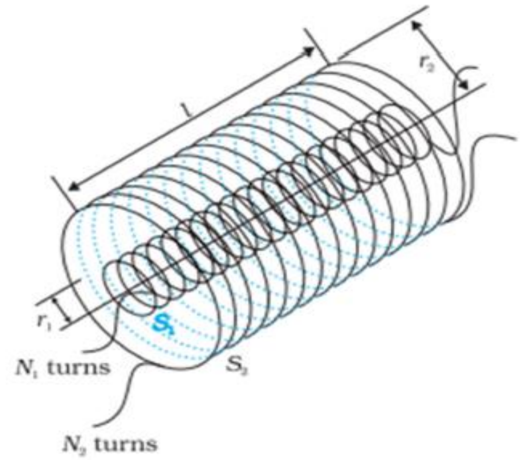
Q.N.	SECTION (A) CARRY 1 MARK EACH	CBSE 2025
1	A coil has 100 turns, each of area 0.05 m^2 and total resistance 1.5 Ω. It is inserted at an instant in a magnetic field of 90 mT, with its axis parallel to the field. The charge induced in the coil at that instant is: (A) 3.0 mC **(B) 0.30 C** (C) 0.45 C (D) 1.5 C **APPROPRIATE OPTION. (B) 0.30 C**	MAIN
2.	You are required to design an air-filled solenoid of inductance 0.016 H having a length 0.81 m and radius 0.02 m. The number of turns in the solenoid should be (A) 2592 **(B) 2866** (C) 2976 (D) 3140 **APPROPRIATE OPTION (B) 2866**	MAIN
3.	A circular coil of diameter 15 mm having 300 turns is placed in a magnetic field of 30 mT such that the plane of the coil is perpendicular to the direction of magnetic field. The magnetic field is reduced uniformly to zero in 20 ms and again increased uniformly to 30 mT in 40 ms. If the emfs induced in the two-time intervals are e1 and e2 respectively, then the value of e1/e2 is: (A) ½ (B) 1 **(C) 2** (D) 4. **APPROPRIATE OPTION (C)2**	MAIN
4.	In the figure X is a coil wound over a hollow wooden pipe.  A permanent magnet is pushed at a constant speed v from the right into the pipe and it comes out at the left end of the pipe. During the entry and the exit of the magnet, the current in the wire YZ will be from (A) Y to Z and then Y to Z (B) Z to Y and then Y to Z (C) Y to Z and then Z to Y (D) Z to Y and then Z to Y **APPROPRIATE OPTION (B)**	MAIN

5.	Two long solenoids of radii r_1 and r_2 ($r_2 > r_1$) and number of turns per unit length n_1 and n_2 respectively are co-axially wrapped one over the other. The ratio of self-inductance of inner solenoid to their mutual inductance is - (A) $\frac{n_1}{n_2}$ (B) $\frac{n_2}{n_1}$ (C) $\frac{n_1 r_1^2}{n_2 r_2^2}$ (D) $\frac{n_2 r_1^2}{n_1 r_2^2}$ **APPROPRIATE OPTION. (A)**	MAIN
6.	A coil of an AC generator has 100 turns and an area of 0.1 m. It rotates at half a rotation per second in a magnetic field of 0.02 T. The maximum EMF generated in the coil is: (A) 0.31 V (B) 0.20 V **(C) 0.63 V** (D) 0.10 V **APPROPRIATE OPTION (C) 0.63 V**	MAIN
7.	When current in a coil change at a steady rate from 8 A to 6 A in 4 ms, an emf of 15 V is induced in it. The value of self-inductance of the coil is: (A) 6 mH (B) 12 mH **(C) 3 mH** (D) 9 mH **APPROPRIATE OPTION (C) 3 mH**	MAIN
8.	The magnetic flux linked with a coil change with time t as $\phi = (8t^2 + 5t + 7)$, where t is in seconds and is ϕ in Wb. The value of emf induced in the coil at t = 4 s is: (A) 32 V (B) 37 V (C) 64 V **(D) 69 V** **APPROPRIATE OPTION. (D) 69 V**	MAIN
9.	A vertically held bar magnet is dropped along the axis of a copper ring having a cut as shown in the diagram. The acceleration of the falling magnet is:  (A) zero g (B) less than **(C) g** (D)greater than g **APPROPRIATE OPTION. (C) g**	MAIN
10.	Whenever a magnet is moved either towards or away from a conducting coil, an emf is induced whose magnitude is independent of the : (A) number of turns in the coil (B) resistance of the coil (C) speed with which the magnet is moved (D) area of the coil **APPROPRIATE OPTION. (B)**	COMP

	SECTION (C) CARRY 3 MARK EACH	
11.	(a) Show that the energy required to build up the current I in a coil of inductance L is (1/2) LI^2. (b) Considering the case of magnetic field produced by air-filled current carrying solenoid, show that the magnetic energy density of a magnetic field B is $B^2 / (2\mu_0)$. **SUGGESTIVE VALUE POINTS** a) Deriving the expression for energy stored in an inductor. 1 ½ b) Deriving the energy density of magnetic field. 1 ½ a) Induced emf in an inductor $\lvert\varepsilon\rvert = L\frac{dI}{dt}$ Rate of work done at any instant $\frac{dW}{dt} = \lvert\varepsilon\rvert I$ Total Amount of work done in establishing current I $W = \int dW = \int_0^I LIdI$ Energy required to build up current I is $W = \frac{1}{2} L I^2$ b) The Magnetic Energy is $W = U_B = \frac{1}{2} LI^2$ $= \frac{1}{2} L \left(\frac{B}{n\mu_0}\right)^2$ as $B = n\mu_0 I$ Using $L = \mu_0 n^2 Al$ $U_B = \frac{1}{2}\left(\mu_0 n^2 Al\right)\left(\frac{B^2}{\mu_0^2 n^2}\right)$ Energy density $= \frac{U_B}{\text{volume}}$ $\frac{U_B}{\text{volume}} = \frac{1}{2} \times \mu_0 n^2 Al \times \frac{B^2}{\mu_0^2 n^2} \times \frac{1}{Al}$ $= \frac{1}{2}\frac{B^2}{\mu_0}$	MAIN
12.	Consider two long co-axial solenoids S_1 and S_2, each of length l (>> r_2) and of radius r_1 and r_2 ($r_2 > r_1$). The number of turns per unit length are n_1 and n_2 respectively. Derive an expression for mutual inductance M_{12} of solenoid S_1 with respect to solenoid S_2. Show that $M_{21} = M_{12}$.	MAIN

SUGGESTIVE VALUE POINTS

Deriving the expression for mutual Inductance	2
Showing $M_{21} = M_{12}$	1



Let N_1 and N_2 be the total number of turns of coils S_1 and S_2 respectively.
When current I_2 is set up in S_2, flux linkage with solenoid S_1 is –

$$N_1\phi_1 = M_{12}I_2 \quad \text{--(i)}$$

$$N_1\phi_1 = (n_1 l)(\pi r_1^2)(\mu_0 n_2 I_2)$$

$$N_1\phi_1 = \mu_0 n_1 n_2 \pi r_1^2 l\, I_2 \quad \text{--(ii)}$$

From (i) and (ii)

$$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$$

Considering Reverse case, when I_1 current is set up in S_1, flux linkage with S_2 is –

$$N_2\phi_2 = M_{21}I_1 \quad \text{--(iii)}$$

$$N_2\phi_2 = (n_2 l)(\pi r_1^2)(\mu_0 n_1 I_1) \quad \text{--(iv)}$$

From (iii) and (iv)

$$M_{21} = n_1 n_2 \pi r_1^2 l$$

$$\therefore M_{12} = M_{21}$$

13. (a) State Lenz's law. MAIN

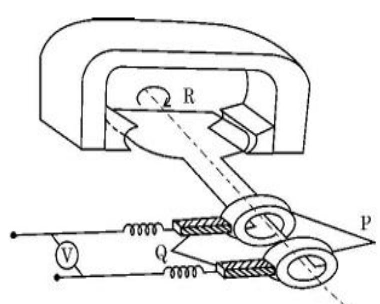
(b) In the given figure:

(i) Identify the machine.

(ii) Name the parts P and Q and R of the machine.

(iii) Give the polarities of the magnetic poles.

(iv) Write the two ways of increasing the output voltage



	SUGGESTIVE VALUE POINTS (a) Statement of Lenz's law ½ (b) (i) Identifying the machine ½ (ii) Naming parts P and Q and R ½ (iii) Giving polarities ½ (iv) Two ways of increasing output voltage ½ +½ (a) Lenz's law- The polarity of induced emf is such that it tends to produce a current which opposes the change in magnetic flux that produced it. (b) (i) AC generator (ii) P – Slip rings Q – Carbon brushes R- Armature coil (iii) Left side of the magnet is North & right side is South or vice-versa. (iv) (Any two) -By increasing the number of turns in the armature coil. -By increasing the speed of rotation of the armature coil. -By increasing the strength of the magnetic field B.	
	SECTION (E) CARRY 5 MARK EACH	
14.	(a) (i) Define self-inductance of a coil. Derive the expression for the energy required to build up a current I in a coil of self-inductance L. (ii) The currents passing through two inductors of self-inductances 10 mH and 20 mH increase with time at the same rate. Draw graphs showing the variation of: (I) the magnitude of emf induced with the rate of change of current in each inductor. (II) the energy stored in each inductor with the current flowing through it **OR** (b) (i) Define the term mutual inductance. Deduce the expression for the mutual inductance of two long coaxial solenoids of the same length having different radii and different number of turns. (ii) The current through an inductor is uniformly increased from zero to 2 A in 40 s. An emf of 5 mV is induced during this period. Find the flux linked with the inductor at t = 10 s. **SUGGESTIVE VALUE POINTS**	MAIN

(a)

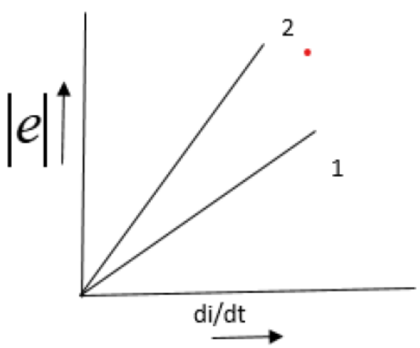
i) Defining self – inductance	1
Deriving expression for energy	1
ii) Drawing graphs showing the variation of	
(I) Magnitude of emf induced with rate of change of current	1½
(II) Energy stored with current	1½

Self Inductance is magnetic flux linked with a coil when the current through the coil is unity.

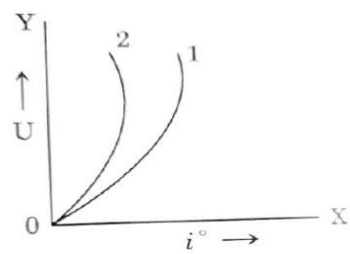
Self Inductance is the induced emf induced in the coil when rate of change of current through the coil is unity.
To maintain growth of current, power has to be supplied from external source.

$$P = |e||I|$$
$$= \frac{dW}{dt} = LI\frac{dI}{dt}$$
$$dW = LIdI$$
$$W = \int LIdI$$
$$= \frac{1}{2}LI^2$$

(I) $E = -L\frac{dI}{dt}$



(II) $U = \frac{1}{2}LI^2$ Parabolic graph obtained.



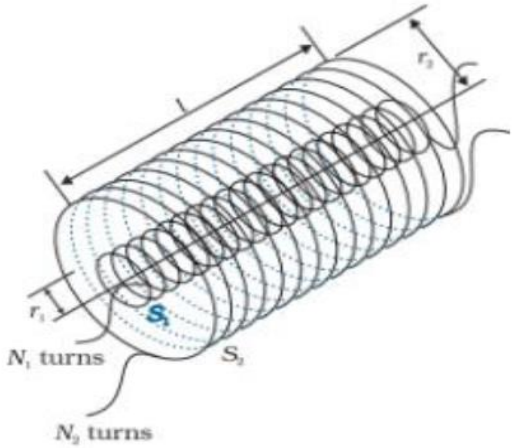
(1 indicates 10mH) & (2 indicates 20mH)

OR

(a)

(i) Defining mutual inductance	1
Deducing expression for mutual inductance	2
(ii) Finding flux linked with the inductor	2

(ii) Mutual inductance is defined as the induced emf in primary coil when the current in secondary coil changes at the unit rate.
Alternatively
Mutual inductance is defined as the magnetic flux linked with the primary coil when the current in secondary coil is unity.



Consider two long co-axial solenoids each of length l. Radius of inner solenoid S_1 is r_1 and number of turns per unit length is n_1.

The corresponding quantities for outer solenoid S_2 are r_2 and n_2 respectively. Let N_1 and N_2 be the total number of turns of coils S_1 and S_2 respectively.

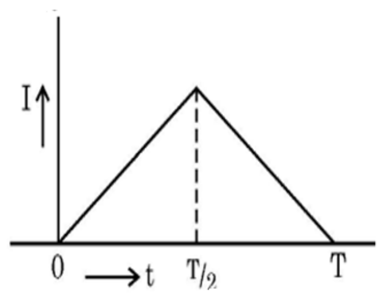
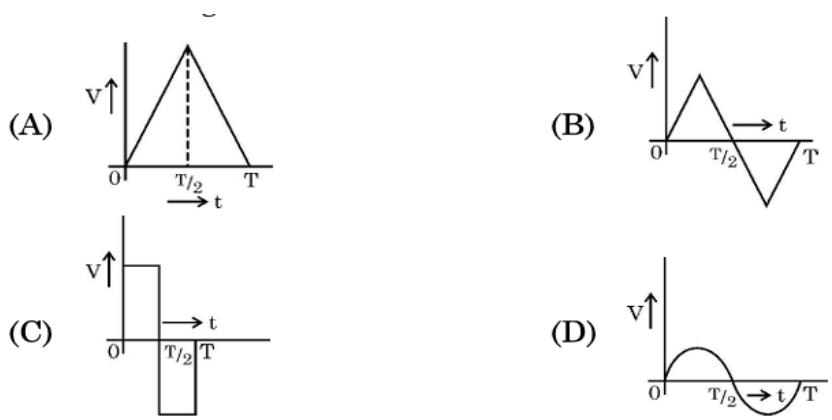
When a current I_2 is set up through S_2, it sets up magnetic flux through S_1.

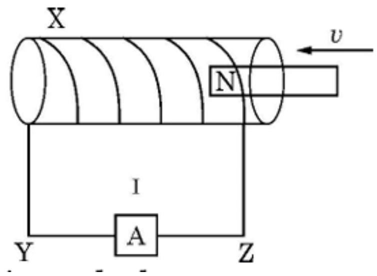
$$N_1\phi_1 = M_{12}I_2$$
$$= (n_1 l)\times(\pi r_1^2)\times(\mu_0 n_2 I_2)$$
$$= \mu_0 n_1 n_2 \pi r_1^2 l I_2$$
$$M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l = M_{21}$$

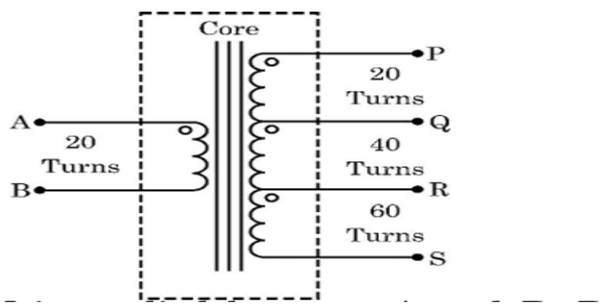
(ii)

$$|e| = L\frac{dI}{dt}$$
$$L = \frac{e}{dI/dt}$$
$$= \frac{5\times10^{-3}}{2/40}$$
$$= 0.1\,H$$
$$\phi = LI$$
$$= 0.1\times\frac{2}{40}\times10$$
$$= 0.05\ Wb$$

CHAPTER- 7 ALTERNATING CURRENT (AC)

Q.N.	SECTION (A) CARRY 1 MARK EACH	CBSE 2025
1.	A voltage $v = v_0 \sin \omega t$ applied to a circuit drives a current $i = i_0 \sin(\omega t + \varphi)$ in the circuit. The average power consumed in the circuit over a cycle is: (A) Zero (B) $i_0 v_0 \cos \varphi$ (C) $i_0 v_0 / 2$ (D) $i_0 v_0 \cos \varphi/2$ **APPROPRIATE OPTION. (D) $i_0 v_0 \cos \varphi/2$**	MAIN
2.	The alternating current I in an inductor is observed to vary with time t as shown in the graph for a cycle.  Which one of the following graphs is the correct representation of wave form of voltage V with time?  **APPROPRIATE OPTION. (C)**	MAIN
3.	A transformer is connected to a 200 V AC source. The transformer supplies 3000 V to a device. If the number of turns in the primary coil is 450, then the number of turns in its secondary coil is: (A) 30 (B) 450 (C) 4500 (D) 6750 **APPROPRIATE OPTION. (D)**	MAIN

<table>
<tr><td>4.</td><td>In the figure X is a coil wound over a hollow wooden pipe.


A permanent magnet is pushed at a constant speed v from the right into the pipe and it comes out at the left end of the pipe. During the entry and the exit of the magnet, the current in the wire YZ will be from
(A) Y to Z and then Y to Z (B) Z to Y and then Y to Z
(C) Y to Z and then Z to Y (D) Z to Y and then Z to Y
APPROPRIATE OPTION. (B)</td><td>MAIN</td></tr>
<tr><td>5.</td><td>The number of turns between different pairs of output terminals are shown for a step-up transformer.


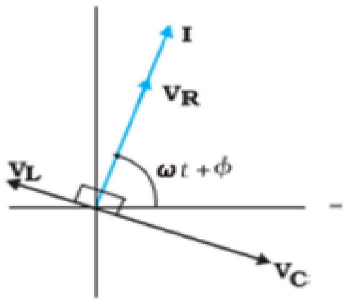
Input voltage of 20 V is applied between A and B. Between which two terminals will the output be 120 V?
(A) P and Q (B) Q and S (C) P and R (D) P and S
APPROPRIATE OPTION. (D) P and S</td><td>MAIN</td></tr>
<tr><td>6.</td><td>An ammeter connected in series in an ac circuit reads 10 A. The maximum value of current at any instant in the circuit is:
(A) $10\sqrt{2}$ A (B) $\frac{10}{\sqrt{2}}$ A
(C) $\frac{10}{\pi}$ A (D) $\frac{10}{\sqrt{2}\,\pi}$ A
APPROPRIATE OPTION. (A)</td><td>MAIN</td></tr>
</table>

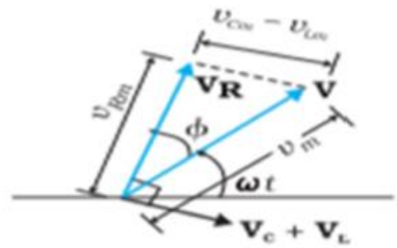
7.	A transformer is a device used for converting: (A) high ac voltage and large ac current to low ac voltage and small ac current (B) high ac voltage and small ac current to low ac voltage and small ac current (C) low ac voltage and large ac current to high ac voltage and small ac current (D) low ac voltage and small ac current to high ac voltage and large ac current **APPROPRIATE OPTION. (C)**	MAIN
8.	An ac source is connected to a resistor and an inductor in series. The voltage across the resistor and inductor are 8 V and 6 V respectively. The voltage of the source is: **(A) 10 V** (B) 12 V (C) 14 V (D) 16 V. **APPROPRIATE OPTION. (A) 10 V**	MAIN
9.	An alternating current is given by $I = I_0 \cos(100\pi)t$. The least time the current takes to decrease from its maximum value to zero will be: (A) $\left(\frac{1}{200}\right)$ s (B) $\left(\frac{1}{150}\right)$ s (C) $\left(\frac{1}{100}\right)$ s (D) $\left(\frac{1}{50}\right)$ s **APPROPRIATE OPTION. (A)**	MAIN
10.	A capacitor and an inductor are connected in series across an ac source of voltage of variable frequency. The frequency is increased continuously. The nature of the circuit before and after the resonance will be: (A) inductive only (B) capacitive only (C) capacitive and inductive respectively (D) inductive and capacitive respectively **APPROPRIATE OPTION. (C)**	MAIN
11.	The average value of voltage of 220 V ac mains during its positive half cycle will be: (A) 156 V (B) 198 V (C) 220 V (D) zero **APPROPRIATE OPTION. (B)**	COMP

12.	Which of the following assumptions has been used to obtain the relation $\frac{V_s}{V_p} = \frac{N_s}{N_p}$ for a transformer? (A) The resistance of the primary coil is large. (B) The same flux links both the primary and the secondary coils. (C) The resistance of secondary coil is large. (D) The transformer is 100% efficient. **APPROPRIATE OPTION. (B)**	COMP
13.	A step-up transformer: (A) decreases the current to transmit power over short distances with minimum loss. (B) increases the current to transmit power over short distances with minimum loss. (C) increases the voltage to transmit power over short distances with minimum loss. (D) increases the voltage to transmit power over long distances with minimum loss. **APPROPRIATE OPTION. (D)**	BLIND
14.	Which of the following statements about transformers is not correct? (A) For ideal transformers, the output power is equal to the input power. (B) A transformer can work for both alternating and direct voltages. (C) For a step-up transformer, the voltage across the secondary coil is higher but the current in it is lower. (D) For an ideal transformer, the magnetic flux linked with the secondary is equal to that linked with the primary. **APPROPRIATE OPTION. (B)**	BLIND COMP
	SECTION (C) CARRY 3 MARK EACH	
15.	An ac source of voltage $v = v_m \sin \omega t$ is connected to a series combination of LCR circuit. Draw the phasor diagram. Using it obtains an expression for the impedance of the circuit and the phase difference between applied voltage and the current. **SUGGESTIVE VALUE POINTS**	MAIN

Drawing phasor diagram	1
Obtaining the expression for	
Impedance of the circuit	1 ½
Phase difference	½

a)





$V_{Rm} = i_m R$, $V_{Cm} = i_m X_c$, $V_{Lm} = i_m X_L$

From Phasor diagram

$$V_m^2 = V_{Rm}^2 + (V_{Cm} - V_{Lm})^2$$

$$V_m^2 = (i_m R)^2 + (i_m X_c - i_m X_L)^2$$

$$= (i_m)^2 \left[R^2 + (X_c - X_L)^2 \right]$$

Or $i_m = \dfrac{V_m}{\sqrt{R^2 + (X_c - X_L)^2}}$

$$\therefore i_m = \frac{V_m}{Z}$$

$$\therefore Z = \sqrt{R^2 + (X_c - X_L)^2}$$

From phasor diagram

$$\tan\theta = \frac{V_{Cm} - V_{Lm}}{V_{Rm}}$$

$$= \frac{X_c - X_L}{R}$$

$$\therefore \theta = \tan^{-1}\left(\frac{X_c - X_L}{R}\right)$$

16. Differentiate between Peak Value and Root Mean Square (RMS) Value of an Alternating Current. Derive the expression for the Root Mean Square Value of Alternating Current, in terms of its Peak Value. MAIN

SUGGESTIVE VALUE POINTS

Differentiating between peak value & root mean square value of AC.	1
Deriving expression for rms value of AC	2

Peak value is the maximum value of the alternating current.

rms current is the equivalent dc current that would produce the same average power loss as the alternating current.

Alternatively: -

$$I_{rms} = \frac{I_o}{\sqrt{2}}$$

Alternatively: -

$$I_{rms} = 0.707\ I_o$$

The instantaneous power dissipated in the resistor is $P = i^2R = i_m^2 R \sin^2 \omega t$

The average power over a cycle is: -

$$\overline{P} = <i^2R> = <i_m^2 R \sin^2\ \omega t>$$

$$<\sin^2\ \omega t> = \frac{1}{2}$$

$$\overline{P} = \frac{1}{2} i_m^2 R \ = I_{rms}^2 R$$

$$I_{rms} = \sqrt{\frac{i_m^2}{2}} = \frac{i_m}{\sqrt{2}}$$

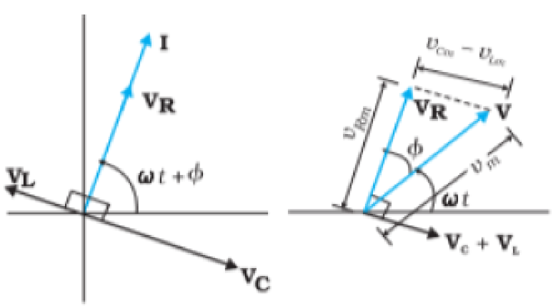
17. (a) AC voltage of frequency ω is applied across a series LCR circuit. Draw the phasor diagram and obtain the impedance of the circuit. — MAIN

(b) Discuss 'resonance' in a series LCR circuit and write the expression for resonant frequency.

SUGGESTIVE VALUE POINTS

(a) Drawing the phasor diagram and obtaining the impedance	2
(b) Discussing 'resonance' and writing the expression for resonant frequency	1

(a)

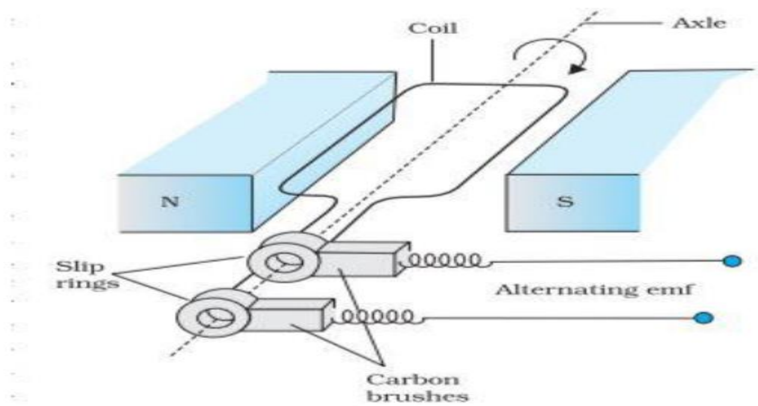


	$\vec{V}_L+\vec{V}_R+\vec{V}_C=\vec{V}$ $v_m^2 = v_{Rm}^2+(v_{Cm}-v_{im})^2$ $=(i_mR)^2+(i_mX_C-i_mX_L)^2$ $v_m^2 = i_m^2\left[R^2+(X_C-X_L)^2\right]$ $i_m=\frac{v_m}{\sqrt{R^2+(X_C-X_L)^2}}$ $=>Z=\sqrt{R^2+(X_C-X_L)^2}$ (b) When $X_L = X_C$, the impedance of the series LCR circuit is minimum and the current flowing through it is maximum. $\omega_o=\frac{1}{\sqrt{LC}}$	
	SECTION (E) CARRY 5 MARK EACH	
18.	(a) (i) Write the principle of working of an ac generator. Draw its labelled diagram and explain its working. (ii) A resistor of 400Ω, an inductor of ($\frac{5}{\pi}$)H and a capacitor ($\frac{50}{\pi}$) μF are joined in series across an ac source v = 140 sin (100 π) t V. Find the rms voltages across these three circuit elements. The algebraic sum of these voltages is more than the rms voltage of source. Explain. **OR** (b) (i) Write the principle of working of a transformer. With the help of a labelled diagram, explain the working of a step-up transformer. (ii) An ideal transformer is designed to convert 50 V into 250 V. It draws 200 W power from an ac source whose instantaneous voltage is given by v_i = 20 sin (100 π) t V Find: (I) rms value of input current. (II) expression for instantaneous output voltage. (III) expression for instantaneous output current.	MAIN

SUGGESTIVE VALUE POINTS

(i)	Writing principle of ac generator	1
	Labelled diagram of ac generator	1
	Working of ac generator	1
(ii)	Finding rms voltages across three circuit elements	1½
	Explanation of the algebraic sum of rms voltages across three circuit elements is more than the rms voltage source	½

(i) Principle: It works on the principle of electromagnetic induction.



Working: The coil is mechanically rotated in the uniform magnetic field. The rotation of the coil causes the magnetic flux through it to change, so an emf is induced in the coil.

(i) $Z=\sqrt{R^2+\left(\omega L-\dfrac{1}{\omega C}\right)^2}$

$$=\sqrt{(400)^2+\left(100\pi\times\frac{5}{\pi}-\frac{1}{100\pi\times\frac{50}{\pi}\times10^{-6}}\right)^2}$$

$=500\,\Omega$

$I_{rms}=\dfrac{V_{rms}}{Z}$

$I_{rms}=\dfrac{140}{\sqrt{2}\times500}=\dfrac{0.28}{\sqrt{2}}$ A

$(V_{rms})_R=I_{rms}\ R$

$=\dfrac{0.28}{\sqrt{2}}\times400$

$=\dfrac{112}{\sqrt{2}}=56\sqrt{2}$ V

$(V_{rms})_L=I_{rms}\,\omega L$

$=\dfrac{0.28}{\sqrt{2}}\times500$

$=\dfrac{140}{\sqrt{2}}=70\sqrt{2}$ V

$$(V_{rms})_C = I_{rms}\frac{1}{\omega C}$$

$$= \frac{0.28}{\sqrt{2}} \times 200$$

$$= \frac{56}{\sqrt{2}} = 28\sqrt{2}\text{ V}$$

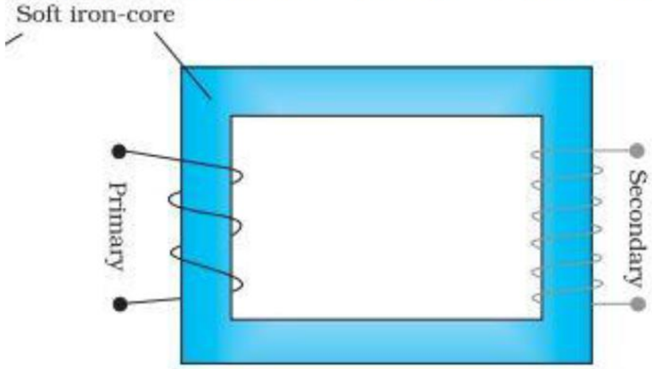
The algebraic sum of voltages is more than the rms voltage of source because voltages across R, L and C are not in phase.

OR

(b)SUGGESTIVE VALUE POINTS

(i)	Writing principle of transformer	1
	Labelled diagram of step-up transformer	1
	Working of step-up transformer	1
(ii)	Finding-	
	• rms value of input current	1
	• expression for instantaneous output voltage	½
	• expression for instantaneous output current	½

(i) **Principle**: It works on the principle of mutual induction.



Working: When an alternating voltage is applied to the primary, the resulting current produces an alternating magnetic flux which links the secondary and induces an emf in it. Since the no. of turns are more in secondary windings an emf induced is proportional to the no. of turns. Therefore more emf is developed across the secondary windings.

(ii) $P_i = V_p I_p$

$$200 = \frac{20}{\sqrt{2}} I_p$$

$$I_p = 10\sqrt{2}\text{A}$$

$$\therefore I_o = \left(2\sqrt{2}\right)\sqrt{2}\sin(100\pi)\text{t}$$

$$I_o = 4\sin(100\pi)\text{t A}$$

$$\frac{V_o}{V_i} = \frac{250}{50}$$

$$5 = \frac{V_o}{V_i}$$

$$V_o = 100\sin(100\pi)\text{t V}$$

$$P_o = (V_o)_{rms}(I_o)_{rms}$$

$$200 = \frac{100}{\sqrt{2}}(I_o)_{rms}$$

$$(I_o)_{rms} = 2\sqrt{2}\text{A}$$

19.

(a) (i) A series combination of L, C and R is connected to an ac source $V = V_m \sin \omega t$. Obtain:

(I) the impedance of the circuit using phasor diagram,

(II) the expression for the instantaneous current I, and

(III) the phase relationship of current to the applied voltage.

(ii) Define power factor of an ac circuit. State the conditions under which it is:

(I) maximum, (II) minimum.

OR

(b) (i) Prove that the voltage is ahead of the current in phase by $\pi/2$ rad in an ac circuit containing an ideal inductor.

(ii) The currents through two inductors of self-inductance 12 mH and 24 mH are increasing with time at the same rate. Draw graphs showing the variation of the:

(I) magnitude of emf induced with the rate of change of current in each inductor.

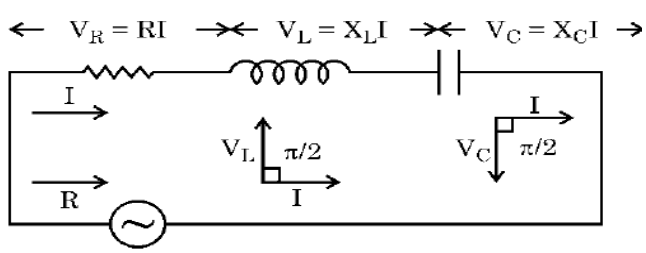
(II) energy stored in each inductor with the current flowing through it.

COMP

(a) SUGGESTIVE VALUE POINTS

(i) Obtaining	
(I) Impedance of the circuit using phase diagram	2
(II) Expression for the instantaneous current	½
(III) Phase relationship of current to the applied voltage	½
(ii) Defining power factor of ac circuit	1
Stating conditions in which power factor is	
(I) Maximum	½
(II) Minimum	½

(a) (i) (I) Let resistance R, inductor L and capacitor C be connected in series with an alternate e.m.f.



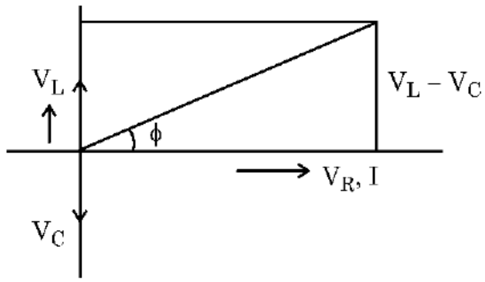
$$\varepsilon = \sqrt{I^2[R^2 + (X_L - X_c)^2]}$$

$$Z = \frac{\varepsilon}{I}$$

$$Z = \sqrt{R^2 + (X_L - X_C)^2}$$

(II) $$I_m = \frac{V_m}{Z}\sin(\omega t - \phi)$$

(III) Phase angle $\tan\phi = \dfrac{V_L - V_C}{V_R}$



(ii) $P = E_V I_V \cos\phi$ where P = true power and $E_V I_V$ is the apparent power. ϕ is phase difference between current and voltage.
Power factor is defined as the ratio of true power to the apparent power.

$$\text{Power factor} = \frac{\textit{True Power (P)}}{\textit{Apparent power } (E_V I_V)} = \cos\phi$$

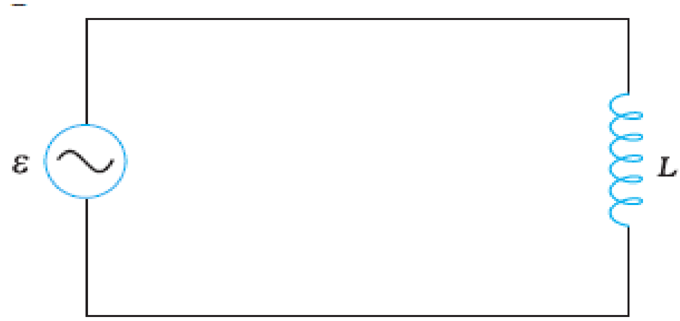
(i) Power factor is maximum when ϕ = 0 purely resistive circuit(It occurs when $\omega = \dfrac{1}{\sqrt{LC}}$ at resonance in an LCR series circuit).

(ii) Power factor is minimum when $\phi = \dfrac{\pi}{2}$, in pure inductive or capacitive circuit.

OR

(b) SUGGESTIVE VALUE POINTS

(i) Proving that the voltage is ahead of current in phase by π/2 radian in an AC circuit containing an ideal inductor	3
(ii) Drawing graph showing the variations of	
(I) Magnitude of induced emf with rate of change of current	1
(II) Energy stored in inductor with current	1



(i) Let the voltage across the source be $v = v_m \sin\omega t$

Using Kirchhoff's loop rule

$$\upsilon - L\frac{di}{dt} = 0$$

$$\frac{di}{dt} = \frac{\upsilon}{L} = \frac{\upsilon_m}{L}\sin\omega t$$

$$di = \frac{\upsilon_m}{L}\sin\omega t\, dt$$

Integrating

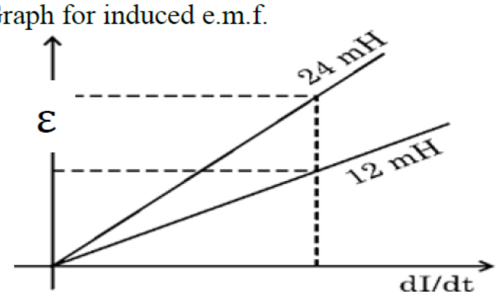
$$i = \frac{\upsilon_m}{\omega L}\cos\omega t$$

$$i = i_m \sin(\omega t - \frac{\pi}{2})$$

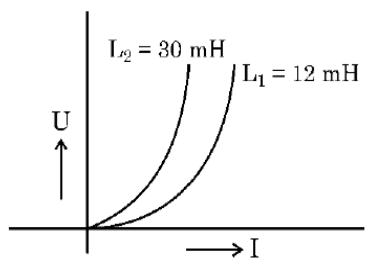
This show that current lags behind the voltage by $\frac{\pi}{2}$ rad.

$\therefore$ Voltage is ahead of current in phase by $\frac{\pi}{2}$ rad

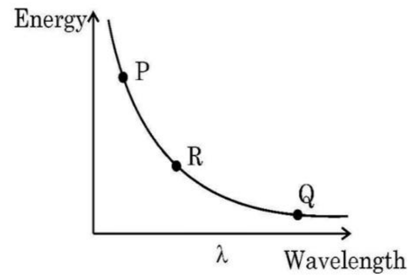
(ii) (I) Graph for induced e.m.f.



(II) Graph for energy stored



CH- 8 ELECTROMAGNETIC WAVE (EMW)

Q.N.	**SECTION (A) CARRY 1 MARK EACH**	**CBSE 2025**
1.	The given diagram exhibits the relationship between the wavelength of the electromagnetic waves and the energy of photon associated with them. The three points P, Q and R marked on the diagram may correspond respectively to:  (A) X-rays, microwaves, UV radiation (B) X-rays, UV radiation, microwaves (C) UV radiation, microwaves, X-rays (D) Microwaves, UV radiation, X-rays **APPROPRIATE OPTION**. (A) X-rays, microwaves, UV radiation	MAIN
2.	X-rays are more harmful to human beings than ultraviolet radiations because X-rays - (A) have frequency lower than that of ultraviolet radiations. (B) have wavelength smaller than that of ultraviolet radiations. (C) move faster than ultraviolet radiations in air. (D) are mechanical waves but ultraviolet radiations are electro-magnetic waves. **APPROPRIATE OPTION**	MAIN
3.	Which of the following rays coming from the Sun plays an important role in maintaining the Earth's warmth. (A) Infrared rays (B)γ- rays (C) UV rays (D) Visible light rays **APPROPRIATE OPTION**	MAIN
4.	The dimensions of $(\mu\ \varepsilon)^{-1}$, where is permittivity and is permeability of a medium, are (A) $[M^0 L^1 T^{-1}]$ (B) $[M^0 L^2 T^{-2}]$ (C) $[M^1 L^2 T^{-2}]$ (D) $[M^1 L^{-1} T^1]$ **APPROPRIATE OPTION**	MAIN
5.	Which of the following electromagnetic waves has photons of largest momentum? (A) X-rays (B) AM radio waves (C) Microwaves (D) TV waves. **APPROPRIATE OPTION**	MAIN

6.	Microwaves Electromagnetic radiation used to kill germs in water purifiers is: (A) Microwave (B) Gamma rays (C) Ultraviolet rays (D) Radio waves **APPROPRIATE OPTION**	COMP
7.	Welders wear special glass goggles or face masks with glass windows to protect their eyes from: (A) UV rays (B) X-rays (C) IR rays (D) Gamma rays **APPROPRIATE OPTION**	COMP
8.	Which of the following electromagnetic waves are known as ‘heat waves? (A) UV rays (B) X-rays (C) IR rays (D) Gamma rays **APPROPRIATE OPTION**	COMP
9.	The electromagnetic radiation used to kill germs in water purifiers is: (A) Ultraviolet rays (B) Infrared waves (C) Visible rays (D) γ-rays **APPROPRIATE OPTION**	BLIND
10.	In free space, which of the following quantities is always larger for X-rays than for a radio wave? (A) Speed (B) Frequency (C) Amplitude (D) Wavelength **APPROPRIATE OPTION**	BLIND COMP
	SECTION (C) CARRY 3 MARK EACH	
11.	**(a)** A parallel plate capacitor is charged by an ac source. Show that the sum of conduction current (Ic) and the displacement current (I_d) has the same value at all points of the circuit. **(b)** In case (a) above, is Kirchhoff's first rule (junction rule) valid at each plate of the capacitor? Explain.	MAIN

SUGGESTIVE VALUE POINTS

a) Showing that ($I_c + I_d$) has the same value.	2
b) Explanation of Kirchhoff's first rule at each plate of capacitor.	1

a) $\because$ Total current $I = I_c + I_d$

outside the capacitor

$I_d = 0$

$\therefore I = I_c$

Inside the capacitor

$I_c = 0$

Alternatively

$\because$ Total current $I = I_c + I_d$

outside the capacitor

$I_d = 0$

$\therefore I = I_c$

Inside the capacitor

$I_c = 0$

$$I = I_d = \varepsilon_0 \frac{d\phi_E}{dt}$$

$$= \varepsilon_0 \frac{d}{dt}\left[\frac{Q}{\varepsilon_0}\right]$$

$$I = \frac{dQ}{dt} = I_c$$

hence $I_c + I_d$ has the same value at all points of the circuit.

b) Yes

Current entering the capacitor is (I_c) and between the plates capacitor is (I_d)

$I_c = I_d$

which validates Kirchhoff's junction rule.

12. (a) The electric field $\vec{E}$ of an electromagnetic wave propagating in north direction is oscillating in up and down direction. Describe the direction of magnetic field $\vec{B}$ of the wave. MAIN

(b) Are the wave length of radio waves and microwaves longer or shorter than those detectable by human eyes?

(c) Write main use of each of the following in human life:

(i) Infrared waves

(ii) Gamma rays

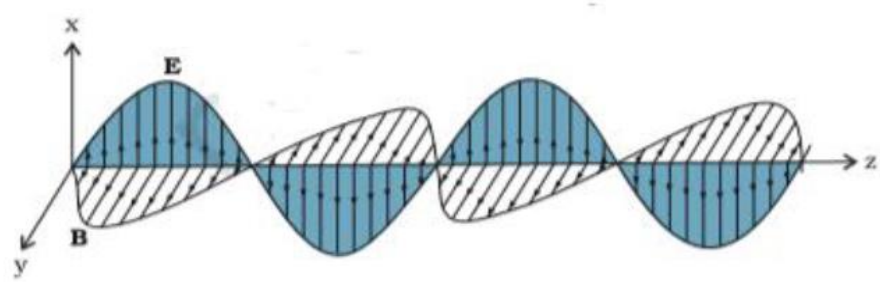
	SUGGESTIVE VALUE POINTS (a) Production of em wave — 1 (b) Direction of magnetic field — 1 (c) Estimating the ratio — 1 (a) Electromagnetic waves are produced by accelerating / oscillating charges. (b) South direction (c) $\frac{\text{Shortest wavelength of radio waves}}{\text{Longest wavelength of gamma waves}} = \frac{0.1}{10^{-12}} = 10^{11}$	
13.	(a) State any three characteristics of electromagnetic waves. (b) Briefly explain how and where the displacement current exists during the charging of a capacitor. **SUGGESTIVE VALUE POINTS** (a) Three characteristics of electro- magnetic wave — 1½ (b) Explanation of displacement current, • how — 1 • Where it exists — ½ (a) (Any three) • Electromagnetic wave carries energy. • Electromagnetic wave carries momentum. • Electromagnetic wave moves with velocity of light in vacuum. • In electromagnetic wave, electric field vector, magnetic field vector and direction of propagation, all are mutually perpendicular. • Electromagnetic waves are transverse in nature. • Electromagnetic waves do not require a physical medium to propagate and can travel through a vacuum. • Electromagnetic waves consist of oscillating electric and magnetic fields. b) • During charging of capacitor, time varying electric field / electric flux between the plates of capacitor induces the displacement current. • Displacement current exists between the plates of capacitor.	MAIN

14.	Depict the variation of electric and magnetic fields in an electromagnetic wave as it propagates along z-axis. In a plane electromagnetic wave in free space, the electric field oscillates sinusoidally at a frequency of $1{\cdot}5\text{X}10^{10}$ Hz with amplitude 36 Vm^{-1}. Find: (a) the wavelength of the wave, and (b) the amplitude of the associated magnetic field.	COMP

SUGGESTIVE VALUE POINTS

- Depicting the variation of electric and magnetic fields of an electromagnetic wave along z-axis 1
- Finding
  - a) The wavelength of the wave 1
  - b) The amplitude of the associated magnetic field 1

a)



$$\lambda = \frac{c}{v}$$

$$= \frac{3\times10^8}{1.5\times10^{10}} = 2\times10^{-2} = 0.02\,\text{m}$$

b) $$B_0 = \frac{E_0}{c}$$

$$= \frac{36}{3\times10^8}$$

$$= 1.2\times10^{-7}\ \text{T}$$

CHAPTER 9 RAY OPTICS

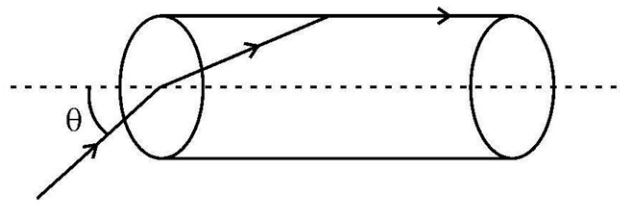
Q.N.	SECTION (A) MCQ AND ASSERTION / REASONING	CBSE 2025
1.	A beaker is filled with water (refractive index 4/3) up to a height H. A coin is placed at its bottom. The depth of the coin, when viewed along the near normal direction, will be (A) H/4 (B) 3H/4 (C) H (D) 4H/3 **APPROPRIATE OPTION** (B) 3H/4	MAIN
2.	The speed of light in two media '1' and '2' are v_1 and v_2 ($v_1 > v_2$) respectively. For a ray of light to undergo total internal reflection at the interface of these two media, it must be incident from (A) medium '1' and at an angle greater than $\sin^{-1}(v_2/v_1)$ (B) medium '1' and at an angle greater than $\cos^{-1}(v_2/v_1)$ (C) medium '2' and at an angle greater than $\sin^{-1}(v_1/v_2)$ (D) medium '2' and at an angle greater than $\cos^{-1}(v_1/v_2)$ **APPROPRIATE OPTION. (A)**	MAIN
3.	A point source is placed at the bottom of a tank containing a transparent liquid (refractive index n) to a depth H. The area of the surface of the liquid through which light from the source can emerge out is (A) $(\pi H^2)/(n - 1)$ (B) $(\pi H^2)/(n^2 - 1)$ (C) $(\pi H^2)/\sqrt{(n^2 - 1)}$ (D) $(\pi H^2)/(n^2 + 1)$ **APPROPRIATE OPTION. (B)**	MAIN
4.	A tub is filled with a transparent liquid to a height of 30.0 cm. The apparent depth of a coin lying at the bottom of the tub is found to be 16.0 cm. The speed of light in the liquid will be: (A) 1.6×10^8 m / s (B) 2.0×10^8 m / s (C) 3.0×10^8 m / s (D) 2.5×10^8 m / s **APPROPRIATE OPTION. (A)**	MAIN

5.	The focal length of a concave mirror in air is f. When the mirror is immersed in a liquid of refractive index 5/3, its focal length will become: (A) $\frac{5}{3}$f (B) $\frac{3}{5}$f (C) $\frac{2}{3}$f (D) f **APPROPRIATE OPTION. (B)**	MAIN
6.	The plane face of a planoconvex lens is silvered. The refractive index of the material and the radius of curvature of the curved surface of the lens are n and R respectively. This lens will behave as a concave mirror of focal length: (A) R/n (B) R/(n-1) (C) nR (D) R/(2(n-1)) **APPROPRIATE OPTION. (D)**	MAIN
7.	The magnification produced by a spherical mirror is 2·0. The mirror used and the nature of the image formed will be: (A) Convex and virtual (B) Concave and real (C) Concave and virtual (D) Convex and real **APPROPRIATE OPTION. (B)**	MAIN
8.	A compound microscope has an objective and an eyepiece of focal lengths fo and fe, respectively. To obtain a large magnification of a small object, the microscope should have: (A) fo and fe small, and fe > fo (B) fo and fe small, and fo > fe (C) fo and fe large, and fe > fo (D) fo and fe large, and fo > fe. **APPROPRIATE OPTION. (A)**	MAIN
9.	A glass slab (μ = 1·5) of thickness 6 cm is placed over a paper. The shift in the letters printed on the paper will be: (A) 2 cm (B) 1 cm (C) 4 cm (D) 3 cm **APPROPRIATE OPTION. (A)**	MAIN
10	A beam of light of wavelength 720 nm in air enters water (refractive index =4/3). Its wavelength in water will be: (A) 540 nm (B) 420 nm (C) 480 nm (D) 720 nm **APPROPRIATE OPTION. (A)**	MAIN

11.	Two thin lenses of focal lengths +40 cm and -20 cm and placed coaxially in contact. An object is placed at infinity, in front of the combination. The image formed by the combination will lie: - (A) at a distance of 60 cm, in front of the combination. (B) at a distance of 40 cm, in front of the combination. (C) at a distance of 20 cm, behind the combination. (D) at infinity **APPROPRIATE OPTION. (B)**	BLIND
12.	The depth of a swimming pool (refractive index of water = 4/3) is 1 m. If one looks straight vertically down, the depth of the pool will appear to be: (A) 0·25 m (B) 0·75 m (C) 0·95 m (D) 1·0 m **APPROPRIATE OPTION**	BLIND COMP
13.	**Assertion (A):** In a reflecting telescope, the image does not have chromatic aberration. **Reason (R):** Chromatic aberration occurs only due to refraction of light through an optical medium. **APPROPRIATE OPTION. (A)**	MAIN
14.	**Assertion (A):** A ray of light is incident normally on the face of a prism. The emergent ray will graze along the opposite face of the prism when the critical angle at glass-air interface is equal to the angle of the prism. **Reason (R):** The refractive index of a prism depends on angle of the prism. **APPROPRIATE OPTION. (C)**	MAIN
15.	**Assertion (A):** The image of an object placed between f and 2f from a convex lens can be seen on a screen. If the screen is removed, image is not formed. **Reason (R):** Rays from a given point on the object placed between f and 2f, after passing through a convex lens, do not converge on a point in space. **APPROPRIATE OPTION. (D)**	COMP
	SECTION (B) SHORT ANSWER QUESTION CARRY 2 MARKS	
16.	A transparent solid cylindrical rod (refractive index $2/\sqrt{3}$) is kept in air. A ray of light incident on its face travels along the surface of the rod, as shown in figure. Calculate the angle θ.	**MAIN**

SUGGESTIVE VALUE POINT.

Calculating angle θ 2



For critical Angle

$$\frac{n_2}{n_1} = \frac{1}{\sin\theta_c}$$

$n_1=1 \quad n_2=\frac{2}{\sqrt{3}}$ (given)

$$\frac{2}{\sqrt{3}} = \frac{1}{\sin\theta_c}$$

$$\sin\theta_c = \frac{\sqrt{3}}{2}$$

$$\theta_c = 60^\circ$$

$$r = 90 - \theta_c$$

$$= 30^\circ$$

From Snell's law at air rod interface

$$n_1 \sin i = n_2 \sin r$$

$$n_2 = \frac{\sin\theta}{\sin r}$$

$$\frac{2}{\sqrt{3}} = \frac{\sin\theta}{\sin 30^\circ}$$

$$\frac{2}{\sqrt{3}} \times \frac{1}{2} = \sin\theta$$

$$\frac{1}{\sqrt{3}} = \sin\theta$$

$$\theta = \sin^{-1}\left(\frac{1}{\sqrt{3}}\right)$$

17. A spherical convex surface of radius of curvature R separates glass (refractive index 1.5) from air. Light from a point source placed in air at distance R/2 from the surface falls on it. Find the position and nature of the image formed. **MAIN**

SUGGESTIVE VALUE POINT.

Finding the position 1½
Nature of the Image formed ½

Refraction from rarer to denser medium

$$\frac{n_1}{-u} + \frac{n_2}{v} = \frac{n_2 - n_1}{R}$$

$$u = -\frac{R}{2}, n_1 = 1, n_2 = 1.5$$

$$\frac{2}{R} + \frac{1.5}{v} = \frac{1.5-1}{R}$$

$$\frac{1.5}{v} = \frac{0.5}{R} - \frac{2}{R}$$

$$\frac{1.5}{v} = -\frac{1.5}{R}$$

$$v = -R$$

The image is virtual in air at distance R.

18. A double convex lens made of glass has both surfaces with the same radius of curvature, which is 17 cm. We need to determine its focal length when it is submerged in water. The refractive index of the glass is 1.5, and the refractive index of water is 1.33. **MAIN**

SUGGESTIVE VALUE POINT.

Finding the focal length in water	2

$$\frac{1}{f}=\left(\frac{n_g}{n_w}-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)$$

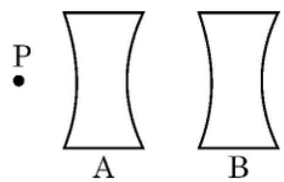
For double convex lens R_1=R and R_2= -R

$$\frac{1}{f}=\left(\frac{1.5}{1.33}-1\right)\left(\frac{2}{R}\right)$$

$$=\left(\frac{1.5-1.33}{1.33}\right)\left(\frac{2}{17}\right)$$

$f = 66.5$ cm

19. Two concave lenses A and B, each of focal length 8.0 cm are arranged coaxially 16 cm apart as shown in figure. An object P is placed at a distance of 4.0 cm from A. Find the position and nature of the final image formed. **MAIN**



SUGGESTIVE VALUE POINT.

Finding the position and nature of the final image	1½ + ½

For the first lens: -

$$\frac{1}{v_1}-\frac{1}{u_1}=\frac{1}{f_1}$$

$$\frac{1}{v_1}+\frac{1}{4}=-\frac{1}{8}$$

$$v_1=-\frac{8}{3}\text{cm}$$

For the second lens: -

$$u_2=-16-\frac{8}{3}=-\frac{56}{3}\text{cm}$$

$$\frac{1}{v_2}-\left(-\frac{3}{56}\right)=-\frac{1}{8}$$

$$v_2=-5.6\text{cm}$$

Image is virtual.

20. A convex lens of focal length 10 cm, a concave lens of focal length 15 cm and a third lens of unknown focal length are placed coaxially in contact. If the focal length of the combination is +12 cm, find the nature and focal length of the third lens, if all lenses are thin. Will the answer change if the lenses were thick? **MAIN**

SUGGESTIVE VALUE POINT.

Finding the nature & focal length of lens	1½
Stating answer for changing thickness	½

$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \frac{1}{f_3}$$

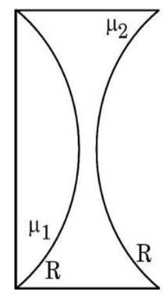
$$\frac{1}{12} = \frac{1}{10} - \frac{1}{15} + \frac{1}{f_3}$$

$$\frac{1}{f_3} = \frac{5-6+4}{60}$$

$$f_3 = 20\,\text{cm}$$

Nature: Convex
Yes

21. (a) A plano-convex lens of refractive index μ1 is placed coaxially in contact with a biconcave lens of refractive index μ2 as shown in the figure. All curved faces are of radius of curvature R each. Obtain the expression for the focal length of the combined lens. **COMP**



OR

(b) A convex lens is kept coaxially on the left side of a concave mirror at a distance of 5f from it where f is focal length of each of them. An object is kept at a distance of 2f on the left side of the convex lens. Draw the ray diagram showing the formation of the image by the combination. Find the distance of the final image from the mirror.

(a) SUGGESTIVE VALUE POINT.

Expression for the focal length of combined lens	2

$$\frac{1}{f} = (\mu - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

For plano convex lens

$$\frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{\infty} - \frac{1}{-R}\right)$$

$$\frac{1}{f_1} = \frac{(\mu_1 - 1)}{R}$$

For concave lens

$$\frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{-R} - \frac{1}{R}\right)$$

$$\frac{1}{f_2} = -2\frac{(\mu_2 - 1)}{R}$$

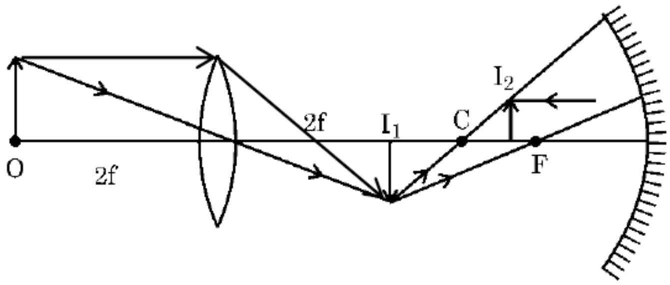
$$\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2}$$

$$f = \frac{R}{\mu_1 - 2\mu_2 + 1}$$

OR

(b) **SUGGESTIVE VALUE POINT.**

• Ray diagram	1
• Calculation of distance of final image from the mirror	1



$$u = -3f$$

$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

$$\frac{-1}{f} = -\frac{1}{3f} + \frac{1}{v}$$

$$v = \frac{-3}{2}f$$

SECTION (C) EACH QUESTION CARRY 3 MARKS

22. (a) When a parallel beam of light enters water surface obliquely at some angle, what is the effect on the width of the beam? **MAIN**

(b) With the help of a ray diagram, show that a straw appears bent when it is partly dipped in water and explain it.

(c) Explain the transmission of optical signal through an optical fibre by a diagram.

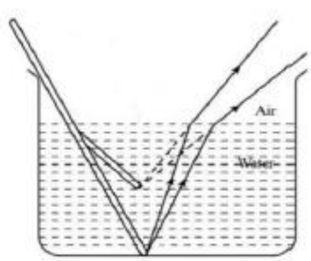
SUGGESTIVE VALUE POINT.

(a) Effect on the width of the beam	1
(b) Ray diagram	1
(c) Diagram showing transmission	1

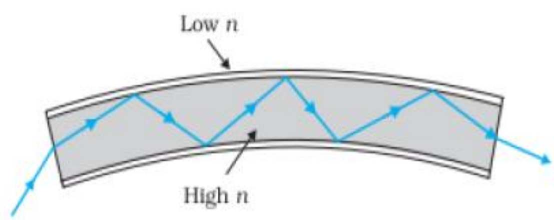
(a) Width of the parallel beam of light increases in water.

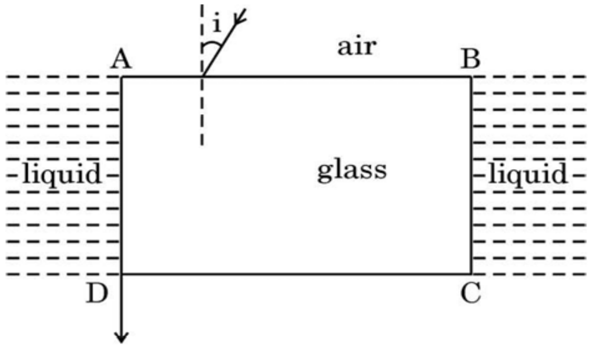
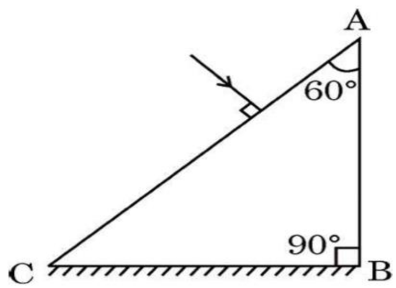
Alternatively: -
If a student explains using diagram, full credit to be given.

(b) Due to refraction of light, the image of the portion immersed in water appears to be raised.



(c)



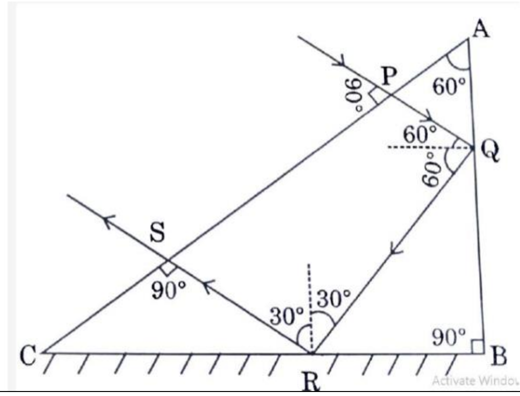
23.	A rectangular glass slab ABCD (refractive index 1·5) is surrounded by a transparent liquid (refractive index 1·25) as shown in the figure. A ray of light is incident on face AB at an angle i such that it is refracted out grazing the face AD. Find the value of angle i.  **SUGGESTIVE VALUE POINT.** Finding value of angle i — 3 For glass- liquid interface $\sin i_c = \frac{1}{n_{21}} = \frac{1.25}{1.5} = \frac{5}{6}$ $i_c + r = 90^0$ $\sin r = \sqrt{1-\cos^2 r} = \frac{\sqrt{11}}{6}$ Since $\frac{Sin\ i}{Sin\ r} = n$ Therefore, $Sin\ i = \frac{\sqrt{11}}{4}$ or $i = Sin^{-1}\frac{\sqrt{11}}{4}$	**MAIN**
24.	A right-angled prism ABC (refractive index $\sqrt{2}$) is kept on a plane mirror as shown in the figure. A ray of light is incident normally on the face AC. (a) Trace the path of the ray as it passes through the prism. (b) Find the angle of deviation produced by the prism.  **SUGGESTIVE VALUE POINTS**	**MAIN**

(a) Tracing path of the ray	2 ½
(b) Finding angle of deviation on	½

$$\sin i_c = \frac{1}{\sqrt{2}}$$

$$i_c = 45^0$$

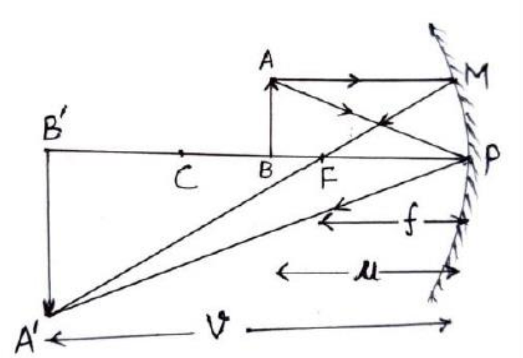
(b) The angle of deviation is 180^o from diagram



25. Draw a ray diagram showing the image formation when a concave mirror produces a real, inverted and magnified image of an object and hence obtain the mirror formula **MAIN**

SUGGESTIVE VALUE POINT.

Drawing the ray diagram	1
Obtaining the mirror formula	2



In similar triangles $\Delta A'B'P$ and ΔABP

$$\frac{A'B'}{AB} = \frac{PB'}{PB} \qquad \text{-------(2)}$$

from equation (1) and (2)

$$\frac{B'F}{FP} = \frac{PB'}{PB}$$

In similar triangles $\Delta A'B'F$ and ΔMPF

$$\frac{A'B'}{MP} = \frac{B'F}{FP}$$

or $\frac{A'B'}{AB} = \frac{B'F}{FP}$ $(\because MP = AB)$ ---------(1)

$$\frac{PB' - PF}{FP} = \frac{PB'}{PB}$$

$$\frac{(-v)-(-f)}{(-f)} = \frac{(-v)}{(-u)}$$

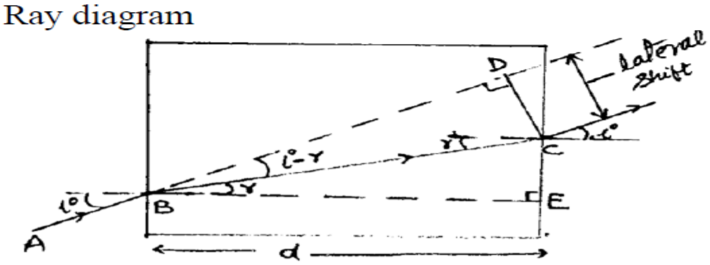
$$\frac{1}{v} + \frac{1}{u} = \frac{1}{f}$$

26. A ray of light is incident at an angle i on a parallel sided glass slab of diagram to show its path as it emerges out of the slab of thickness ‘d’ and gets refracted into the slab at an angle r. Hence, obtain an expression for the lateral shift of the ray. Under what condition will the shift be minimum? **MAIN**

SUGGESTIVE VALUE POINT.

Obtaining expression for lateral shift	2½
Condition for shift to be minimum	½

Ray diagram



$$\sin(i-r) = \frac{CD}{BC} \qquad ---------(1)$$

$$\cos r = \frac{BE}{BC} = \frac{d}{BC}$$

Putting in equation (1)

$$CD = \frac{d\sin(i-r)}{\cos r}$$

Shift will be minimum for minimum angle of incidence.

27. (a) A concave mirror has radius of curvature 20 cm. Calculate the distance of an object from the mirror so as to form an image of magnification. Also find the location of the image.

(b) If the silver coating around the centre of a concave mirror is removed, will the mirror still form the image of an object? Justify your answer. **MAIN**

SUGGESTIVE VALUE POINT.

(a) Calculating	
• Object distance	1
• Image distance	1
(b) Justification if the silver coating around the centre of a concave mirror is removed	1

(a) $m = -\frac{v}{u}$

$-2 = -\frac{v}{u}$

$v = 2u$

$\frac{1}{f} = \frac{1}{v} + \frac{1}{u}$

$\frac{1}{-10} = \frac{1}{2u} + \frac{1}{u}$

$u = -15\,\text{cm}$

$v = -30\,\text{cm}$

Yes, same image is formed with reduced intensity, because reflecting area get reduced and laws of reflection still hold good for remaining part of the mirror.

	SECTION (E) LONG ANSWER EACH QUESTION CARRY 5 MARKS	
28.	(i) A thin pencil of length (f/4) is placed coinciding with the principal axis of a mirror of focal length f. The image of the pencil is real and enlarged, just touches the pencil. Calculate the magnification produced by the mirror. (ii) A ray of light is incident on a refracting face AB of a prism ABC at an angle of 45°. The ray emerges from face AC and the angle of deviation is 15°. The angle of prism is 30°. Show that the emergent ray is normal to the face AC from which it emerges out. Find the refraction index of the material of the prism. **SUGGESTIVE VALUE POINTS** (i) Calculating magnification — 2½ (ii) Showing emergent ray is normal — 1½ Finding refractive index — 1 (i) As the pencil lies between f and 2f such that one end of the pencil coincides with 2f. Position of the other end $(u) = -\left(2f - \frac{f}{4}\right) = -\frac{7f}{4}$ Magnification $(m) = \frac{f}{f-u}$ $= \frac{-f}{-f-\left(-\frac{7f}{4}\right)}$ $m = -\frac{4}{3}$ (ii) For prism; $i + e = A + \delta$ $45^\circ + e = 30^\circ + 15^\circ$ $\therefore e = 0^\circ$ Hence, $r_2 = 0^\circ$ $\therefore$ Emergent ray is perpendicular to face AC.	MAIN
29.	(a) (i) An object is placed 30 cm from a thin convex lens of focal length 10 cm. The lens forms a sharp image on a screen. If a thin concave lens is placed in contact with the convex lens, the sharp image on the screen is formed when the screen is moved by 45 cm from its initial position. Calculate the focal length of the concave lens.	**MAIN**

(ii) Calculate the angle of minimum deviation of an equilateral prism. The refractive index of the prism is $\sqrt{3}$. Calculate the angle of incidence for this case of minimum deviation also.

SUGGESTIVE VALUE POINTS

(i) Calculation of focal length of concave lens	3
(ii) Calculation of	
• Angle of minimum deviation	1
• Angle of incidence	1

For real image form by Convex lens

$$\frac{1}{f_1}=\frac{1}{v_1}-\frac{1}{u_1}$$

$$\frac{1}{10}=\frac{1}{v_1}-\frac{1}{(-30)}$$

$$v_1=15\,cm$$

For Combination of lenses, let the focal length of combination of lens is f_3

$$\frac{1}{f_3}=\frac{1}{v_3}-\frac{1}{u_3}$$

$$\frac{1}{f_3}=\frac{1}{(15+45)}+\frac{1}{30}$$

$$f_3=20cm$$

Let the focal length of concave lens is f_2

$$\frac{1}{f_2}=\frac{1}{20}+\frac{1}{10}$$

F=-20cm

Angle of minimum deviation

$$\mu=\frac{\text{Sin}\frac{(A+\delta_m)}{2}}{\text{Sin}\frac{A}{2}}$$

$$\sqrt{3}=\frac{\text{Sin}\frac{(60^\circ+\delta_m)}{2}}{\text{Sin }30}$$

$$60^\circ=\frac{(A+\delta_m)}{2}$$

$$\delta_m=60^\circ$$

Angle of incidence

$$i+e=A+\delta$$

$$2i=A+\delta_m$$

$$i=\frac{A+\delta_m}{2}$$

$$i=60^\circ$$

30.	(a) (i) Draw a ray diagram of a reflecting telescope (Cassegrain) and explain the formation of image. State two important advantages that a reflecting telescope has over a refracting telescope. (ii) In a refracting telescope, the focal length of the objective is 50 times the focal length of the eyepiece. When the final image is formed at infinity, the length of the tube is 102 cm. Find the focal lengths of the two lenses.	**MAIN**

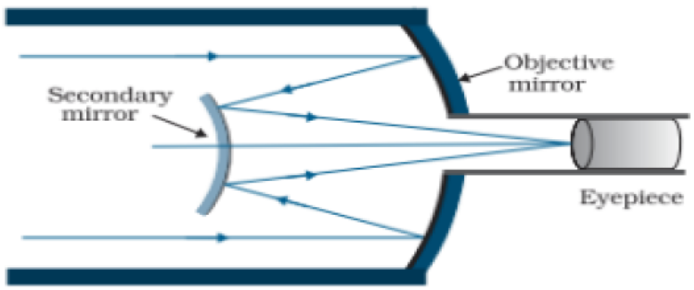
OR

(b) (i) Write any two advantages of a compound microscope over a simple microscope. Draw a ray diagram for the image formation at the near point by a compound microscope and explain it.

(ii) A thin planoconcave lens with its curved face of radius of curvature R is made of glass of refractive index n_1. It is placed coaxially in contact with a thin equiconvex lens of same radius of curvature of refractive index n_2. Obtain the power of the combination lens.

(a) SUGGESTIVE VALUE POINTS

(a)	Drawing ray diagram of reflecting telescope	1
	Explanation of formation of image	1
	Advantages	½ + ½
(b)	Finding focal lengths of the two lenses	2



The parallel rays from a distant object are reflected by a large concave mirror. These rays are then reflected by a convex mirror placed just before the focus of concave mirror and are converged to a point outside the hole. The final image is viewed through eye piece.

Advantages (any two)

1) No chromatic aberration.
2) Less spherical aberration
3) Less mechanical support required
4) Brighter Image
5) High resolving power.
6) High magnifying power

(ii) For image at infinity

$$|f_o| + |f_e| = L$$

According to question

$$f_o = 50 \times f_e$$

$$f_e + 50fe = 102$$

$$f_e = 2 \text{ cm}$$

$$f_o = 100 \text{ cm}$$

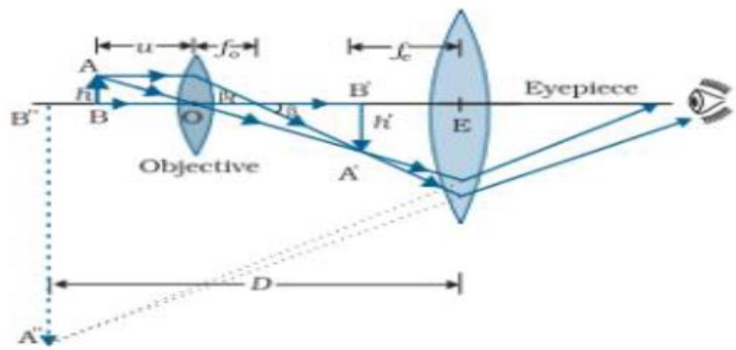
(b) SUGGESTIVE VALUE POINTS

(i)	Two advantages of a compound microscope over simple microscope	½ + ½
	Drawing ray diagram and Explanation	1 + 1
(ii)	Obtaining power of combined lens	2

(i) Advantages (any two)

1) Larger magnification
2) Brighter image

Any other valid advantage



The lens nearest the object, called the objective, forms a real, inverted, magnified image of the object. This serves as the object for the second lens, the eye piece, functions like a simple microscope and produces final image which is enlarged and virtual.

(ii) Power of plano concave lens $= P_1 = \dfrac{-(n_1-1)}{R}$

Power of convex lens $= P_2 = (n_2-1)\left(\dfrac{2}{R}\right)$

$$P = P_1 + P_2$$

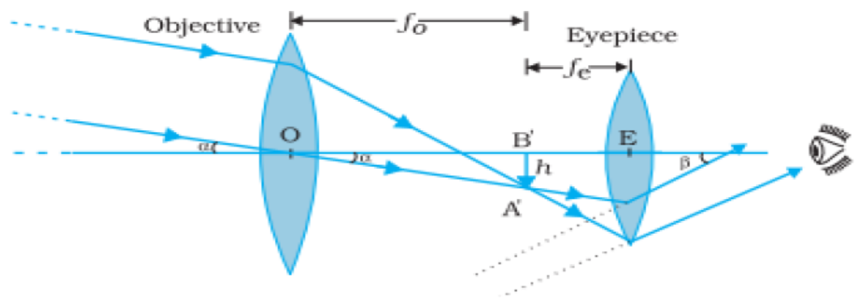
$$= \frac{(2n_2 - n_1 - 1)}{R}$$

31. (i) Explain with the help of a labelled ray diagram the formation of final image by an astronomical telescope at infinity. Write the expression for its magnifying power. **MAIN**

(ii) The total magnification produced by a compound microscope is 20. The magnification produced by the eyepiece is 5. When the microscope is focused on a certain object, the distance between the objective and eyepiece is observed to be 14 cm. Calculate the focal lengths of the objective and the eyepiece. (Given that the least distance of distinct vision = 25 cm)

(i) SUGGESTIVE VALUE POINTS

(i) Drawing labeled Diagram 1½ Explanation ½ Writing expression of Magnifying power 1 (ii) Calculating the focal length of objective & eye piece 2



(Note: Deduct ½ mark, for not showing arrows with the rays)

Light from distant object enters the objective lens & forms a real image A'B' at f_o .

This image A'B' acts as an object for eye piece and eye piece forms a magnified image at infinity.

Magnifying Power = f_o / f_e

(ii) Image is formed at least distance of distinct vision

$$20 = m_o \times m_e$$

$$m_o = \frac{20}{5} = 4$$

$$m_e = 1 + \frac{D}{f_e}$$

$$f_e = \frac{25}{4} cm$$

$$\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$$

$$\frac{1}{-25} - \frac{1}{u_e} = \frac{4}{25}$$

$$u_e = -5cm$$

$$L = v_0 + |u_e|$$

$$v_0 = 9\,cm$$

Given, $\frac{v_0}{u_0} = 4$

$$\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$$

$$\frac{1}{f_0} = \frac{1}{9} - \left(-\frac{4}{9}\right)$$

$$f_0 = \frac{9}{5} cm$$

CHAPTER- 10 WAVE OPTICS

Q.N.	SECTION (A) CARRY 1 MARK EACH	CBSE 2025
1	Two coherent light waves, each having amplitude 'a', superpose to produce an interference pattern on a screen. The intensity of light as seen on the screen varies between: (A) 0 and $2a^2$ (B) 0 and $4a^2$ (C) a^2 and $2a^2$ (D) $2a^2$ and $4a^2$ **APPROPRIATE OPTION. (B)**	MAIN
2.	Two coherent waves, each of intensity I_0, produce interference pattern on a screen. The average intensity of light on the screen is: (A) zero (B) I_0 (C) $2I_0$ (D) $4I_0$ **APPROPRIATE OPTION. (D)**	MAIN
3.	**Assertion (A):** In double slit experiment if one slit is closed, diffraction pattern due to the other slit will appear on the screen. **Reason (R)**: For interference, at least two waves are required. **APPROPRIATE OPTION. (B)**	MAIN
4.	**Assertion (A):** When two coherent sources in Young's double-slit experiment (YDSE) are infinitely close to each other, an interference pattern is observed on a screen. **Reason (R):** The fringe width in YDSE does not depend on the separation between the two slits. **APPROPRIATE OPTION. (D)**	BLIND
5.	**Assertion (A):** In a Young's double-slit experiment, interference pattern is obtained by using yellow light. If yellow light is replaced by red light, the fringe width increases. **Reason (R):** Fringe width is inversely proportional to the distance of the screen from the slits. **APPROPRIATE OPTION**. (B)	BLIND COMP
	SECTION (B) SHORT ANSWER CARRY 2 MARKS	
6.	(a) In a diffraction experiment, the slit is illuminated by light of wavelength 600 nm. The first minimum of the pattern falls at $\theta = 30°$. Calculate the width of the slit.	MAIN

	OR (b) In a Young's double-slit experiment, two light waves, each of intensity I_0, interfere at a point, having a path difference $\lambda/8$ on the screen. Find the intensity at this point. **SUGGESTIVE VALUE POINTS** (a) Calculating the width of the slit — 2 Condition for Minima $a \sin\theta = n\lambda$ For First Minima n=1 $a \sin 30^\circ = 600 \times 10^{-9}$ m $a \times \frac{1}{2} = 600 \times 10^{-9}$ m $a = 1200 \times 10^{-9}$ m $= 1.2 \times 10^{-6}$ m **OR** **(b) SUGGESTIVE VALUE POINTS** (b) Finding the Intensity — 2 Phase difference $= \frac{2\pi}{\lambda} \times$ path difference $\Delta\phi = \frac{2\pi}{\lambda}\Delta x$ $\because \Delta x = \frac{\lambda}{8}$ (given) $\Delta\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{8}$ $\Delta\phi = \frac{\pi}{4}$ $I = I_\circ + I_\circ + 2\sqrt{I_\circ I_\circ}\cos\frac{\pi}{4}$ $= 2I_\circ + 2I_\circ \times \frac{1}{\sqrt{2}}$ $I = 2I_\circ\left(1 + \frac{1}{\sqrt{2}}\right)$ $= I_\circ(2 + \sqrt{2})$ $I = 3.414\, I_\circ$	
7.	In a double-slit experiment, 6th dark fringe is observed at a certain point of the screen. A transparent sheet of thickness t and refractive index n is now introduced in the path of one of the two interfering waves to increase its phase by $2\pi (n-1) t/\lambda$. The pattern is shifted and 8th bright fringe is observed at the same point. Find the relation for thickness t in terms of n and λ. **SUGGESTIVE VALUE POINTS**	MAIN

	Finding the relation 2 Phase difference for 6^{th} dark fringe = 11π Phase difference for 8^{th} bright fringe = 16π $$\Delta\phi+\phi_6=\phi_8$$ $$2\pi(n-1)\frac{t}{\lambda}+11\pi=16\pi$$ $$t=\frac{5\lambda}{2(n-1)}$$	
8.	In a double slit experiment, it is observed that the angular width of one fringe formed on the screen is 0.2°. The wavelength of light used in the experiment is 500 nm. Calculate the separation of the two slits. **SUGGESTIVE VALUE POINTS** Calculating the separation of the two slits. 2 Angular width $(\theta)=\frac{\lambda}{d}$ $$d=\frac{\lambda}{\theta}$$ $$=\frac{500\times10^{-9}}{0.2\times\frac{\pi}{180}}$$ $$d=\frac{45}{\pi}\times10^{-5}\ m$$ $$=0.14\ mm$$	MAIN
9.	Find the angle of diffraction (in degrees) for first secondary maximum of the pattern due to diffraction at a single slit. The width of the slit and wavelength of light used are 0·55 mm and 550 nm, respectively. **SUGGESTIVE VALUE POINTS** Finding the angle of diffraction for first secondary maximum. 2 $$\theta=(2n+1)\frac{\lambda}{2a}$$	MAIN

	For first secondary maxima n=1 $\theta = \frac{3\lambda}{2a}$ $\theta = \frac{3\times 550\times 10^{-9}}{2\times 0.55\times 10^{-3}}$ $\theta = 1.5\times 10^{-3}$ radian $= 0.086$ degree	
10.	In Young's double slit set -up, the intensity of the central maximum is Io. Calculate the intensity at a point where the path difference between two interfering waves is λ/3. **SUGGESTIVE VALUE POINTS** Calculating intensity for the path difference $\lambda/3$ — 2 $\phi = \frac{2\pi}{\lambda}\times\Delta x = \frac{2\pi}{\lambda}\times\frac{\lambda}{3} = \frac{2\pi}{3}$ $I' = 4I\,Cos^2\,\phi/2 = I_0\,Cos^2\,2\pi/6 = \frac{I_0}{4}$ *Given* $4I = I_0$	MAIN
11.	Write two differences in the patterns of double-slit interference experiment and single-slit diffraction experiment. Light waves from two pinholes illuminated by two sodium lamps do not produce interference patterns. Explain why. **SUGGESTIVE VALUE POINTS** Difference between Interference & Diffraction patterns — 1 Reason — 1	MAIN

Interference pattern	Diffraction pattern
1. The interference pattern has a number of equally spaced bright and dark bands.	1. The diffraction pattern has a central bright maximum which is twice as wide as the other maxima.
2. The interference pattern is obtained by superposing two waves originating from the two narrow slits.	2. The diffraction pattern is obtained by superposition of a continuous family of waves originating from each point on a single slit.
3. The maximas are of same intensity.	3. The intensity falls as we go to successive maxima away from the centre, on either side.

	The light wave coming out of two independent source of light will not have constant phase with time. **Alternatively**: Two sodium lamps are incoherent source of light.	
12.	The ratio of Intensities at maxima to minima in Young's double slit experiment is 25: 9. Calculate the ratio of intensities of the interfering waves. **SUGGESTIVE VALUE POINTS** Calculating the ratio of intensities 2 Given, $\frac{I_{max}}{I_{min}}=\frac{25}{9}$ $\frac{I_{max}}{I_{min}}=\frac{(a_1+a_2)^2}{(a_1-a_2)^2}=\frac{25}{9}$ $3(a_1+a_2)=5(a_1-a_2)$ $\frac{a_1}{a_2}=\frac{4}{1}$ $\frac{I_1}{I_1}=\frac{16}{1}$	MAIN
	SECTION (C) SHORT ANSWER TYPE 2 CARRY 3 MARKS	
13.	(a) The amplitude of a light wave becomes n times. This results in intensity of the wave becoming m times. What is the relation between n and m? (b) White light is incident on three identical surfaces – a black surface, a yellow surface and a white surface, one by one. For which surface, the pressure exerted on the surface by the incident light will be (i) maximum (ii) minimum? Justify your answer. **SUGGESTIVE VALUE POINTS** (a) Establishing relation between n and m 1 (b) Finding on which surface pressure is (i) Maximum ½ (ii) Minimum ½ With justification ½+½	MAIN

	(a) Intensity (I) α (amplitude) => $m = n^2$ (b) (i) White surface As white surface will reflect maximum light falling on it, the change in momentum of light will be maximum and as a consequence the pressure exerted by the light will be maximum. (ii) Black surface As black surface absorbs maximum light falling on it, the change in momentum of light will be minimum and as a consequence the pressure exerted by the light will be minimum.	
14.	A double slit set-up was initially placed in a tank filled with water and the interference pattern was obtained using a laser light. When water is replaced by a transparent liquid of refractive index $n > n_{water}$, what will be the effect on the following? (a) Speed, frequency and wavelength of the light of laser beam. (b) The fringe width, shape of interference fringes and shift in the position of central maximum. **SUGGESTIVE VALUE POINTS** Effect on (a) Speed, frequency and wavelength of light 1½ (b) Fringe width, shape of fringes and shift of position of central maximum 1½ (a) • Speed of light will decrease • Frequency remains unaffected • Wavelength decreases (b) • Fringe width decreases • Shapes does not change • Position of central maxima does not change.	MAIN
15.	In Young's double slit experiment, the separation between two slits 1·0 mm and the screen is 1·0 m away from the slits. A beam of light consisting of two wavelengths 500 nm and 600 nm is used to obtain interference fringes. Calculate: (a) the distance between the first maxima for the two wavelengths. (b) the least distance from the central maximum, where the bright fringes due to both the wavelengths coincide. **SUGGESTIVE VALUE POINTS**	MAIN

a) Calculating distance between first maxima for two wavelengths 1 ½
b) Calculating least distance from central maxima 1 ½

a) Distance $= \dfrac{n\lambda_1 D}{d} - \dfrac{n\lambda_2 D}{d}$

For n=1

Distance $= \dfrac{(600-500)\times 10^{-9}\times 1}{10^{-3}}$

$= 10^{-4} m$

b) $n\lambda_1 \dfrac{D}{d} = (n+1)\lambda_2 \dfrac{D}{d}$

$n \times 600 \times 10^{-9} = (n+1)\times 500 \times 10^{-9}$

$n = 5$

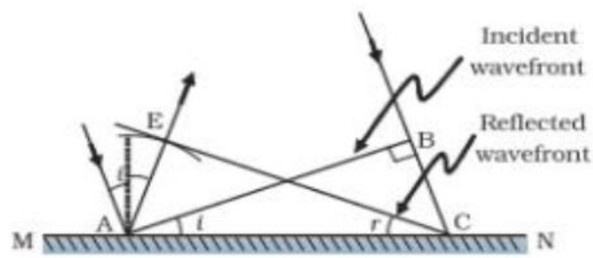
$x = 5 \times \dfrac{\lambda_1 D}{d}$

PUTTING THE VALUE X =3mm

16. Using the Huygen's principle, briefly describe the reflection of wavefront from a reflecting surface. Hence, prove the laws of reflection. MAIN

SUGGESTIVE VALUE POINTS

Describing reflection of plane wavefront using Huygen's principle 2
Proving law of reflection 1



Consider a plane wave AB incident at an angle i on a reflecting surface MN. v represents speed of the wave in the medium and τ represents the time taken by wavefront to advance from point B to C.

$BC = \vartheta\tau$

To construct the reflected wavefront , a sphere of radius $v\tau$ from point A is drawn.

$AE = BC = \vartheta\tau$

Also $\Delta EAC \cong \Delta BAC$

$\therefore \; i = r$

17. (a) "You cannot see a person standing on the other side of the boundary wall but can hear him." Explain with reason. MAIN

(b) Light of wavelength 750 nm is incident normally on a slit of width 1·5 mm. Diffraction pattern is obtained on a screen 1·0 m away from the slit. Find the distance of the nearest point from the central maxima at which the intensity is zero.

	SUGGESTIVE VALUE POINTS (a) Explanation 1 (b) Finding distance from central maxima where Intensity is zero 2 (a) Wavelength of light is very small as compared to size of obstacles so diffraction of light is not seen easily. But sound waves have large wavelength, so they get diffracted easily by obstacles. (b) Position of first minima $x = \frac{\lambda D}{a}$ $= \frac{750\times10^{-9}\times1}{1.5\times10^{-3}}$ $= 0.5\ mm$	
	SECTION (E) LONG ANSWER EACH QUESTION CARRY 5 MARKS	
18.	**(a) (i)** (1) What are coherent sources? Why are they necessary for observing a sustained interference pattern? (2) Lights from two independent sources are not coherent. Explain. (ii) Two slits 0.1 mm apart are arranged 1.20 m from a screen. Light of wavelength 600 nm from a distant source is incident on the slits. (1) How far apart will adjacent bright interference fringes be on the screen? (2) Find the angular width (in degree) of the first bright fringe. **OR** (b) (i) Define a wavefront. An incident plane wave falls on a convex lens and gets refracted through it. Draw a diagram to show the incident and refracted wavefront. (ii) A beam of light coming from a distant source is refracted by a spherical glass ball (refractive index 1.5) of radius 15 cm. Draw the ray diagram and obtain the position of the final image formed. **SUGGESTIVE VALUE POINTS** i) 1) Definition of coherent sources. 1 Necessity of coherent sources for sustained interference pattern 1 2) Explanation 1 ii) 1) Finding distance between adjacent bright fringes. 1 2) Finding angular width 1	MAIN

i) 1) If the phase difference between the displacement produced by each of the wave from two sources does not change with time then two sources are said to be coherent.

Alternatively

Two sources are said to be coherent if they emit light continuously of same frequency / wavelength and having zero or constant phase difference.

Coherent sources are required to get constant phase difference.

2) Two independent sources will never be coherent because phase difference between them will not be constant.

ii) 1) Distance between adjacent bright fringe = fringe width

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

$$= \frac{600 \times 10^{-9} \times 1.2}{0.1 \times 10^{-3}} = 7.2\,\text{mm}$$

2) $$\theta = \frac{\lambda}{d}$$

$$= \frac{600 \times 10^{-9}}{0.1 \times 10^{-3}} = 6 \times 10^{-3}\,\text{rad} = 0.34°$$

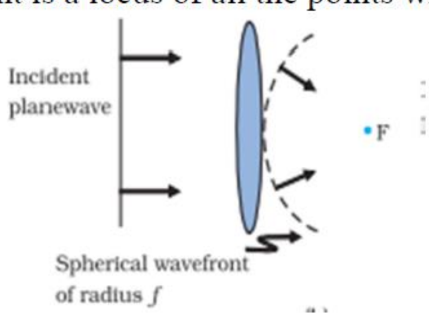
Give full marks if the student writes the answer in radians only.

OR

SUGGESTIVE VALUE POINTS

i) Definition of wave front.	1
Drawing the incident and refracted wave front	½ + ½
ii) Drawing the ray diagram	1
Obtaining the position of final image	2

i) A wavefront is a locus of all the points which oscillate in phase.



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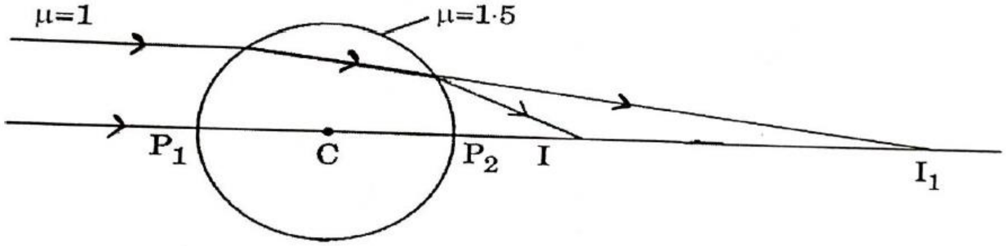

From Ist surface , Refraction is from rarer to denser medium and object is at ∞

$n_1 = 1$, $n_2 = 1.5$, R = 15 cm , u= ∞

$$\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$$

$$\frac{1.5}{v} - \frac{1}{\infty} = \frac{1.5 - 1}{15}$$

v= 45 cm

From 2nd surface , Refraction is from denser to rarer medium and object is at 15 cm

$n_1 = 1$, $n_2 = 1.5$, R = -15 cm , u= 15cm

$$\frac{n_1}{v} - \frac{n_2}{u} = \frac{n_1 - n_2}{R}$$

$$\frac{1}{v} - \frac{1.5}{15} = \frac{1 - 1.5}{-15}$$

v= 7.5 cm
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(i) Light consisting of two wavelengths 600 nm and 480 nm is used to obtain interference fringes in a double slit experiment. The screen is placed 1.0 m away from slits which are 1.0 nm apart.

(1) Calculate the distance of the third bright fringe on the screen from the central maximum for wavelength 600 nm.

(2) Find the least distance from the central maximum where the bright fringes due to both the wavelengths coincide.

(ii) (1) Draw the variation of intensity with angle of diffraction in single slit diffraction pattern. Write the expression for value of angle corresponding to zero intensity locations.

(2) In what way diffraction of light waves differs from diffraction of sound waves?

SUGGESTIVE VALUE POINTS
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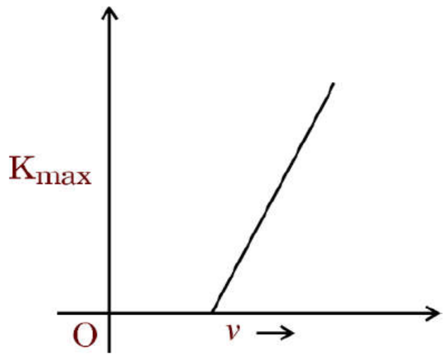
	(i) (1) Calculating distance of the third bright fringe from central maximum 1 (2) Finding the least distance 1 (ii) (1) Diagram showing variation of intensity with angle of diffraction 1 Writing expression for value of angle corresponding to zero intensity 1 (2) Difference between diffraction of light and sound waves 1	
20.	(i) Two coherent light waves, each of intensity I superpose each other and produce interference pattern on a screen. Obtain the expression for the resultant intensity at a point where the phase difference between the waves is ϕ. Write its maximum and minimum possible values. (ii) In a single slit diffraction experiment, the aperture of the slit is 3 mm and the separation between the slit and the screen is 1·5 m. A monochromatic light of wavelength 600 nm is normally incident on the slit. Calculate the distance of (I) first order minimum, and (II) second order maximum, from the centre of the screen. **SUGGESTIVE VALUE POINTS.** (i) Obtaining the expression for resultant intensity of interference pattern 2 Writing maximum & minimum values of resultant intensity 1 (ii) Calculating the distance of **(I)** First order minimum 1 **(II)** Second order maximum from centre of screen 1 (i) $y_1 = a\cos\omega t$ $y_2 = a\cos(\omega t+\phi)$ According to Principle of Superposition $y = y_1 + y_2$ $= a\left[\cos\omega t + \cos(\omega t+\phi)\right]$	MAIN

	$= 2a\cos\phi/2\,\cos(\omega t + \phi/2)$ $y = A\cos\left(\omega t + \phi/2\right)$ where, $A = 2a\cos\phi/2$ $I = kA^2$ $I = k\left(4a^2\cos^2\phi/2\right)$ $I = 4I_0\cos^2\phi/2$ **Alternatively**: If student writes $I = I_1 + I_1 + 2\sqrt{I_1 I_1}\cos\phi$ **(award one mark)** Maximum value $I = 4I_0$ Minimum value $I = 0$ (ii) **(I)** Position of first order minimum $y = \frac{n\lambda D}{a}$ $y_1 = \frac{\lambda D}{a}$ $= \frac{600\times10^{-9}\times1.5}{3\times10^{-3}} = 3\times10^{-4}\,\text{m}$ **(II)** Position of second order maximum $y_n = (2n+1)\frac{\lambda D}{2a}$ $n = 2,\quad y_2 = \frac{5\lambda D}{2a}$ $= \frac{5\times600\times10^{-9}\times1.5}{2\times3\times10^{-3}} = 7.5\times10^{-4}\,\text{m}$	
21.	State Huygens principle. Using it, draw a diagram and discuss the case of refraction of plane wave of light from a rarer medium to a denser medium at their plane interface. Hence derive Snell's law. **SUGGESTIVE VALUE POINTS** • Stating Huygen's principle — 1 • Drawing diagram — 1 ½ • Discussing the case of refraction of plane wave of light from rarer to a denser medium — ½ • Deriving Snell's law — 2	COMP

CHAPTER- 11 (DUAL NATURE OF RADIATION AND MATTER)

Q.N.	SECTION (A) CARRY 1 MARK EACH	CBSE 2025
1.	The stopping potential V_0 measured in a photoelectric experiment for a metal surface is plotted against frequency ν of the incident radiation. Let m be the slope of the straight line so obtained. Then the value of charge of an electron is given by (h is the Planck's constant.) (A) mh (B) $\frac{m}{h}$ (C) $\frac{h}{m}$ (D) $\frac{1}{mh}$ **APPROPRIATE OPTION**. (C) h/m	MAIN
2.	Let λ_e, λ_p and λ_d be the wavelengths associated with an electron, a proton and a deuteron, all moving with the same speed. Then the correct relation between them is: (A) $\lambda_d > \lambda_p > \lambda_e$ (B) $\lambda_e > \lambda_p > \lambda_d$ (C) $\lambda_p > \lambda_e > \lambda_d$ (D) $\lambda_e = \lambda_p = \lambda_d$ **APPROPRIATE OPTION. (B)**	MAIN
2.	A source produces monochromatic light of frequency 5.0×10^{14} Hz and the power emitted is 3.31 mW. The number of photons emitted per second by the source, on an average is (A) 10^{16} (B) 10^{24} (C) 10^{10} (D) 10^{20} **APPROPRIATE OPTION. (A)**	MAIN
3.	In a photoelectric experiment with a material of work function 2.1 eV, the stopping potential is found to be 2.5 V. The maximum kinetic energy of ejected photoelectrons is: (A) 0.4 Ev (B) 2.1 eV (C) 2.5 eV (D) 4.6 eV **APPROPRIATE OPTION. (C)**	MAIN
4.	A beam of red light and a beam of blue light have equal intensities. Which of the following statements is true? (A)The blue beam has a greater number of photons than the red beam. (B) The red beam has a greater number of photons than the blue beam.	MAIN

	(C) Wavelength of red light is lesser than wavelength of blue light. (D) The blue light beam has lesser energy per photon than that in the red-light beam. **APPROPRIATE OPTION. (B)**	
5.	The kinetic energy of an alpha particle is four times the kinetic energy of a proton. The ratio ($\frac{\lambda_\alpha}{\lambda_p}$) of de Broglie wavelengths associated with them will be: (A) 1/16 (B) 1/8 (C) 1/4 (D) 1/2 **APPROPRIATE OPTION. (C)**	MAIN
6.	Choose the correct statement: (A) Photons of light show diffraction whereas electrons do not show diffraction. (B) Electrons have momentum whereas photons do not have momentum. (C) Photons of light and electrons both exhibit dual nature. (D) All electromagnetic radiations do not have photons. **APPROPRIATE OPTION. (C)**	MAIN
7.	The work function of a material is 2 21 eV. Which of the following cannot produce photoelectrons from it? (A) Red light (B) Blue light (C) Violet light (D) Green light **APPROPRIATE OPTION. (A)**	MAIN
8.	The momentum (in kg m/s) of a photon of frequency 6.0X 10^{14} Hz is: (A) 6 .63 x10^{-25} (B) 1. 326x 10^{-27} (C) 2. 652x10^{-26} (D) 3. 978x 10^{-24} **APPROPRIATE OPTION. (B)**	MAIN
9.	The frequency of a photon of energy 1·326 eV is: (A) 1·18 x10^{14} Hz (B) 3·20x 10^{14} Hz (C) 4·20x10^{15} Hz (D) 4·80x 10^{15} Hz **APPROPRIATE OPTION. (B)**	MAIN
10.	**Assertion (A):** For monochromatic incident radiation, the emitted photoelectrons from a given metal have speed ranging from zero to a certain maximum value. **Reason (R):** Each metal has a definite work function. **APPROPRIATE OPTION. (B)**	MAIN

11.	The figure shows the variation of maximum kinetic energy (Kmax) of emitted electrons as a function of the frequency *v* of radiation incident on a photosensitive surface. The slope of the curve is:  (A) h (B) $\frac{h}{v}$ (C) $\frac{h}{e}$ (D) he **APPROPRIATE OPTION. (C)**	COMP
12.	**Assertion (A):** The minimum negative potential applied to the anode in a photoelectric experiment at which photoelectric current becomes zero, is called cut-off voltage. **Reason (R):** The threshold frequency for a metal is the minimum frequency of incident radiation below which emission of photoelectrons does not take place. **APPROPRIATE OPTION. (A)**	
	SECTION (B) CARRY 2 MARK EACH	
13.	A light of wavelength 400 nm is incident on a metal surface whose work function is 3.0 × 10^{-19} J. Calculate the speed of the fastest photoelectrons emitted. **SUGGESTIVE VALUE POINTS** Calculating Speed — 2 $h\nu = \phi_o + K_{max}$ $\frac{hc}{\lambda} = \phi_0 + \frac{1}{2}mv_{max}^2$ $\frac{6.63\text{x}10^{-34}\text{x } 3\text{x}10^{8}}{4\text{x}10^{-7}} = 3\text{x}10^{-19} + \frac{1}{2}mv_{max}^2$ $\frac{19.89}{4}\text{x}10^{-19} = 3\text{x}10^{-19} + \frac{1}{2}mv_{max}^2$ $\frac{4\text{x}10^{-19}}{9\text{x}10^{-31}} = v_{max}^2$ $v_{max} = \frac{2}{3}\text{x}10^{6}\text{m/s}$	MAIN
14.	The threshold wavelength of a metal is 450 nm. Calculate (i) the work function of the metal in eV and (ii) the maximum energy of the ejected photoelectrons in eV by incident radiation of 250 nm. **SUGGESTIVE VALUE POINTS**	MAIN

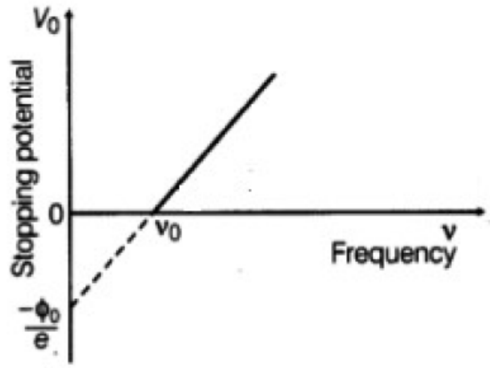
	Calculating (i) the work function in eV 1 (ii) the maximum energy of the ejected photoelectrons in eV 1 (i) $\phi = \frac{hc}{\lambda_o}$ $\phi = \frac{6.63 x 10^{-34} x 3 x 10^{8}}{450 x 10^{-9} x 1.6 x 10^{-19}}$ $\phi = 2.76$ eV (ii) $K_{max} = h\nu - \phi$ $h\nu = \frac{hc}{\lambda} = \frac{6.63 x 10^{-34} x 3 x 10^{8}}{250 x 10^{-9} x 1.6 x 10^{-19}} = 4.97\,eV$ $K_{max} = 4.97 - 2.76$ $K_{max} = 2.21\,eV$	
15.	Find the ratio of minimum to maximum wavelength of radiations emitted when electron jumps from higher energy state into ground state of hydrogen atom. **SUGGESTIVE VALUE POINTS** Finding the ratio of minimum to maximum wavelength of radiations 2 for λ_{min} , $n_1 = 1$ $n_2 = \infty$ $E_2 - E_1 = \frac{hc}{\lambda_{min}}$ $0 - (-13.6) = \frac{hc}{\lambda_{min}}$ $\lambda_{min} = \frac{hc}{13.6}$ λ_{max} $n_1 = 1$ $n_2 = 2$ $\lambda_{max} = \frac{hc}{-3.4 - (-13.6)}$ $\lambda_{max} = \frac{hc}{10.2}$ $\frac{\lambda_{min}}{\lambda_{max}} = \frac{3}{4}$	MAIN
16.	The threshold frequency for a given metal is 3·6 x10^{14} Hz. If monochromatic radiations of frequency 6·8 x10^{14} Hz are incident on this metal, find the cut-off potential for the photoelectrons. **SUGGESTIVE VALUE POINTS**	MAIN

	Finding the cut-off potential 2 $eV_0 = h(\upsilon - \upsilon_0)$ $V_0 = \dfrac{6.63\times10^{-34}\times(6.8-3.6)\times10^{14}}{1.6\times10^{-19}}$ $=1.33\,V$	
17.	A laser beam of frequency 3·0 × 1014 Hz produces average power of 9 mW. Find (i) the energy of photon of the beam, and (ii) the number of photons emitted per second on an average by the source. **SUGGESTIVE VALUE POINTS** Finding- (i) The energy of photon of the beam 1 (ii) The average number of photons emitted per second (N) 1 (i) $E = h\nu$ $= 6.63\times10^{-34}\times3.0\times10^{14}$ $= 1.99\times10^{-19}\ J$ (ii) $N = \dfrac{P}{E}$ $= \dfrac{9\times10^{-3}}{1.99\times10^{-19}}$ $= 4.5\times10^{16}$	MAIN
18.	The work function of Caesium is 2·14 eV. (a) Find the threshold frequency for Caesium. (b) Find the wavelength of the incident light if the photocurrent is brought to zero by a stopping potential of 0·86 V. **SUGGESTIVE VALUE POINTS** (a) Finding the threshold frequency for Caesium 1 (b) Finding the wavelength of the incident light 1 (a) $\dfrac{\phi_0}{h} = \nu_0$ $= \dfrac{2.14\times1.6\times10^{-19}}{6.63\times10^{-34}}$ $= 5.16\times10^{14}\ Hz$ (b) $\dfrac{hc}{\lambda} = K_{max} + \phi_0$ $\lambda = \dfrac{hc}{K_{max}+\phi_0}$ $\lambda = \dfrac{6.63\times10^{-34}\times3\times10^{8}}{(2.14+0.86)\times1.6\times10^{-19}}$ $\lambda = 4.14\times10^{-7}\ m$	COMP
	SECTION (C) CARRY 3 MARK EACH	

18.	**Answer the following giving reason:** **(a)** All the photo electrons do not eject with the same kinetic energy when monochromatic light is incident on a metal surface. **(b)** The saturation current in case (a) is different for different intensity. **(c)** If one goes on increasing the wavelength of light incident on a metal surface, keeping its intensity constant, emission of photo electrons stops at a certain wavelength for this metal. **SUGGESTIVE VALUE POINTS** Reason for a) All photoelectrons not having same Kinetic Energy. 1 b) Having different saturation current for different intensity. 1 c) Stopping of emission of photoelectrons at a certain wavelength. 1 a) When monochromatic light is incident on a metal surface then more/less tightly bound electrons will emerge with less/more kinetic energy. So all the photoelectrons do not eject with same kinetic energy. b) Maximum number of photoelectrons ejected per second (saturation current) is directly proportional to the Intensity of incident radiation Hence saturation current is different for different intensities. c) when λ increases , ν decreases and energy of incident photon ($h\nu$) also decreases. When $\lambda > \lambda_0$, $\nu < \nu_0$ (threshold frequency) , no photoelectron is ejected. Emission of photoelectrons stop at $\lambda > \lambda_0$.	MAIN
19.	(a) Draw a plot of frequency ν of incident radiations as a function of stopping potential V_0 for a given photo emissive material. What information can be obtained from the value of the intercept on the stopping potential axis? (b) Calculate: (i) the momentum and (ii) de Broglie wavelength, of an electron with kinetic energy of 80 eV. **SUGGESTIVE VALUE POINTS**	MAIN

a) Drawing a plot of frequency(ν) as a function of stopping potential (V_0) 1
Obtaining information from intercept ½
b) Calculating
i) the momentum 1
ii) de Broglie wavelength ½

a)



Value of work function can be obtained from intercept.

b) i) $p=\sqrt{2mK}$

$$= \sqrt{2\times9.1\times10^{-31}\times80\times1.6\times10^{-19}}$$

$$= 4.8\times10^{-24}\text{kg m/s}$$

ii) $$\lambda=\frac{h}{p}=\frac{6.63\times10^{-34}}{4.8\times10^{-25}}=1.38\times10^{-9}\text{m}$$

20. Explain the following observations using Einstein's photo electric equations: MAIN

(a) Photoelectric emission does not occur from a surface when the frequency of the light incident on it is less than a certain minimum value.

(b) It is the frequency, and not the intensity of the incident light which affects the maximum kinetic energy of the photoelectrons.

(c) The cut-off voltage (Vo) versus frequency (v) of the incident light curve is a straight line with a slope h/e.

SUGGESTIVE VALUE POINTS

Explanation of
(a) Photoelectric emission 1
(b) Dependency of maximum kinetic energy on frequency only 1
(c) Explanation of slope of cut off voltage versus frequency graph 1

	(a) Einstein Photo electric equation $h\nu = h\nu_o + K_{max}$ $K_{max} = h(\nu - \nu_o)$ For $\nu < \nu_o$, K_{max} will be negative Hence, Photoelectric emission is not possible. (b) According to Einstein Photoelectric equation $K_{max} = h(\nu - \nu_o)$ Hence $K_{max} \alpha \nu$ It shows K_{max} depends upon frequency only and not depends upon intensity. (c) $eV_o = h\nu - h\nu_o$ $V_o = \frac{h}{e}\nu - \frac{h}{e}\nu_o$ This equation represents the equation of straight line (y = mx + c) with the slope $\frac{h}{e}$.	
21.	(a) Define 'work function' of a metal. How can its value be determined from a graph between stopping potential and frequency of the incident radiation? (b) The work function of a metal is 2·4 eV. A stopping potential of 0·6 V is required to reduce the photocurrent to zero, in a photoelectric experiment. Calculate the wavelength of light used. **SUGGESTIVE VALUE POINTS** (a)Defining work function ½ Determining the value of work function from graph 1 (b)Calculating wavelength of light 1½ Minimum energy required by an electron to escape from metal surface. Work function ϕ_0 =h × intercept on x-axis. **(Note: Please award ½ mark, even if a student draws the following graph instead of determining the value of work function)**	MAIN

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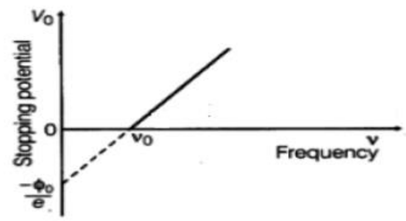

(b) $eV_o = \frac{hc}{\lambda} - \phi_0$

$0.6 = \frac{hc}{\lambda} - 2.4$

$3 = \frac{hc}{\lambda} \Rightarrow 3 \times 1.6 \times 10^{-19} = \frac{6.63 \times 10^{-34} \times 3 \times 10^{8}}{\lambda}$

$\lambda = \frac{1241}{3} = 413.6nm$

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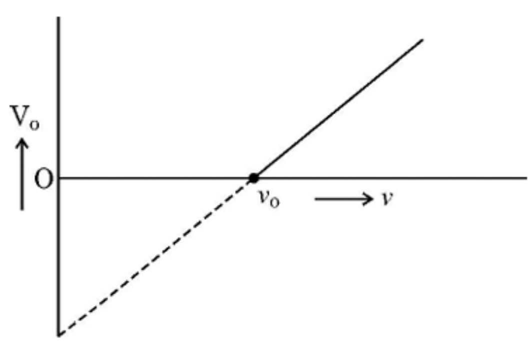
When a photon of suitable frequency is incident on a metal surface, photoelectron is emitted from it. If the frequency is below a threshold frequency (ν_o) for the surface, no photoelectron is emitted. For a photon of frequency $\nu(\nu>\nu_o)$, the kinetic energy of the emitted photoelectrons is

$h(\nu-\nu_o)$. The photocurrent can be stopped by applying a potential Vo called 'stopping potential' on the anode. Thus, maximum kinetic energy of photoelectrons $K_m=h(\nu-\nu_o)$. The experimental graph between Vo and ν for a metal is shown in figure. This is a straight line of slope m.



(i) The straight-line graphs obtained for two metals

(A) coincide each other.

(B) are parallel to each other.

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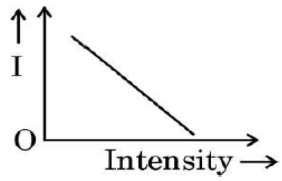
	(C) are not parallel to each other and cross at a point on ν- axis. (D) are not parallel to each other and do not cross at a point on ν-axis. **APPROPRIATE OPTION (B)** (ii) The value of Planck's constant for this metal is (A) e/m (B) 1/me **(C) me** (D) m/e **APPROPRIATE OPTION. (C)** (iii) The intercepts on v-axis and V_0-axis of the graph are respectively: (A) $\nu_o, \frac{h\nu_o}{e}$ (B) $\nu_o, h\nu_o$ (C) $\frac{h\nu_o}{e}, \nu_o$ (D) $h\nu_o, \nu_o$ **OR** **(iii**) When the wavelength of a photon is doubled, how many times its wave number and frequency become, respectively? (A) 2, ½ **(B) 1/2, 1/2** (C) 1/2, 2 (D) 2, 2 **APPROPRIATE OPTION. (B)** (iv) The momentum of a photon is 5.0×10^{-29} kg. m/s. Ignoring relativistic effects (if any), the wavelength of the photon is (A) 1.33 µm (B) 3.3 µm (C) 16.6 µm **(D) 13.3 µm** **APPROPRIATE OPTION. (D)**	
23.	Einstein explained photoelectric effect on the basis of Planck's quantum theory, where light travels in the form of small bundles of energy called photons. The energy of each photon is hv, where ν is the frequency of incident light and 'h' is the Planck's constant. The number of photons in a beam of light determines the intensity of the incident light. A photon incident on a metal surface transfers its total energy hν to a free electron in the metal. A part of this energy is used in ejecting the electron from the metal and is called its work function. The rest of the energy is carried by the ejected electron as its kinetic	MAIN

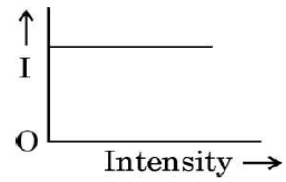
energy.

(i) Which of the following graphs shows the variation of photoelectric current I with the intensity of light?

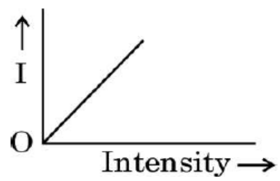
(A)



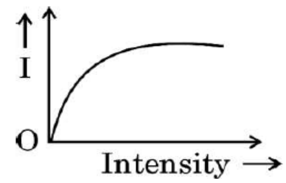
(B)



(C)



(D)



APPROPRIATE OPTION .(C)

(ii) When the frequency of the incident light is increased without changing its intensity, the saturation current:

(A) increases linearly (B) decreases

(C) increases non-linearly (D) remains the same

APPROPRIATE OPTION. (D)

(iii) Which of the following graphs can be used to obtain the value of Planck's constant?

(A) Photocurrent versus Intensity of incident light

(B) Photocurrent versus Frequency of incident light

(C) Cut-off potential versus Frequency of incident light

(D) Cut-off potential versus Intensity of incident light

APPROPRIATE OPTION(C)

(iv) (a) Red light, yellow light and blue light of the same intensity are incident on a metal surface successively. K_R, K_Y and K_B represent the maximum kinetic energy of photoelectrons respectively, then:

(A) $K_R > K_Y > K_B$ (B) $K_Y > K_B > K_R$

(C) $K_B > K_Y > K_R$ (D) $K_R > K_B > K_Y$

APPROPRIATE OPTION. (C)

CHAPTER- 12 ATOMS

Q.N.	**SECTION (A) CARRY 1 MARK EACH**	**CBSE 2025**
1.	Atomic spectral emission lines of hydrogen atom are incident on a zinc surface. The lines which can emit photoelectrons from the surface are members of: (A) Balmer series (B) Paschen series **(C) Lyman series** (D) Neither Balmer, nor Paschen nor Lyman series **APPROPRIATE OPTION. (C) Lyman series**	MAIN
2.	The energy of an electron in a hydrogen atom in ground state is -13.6 eV. Its energy in an orbit corresponding to quantum number n is -0.544 eV. The value of n is: (A) 2 (B) 3 (C) 4 **(D) 5** **APPROPRIATE OPTION. (D) 5**	MAIN
3.	Out of the four options given, in which transition will the emitted photon have the maximum wavelength? (A) n = 4 to n = 3 (B) n = 3 to n = 2 (C) n = 2 to n = 1 (D) n = 3 to n = 1 **APPROPRIATE OPTION. (A)**	MAIN
4.	In a Rutherford scattering experiment, when an alpha particle of mass m_1 approaches a target nucleus of charge Ze and mass m_2, the distance of the closest approach is d0. The energy of the particle is: (A) directly proportional to Z (B) inversely proportional to Z (C) directly proportional to mass m_2 (D) directly proportional to m_1m_2 **APPROPRIATE OPTION.**	COMP
5.	Which one out of the following transitions of an electron in Bohr's model of hydrogen atom will emit a photon with the greatest frequency ? (A) n = 3 to n = 1 (B) n = 3 to n = 2 (C) n = 4 to n = 3 (D) n = 4 to n = 2 **APPROPRIATE OPTION.(A)**	BLIND

6.	**Assertion (A):** The potential energy of an electron revolving in any stationary orbit in a hydrogen atom is positive. **Reason (R):** The total energy of a charged particle is always positive. **APPROPRIATE OPTION**. (D)	MAIN
7.	**Assertion (A):** In Bohr model of hydrogen atom, the angular momentum of an electron in nth orbit is proportional to the square root of its orbit radius r_n. **Reason (R):** According to Bohr model, electron can jump to its nearest orbits only. **APPROPRIATE OPTION**. (C)	MAIN
8.	**Assertion (A):** The Balmer series in hydrogen atom spectrum is formed when the electron jumps from higher energy state to the ground state. **Reason (R):** In Bohr's model of hydrogen atom, the electron can jump between successive orbits only. **APPROPRIATE OPTION. (D)**	MAIN
9.	**Assertion (A):** In Rutherford's alpha particle scattering experiment, the presence of only few alpha particles at angle of scattering led him to the discovery of nucleus. **Reason (R):** The size of nucleus is approximately 10 5 times the size of an atom and therefore only few alpha particles are rebounded. **APPROPRIATE OPTION. (A)**	MAIN
	SECTION (B) EACH QUESTION CARRY 2 MARK	
10.	Prove that, in the Bohr model of a hydrogen atom, the time period of revolution of an electron in the n^{th} orbit is proportional to n^3. **SUGGESTIVE VALUE POINTS** Proving Time period of Revolution ,T α n^3 2 $T=\frac{2\pi r}{v}$ ---------- (1) From Bohr's quantization condition $mvr=\frac{nh}{2\pi}$ $v=\frac{nh}{2\pi mr}$ ---------- (2)	MAIN

	From (1) and (2) $T=\frac{2\pi r}{\left(nh/2\pi mr\right)}$ $T=\frac{2\pi r(2\pi mr)}{nh}$ $T=\frac{4\pi^2 mr^2}{nh}$ From $r=\frac{n^2h^2}{4\pi^2mke^2}$ $T=\frac{4\pi^2 m}{nh}\left(\frac{n^2h^2}{4\pi^2mke^2}\right)^2$ $T=\frac{n^3h^3}{4\pi^2mk^2e^4}$ $\Rightarrow T \alpha n^3$	
11.	An electron in Bohr model of hydrogen atom makes a transition from energy level -1.51 eV to -3.40 eV. Calculate the change in the radius of its orbit. The radius of orbit of electron in its ground state is 0.53 Å. **SUGGESTIVE VALUE POINTS** Calculation of change in the radius — 2 $E_n = \frac{-13.6}{n^2} eV$ $For\ E_n = -1.51 eV$ $-1.51 = \frac{-13.6}{n^2}$ n=3 $For\ E_n = -3.40 eV$ $-3.40 = \frac{-13.6}{n^2}$ n= 2 $\because r = 0.53 n^2\ \mathring{A}$ $\therefore$ change in radius $\Delta r = 0.53[3^2 - 2^2]$ $= 0.53 \times 5$ $= 2.65\ \mathring{A}$	MAIN
12.	In the Bohr model of a hydrogen atom, find the percentage change in radius of its orbit when an electron makes a transition from n = 3 state to n = 2 state. **SUGGESTIVE VALUE POINTS** Calculation of percentage change in radius — 2 $r \alpha n^2$ $\frac{r_2}{r_3} = \frac{4}{9}$ Percentage change when electron makes transition from n=3 to n=2 $= \frac{\lvert r_2 - r_3 \rvert}{r_3} \times 100$ $= \left(\frac{\lvert 4-9 \rvert}{9}\right) \times 100$ =55.55%	MAIN

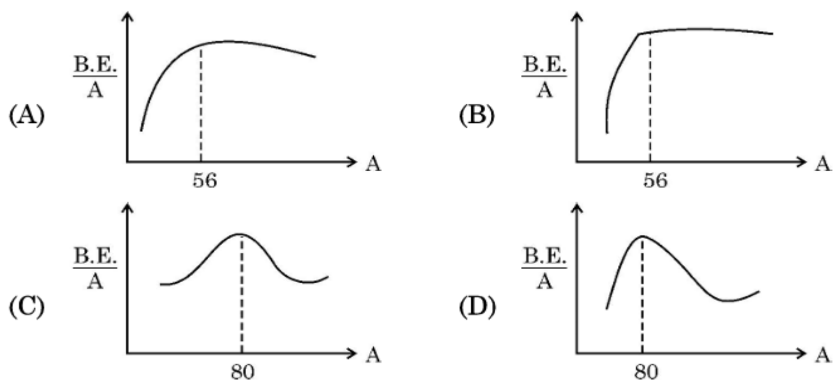
13.	Define the term "distance of closest approach". A proton of 3.95 MeV energy approaches a target nucleus Z = 79 in head-on position. Calculate its distance of closest approach. **SUGGESTIVE VALUE POINTS** Defining distance of closest approach — 1 Calculating distance of closest approach — 1 It is the distance from nucleus at which α particles stops momentarily and then begins to retrace its path. **Alternatively** It is the distance from nucleus at which entire intial kinetic energy of the α particle gets converted into electrostatic potential energy. $r_0 = \frac{1}{4\pi\varepsilon_0}\frac{ze^2}{K.E}$ $= \frac{9\times10^9\times79\times(1.6\times10^{-19})^2}{3.95\times10^6\times1.6\times10^{-19}}$ $= 28.8\times10^{-15}\ m$	MAIN
14.	An alpha particle and a deuterium ion are accelerated through the same potential difference. These are then directed towards a target nucleus to make head-on collision. It is observed that their distance of closest approach is the same. Justify it theoretically. **SUGGESTIVE VALUE POINTS** Theoretical justification for same value of distance of closest approach — 2 For a given nucleus, the distance of closest approach for a charged particle depends only on the accelerating potential difference. Since both α -particle and a deuterium ion are accelerated through same potential difference, therefore distance of closest approach will be same for both.	MAIN
15.	The total energy of an electron in the hydrogen atom in the ground state is –13.6 eV. Find : (a) the potential energy of the electron. (b) the kinetic energy of the electron. (c) the ratio of the magnitude of the total energy to the kinetic energy of the electron. **SUGGESTIVE VALUE POINTS**	BLIND

	Finding (a) the potential energy of electron ½ (b) the kinetic energy of electron ½ (c) the ratio of the magnitude of total energy to kinetic energy 1 (a) $U = 2E = 2\times(-13.6) = -27.2\,eV$ (b) $K = -E = -(-13.6)eV = +13.6\,eV$ (c) $\frac{E}{K} = \frac{13.6eV}{13.6eV} = 1$	
16.	(a) An electron makes a transition from (i) state n = 3 to state n = 2, and (ii) state n = 2 to state n = 1, in hydrogen atom (Bohr model). Find the ratio of the wavelengths of radiations emitted in the two cases. **OR** (b) Find the ratio of nuclear radii of Iodine $_{53}I^{125}$ and Aluminium $_{13}Al^{27}$. **SUGGESTIVE VALUE POINTS** Finding the ratio of wavelengths 2 $\frac{1}{\lambda} = R\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$ $\frac{1}{\lambda_1} = R\left[\frac{1}{(2)^2} - \frac{1}{(3)^2}\right] = \frac{5}{36}R$ $\frac{1}{\lambda_2} = R\left[\frac{1}{(1)^2} - \frac{1}{(2)^2}\right] = \frac{3}{4}R$ $\frac{\lambda_2}{\lambda_1} = \frac{5}{27}$	COMP BLIND
	SECTION(C) DESCRIPTIVE TYPE CARRY 3 MARK EACH	
17.	How is the necessary force provided to an electron to keep it moving in a circular orbit according to Bohr model of hydrogen atom? Derive an expression for the total energy of an electron moving in an orbit of radius r in hydrogen atom. Give the significance of negative sign in this expression. **SUGGESTIVE VALUE POINTS** • To state the necessary force for revolving electron around the nucleus ½ • Deriving the expression for total energy of electron in hydrogen atom 2 • Significance of negative sign ½ The electrostatic force of attraction between the electrons and the nucleus provides the necessary centripetal force required to an electron to revolve in the orbit.	MAIN

	$\frac{mv^2}{r} = \frac{e^2}{4\pi\varepsilon_0 r^2}$ -------(1) (Z = 1 for hydrogen atom) Kinetic energy of the electron $K = \frac{1}{2}mv^2$ $K = \frac{e^2}{8\pi\varepsilon_0 r}$ (from eq (1)) Potential energy of the electron $U = \frac{-e^2}{4\pi\varepsilon_0 r}$ $\left(\because U = \frac{q_1 q_2}{4\pi\varepsilon_0 r}\right)$ Total energy of the electron E = K + U $E = \frac{-e^2}{8\pi\varepsilon_0 r}$ Note: Full credit of this part should be given if a student shows this derivation using alternative method Negative sign signifies that electron is bound to the nucleus OR force is attractive.	
18.	In Bohr model of hydrogen atom, an electron is revolving in second orbit. Find the value of: (i) angular momentum of electron, (ii) radius of the orbit, and (iii) kinetic energy of electron. Take radius of first orbit of hydrogen atom as 0.5Å. **SUGGESTIVE VALUE POINTS** Finding the value of- (i) Angular momentum of electron 1 (ii) Radius of the orbit 1 (iii) Kinetic energy of electron 1 (i) $L = \frac{nh}{2\pi}$ $for\ n = 2$ $L = \frac{2\times 6.63\times 10^{-34}}{2\times 3.14}$ $= 2.11\times 10^{-34}\ kg\, m^2\, s^{-1}$ (ii) $r_n = n^2 r_0$ $r_2 = 4(0.5\,\mathring{A})$ $r_2 = 2\,\mathring{A}$ (iii) Total energy of electron $= -\frac{13.6}{n^2}$ eV $E = -3.4\,\text{eV}$ $(n=2)$ $K = -E$ $K = 3.4\,\text{eV}$	MAIN

19.	State postulates of Bohr model of hydrogen atom. Using Bohr's second postulate, show that the circumference of n^{th} orbit in hydrogen atom is n times the de Broglie wavelength associated with the electron revolving in it. **SUGGESTIVE VALUE POINTS** Stating Bohr's postulates 1½ Showing $2\pi r_n = n\lambda$ 1½ **Bohr's Postulates** (i) an electron in an atom could revolve in certain stable orbits without the emission of radiant energy. (ii) The electron revolves around the nucleus only in those orbits for which the angular momentum is some integral multiple of $\frac{h}{2\pi}$. Alternatively, $L = \frac{nh}{2\pi} = mvr$ (iii) An electron might make a transition from one of its specified non radiating orbits to another of lower energy , if it does so a photon is emitted having energy equal to the energy difference between the intial and final states.The frequency of emitted photon is then given by $E_i - E_f = h\upsilon$ From second postulates $2\pi r_n = n\lambda$ $mv_n r_n = \frac{nh}{2\pi}$ $2\pi r_n = \frac{nh}{mv_n}$	BLIND

CHAPTER- 13 NUCLEI

Q.N.	SECTION (A)	CBSE 2025
1.	Which of the following figures correctly represent the shape of curve of binding energy per nucleon as a function of mass number?  **APPROPRIATE OPTION**. (A)	MAIN
2.	. Inside a nucleus, the nuclear forces between proton and proton, proton and neutron, neutron and neutron are Fpp, Fpn and Fnn respectively. Then: (A) Fpp > Fpn > Fnn (B) Fpn > Fnn > Fpp (C) Fnn > Fpp > Fpn (D) Fpp = Fpn = Fnn **APPROPRIATE OPTION. (D)**	MAIN
3.	Isotones are the nuclides having: (A) same mass numbers (B) same atomic numbers (C) same neutron number, but different atomic number (D) different neutron number, and different mass number **APPROPRIATE OPTION. (C)**	MAIN
4.	The mass numbers of two nuclei A and B are 27 and 64 respectively. The ratio of their radii $(\frac{r_A}{r_B})$ will be: (A) $\frac{27}{64}$ (B) $\frac{9}{16}$ (C) $\frac{3\sqrt{3}}{8}$ (D) $\frac{3}{4}$ **APPROPRIATE OPTION. (D)**	MAIN

5.	The potential energy of a pair of nucleons is minimum when they are separated by about: (C) $2 \cdot 0 \times 10^{-13}$ m (A) 0·8 (D) $2 \cdot 0 \times 10^{-14}$ m (B) $0 \cdot 8 \times 10^{-10}$ m **APPROPRIATE OPTION**	COMP
6.	If 1·0 milligram of mass is converted into energy, the energy released will be: (A) 9×10^{16} J (C) 9×10^{10} J (B) 3×10^{12} J (D) 3×10^{8} J **APPROPRIATE OPTION**	BLIND
7.	**Assertion (A):** During formation of a nucleus, the mass defect produced is the source of the binding energy of the nucleus. **Reason (R):** For all nuclei, the value of binding energy per nucleon increases with mass number. **APPROPRIATE OPTION. (C)**	MAIN
8.	**Assertion (A):** The binding energy per nucleon is practically constant for mass number in the range (30 < A < 170). **Reason (R):** Nuclear forces between the nucleons for mass numbers in the range (30 < A < 170) are not short-range. **APPROPRIATE OPTION. (C)**	MAIN
9.	**Assertion (A):** Nuclear forces are always attractive in nature. **Reason (R):** Nuclear forces are charge-dependent forces. **APPROPRIATE OPTION. (C)**	BLIND COMP
	SECTION (B) EACH QUESTION CARRY 2 MARK	
10.	Calculate the mass of an -particle in atomic mass unit (u). Given, Mass of a normal helium atom = 4·002603 u Mass of carbon atom = 1·9926 × 10 ^{26} kg **SUGGESTIVE VALUE POINTS** Calculation of mass of an α -particle in u 2 $1u = \frac{1}{12}$ mass of carbon atom $= \frac{1.9926 \times 10^{-26} kg}{12} = 1.66 \times 10^{-27} kg$ mass of an electron $= 9.1 \times 10^{-31}$ kg	MAIN

	mass of two electrons $= \dfrac{2\times 9.1\times 10^{-31}}{1.66\times 10^{-27}}$ $= 0.00109638$ u mass of α-particle = mass of the normal helium atom - mass of two electrons $= 4.0026030 - 0.00109638$ $= 4.00150662$ u	
11.	When a neutron collides with $^{235}_{92}U$, the nucleus gives $^{140}_{54}Xe$ and $^{94}_{38}Sr$ as fission products and two neutrons are ejected. Calculate the mass defect and the energy released (in MeV) in the process. Given : $m\left(^{235}_{92}U\right) = 235{\cdot}04393$ u, $m\left(^{140}_{54}Xe\right) = 139{\cdot}92164$ u $m\left(^{94}_{38}Sr\right) = 93{\cdot}91536$ u, $^{1}_{0}n = 1{\cdot}00866$ u $1\ u = 931\ MeV/c^2$ **SUGGESTIVE VALUE POINTS** Calculation of mass defect and energy released 1 ½ + ½ $^{235}_{92}U + ^{1}_{0}n \rightarrow ^{192}_{54}Xe + ^{94}_{38}Sr + 2(^{1}_{0}n)$ $\Delta m = m(^{1}_{0}n) + m(^{235}_{92}U) - (m(^{140}_{54}Xe) + m(^{94}_{38}Sr) + 2\times m(^{1}_{0}n))$ $= 1.00866 + 235.04393 - 139.92164 - 93.91536 - 2\times 1.00866$ $= 0.19827\,u$ Energy released $= \Delta m \times 931\,MeV$ $= 0.19827\times 931$ MeV $= 184.59$ MeV	MAIN
12.	(a) Why is the mass of a nucleus always less than the sum of the masses of its constituents, i.e., free neutrons and free protons? (b) How is Coulomb repulsion between protons in a nucleus overcome? Explain. **SUGGESTIVE VALUE POINTS** (a) Reason for lesser mass of nucleus as compared to sum of masses of constituents 1 (b) Explanation 1 (a) Because of binding of nucleus some energy is released and hence mass decreases during formation of nucleus. (b) By very strong attraction due to nuclear forces	MAIN

13.	Briefly explain how energy is produced in stars, giving two examples of the nuclear reactions involved. **SUGGESTIVE VALUE POINTS** Explaining energy produced in stars — 1 Two examples of nuclear reactions involved — ½+½ Energy is produced in stars due to Nuclear fusion. Two lighter nuclei fuse to form a heavier nucleus which is more stable, hence energy is released. **Alternatively:** Due the difference in masses in reactants and products, mass is converted into energy. Hence energy is released.	MAIN
	SECTION(C) DESCRIPTIVE TYPE CARRY 3 MARK EACH	
14.	**(a)** Define 'Mass defect' and 'Binding energy' of a nucleus. Describe 'Fission process' on the basis of binding energy per nucleon. **(b)** A deuteron contains a proton and a neutron and has a mass of 2.013553 u. Calculate the mass defect for it in u and its energy equivalence in MeV. (m_p = 1.007277 u, m_n = 1.008665 u, 1u = 931.5 MeV/c^2) **SUGGESTIVE VALUE POINTS -** a) Defining Mass Defect — ½ Defining Binding Energy — ½ Describing Fission Process — ½ b) Calculation of Mass Defect — 1 Calculation of Energy — ½ a) Difference in the mass of the nucleus and its constituents is defined as mass defect. Binding Energy is the energy required to separate the nucleons from the nucleus. In Fission process a heavy nucleus splits into lighter nuclei and energy is released. As a result the Binding Energy per nucleon increases. b) $\Delta m = (m_p + m_n) - m_d$ $\Delta m = (1.007277 + 1.008665) - 2.013553$ $\Delta m = 0.002389$ u Energy released = $\Delta m \times c^2$ Energy released = 0.002389×931.5 = 2.2253 MeV ≈2.22 MeV	MAIN
15.	(a) Show the variation of binding energy per nucleon with mass number. Write the significance of the binding energy curve. (b) Two nuclei with lower binding energy per nucleon form a nuclei with more binding	MAIN

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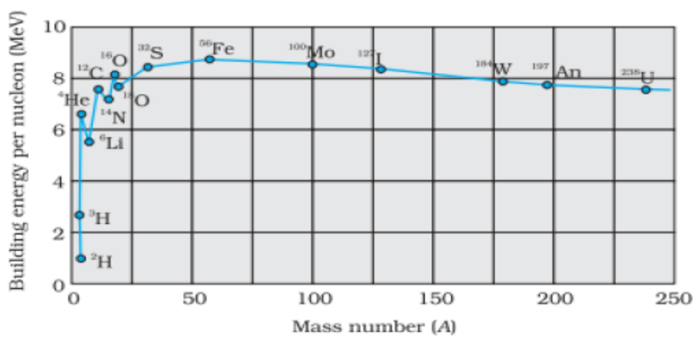
energy per nucleon. (i) What type of nuclear reaction is it?

(ii) Whether the total mass of nuclei increases, decreases or remains unchanged?

(iii) Does the process require energy or produce energy?

SUGGESTIVE VALUE POINTS

(a) Showing variation of binding energy per nucleon with mass number — 1
Significance of binding curve — ½
(b) (i) Stating the type of reaction — ½
(ii) To state whether total mass of nuclei increases, decreases or remains unchanged — ½
(iii) Stating whether process requires energy or produces energy — ½

(a)


Note: - Full credit to be given even if the values are not shown.

Significance of the binding energy curve –
(Any one)
- Why lighter nuclei undergo fusion and heavier nuclei undergo fission.
- Nuclear forces are short ranged.
- Energy is released in both nuclear fission and nuclear fusion.

(b) (i) Nuclear fusion
(ii) Decreases
(iii) Energy is produced
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<td>16.</td>
<td>
(a) Consider the so-called ‘D-T reaction’ (Deuterium -Tritium reaction). In a thermonuclear fusion reactor, the following nuclear reaction occurs:

$${}^{2}_{1}H + {}^{3}_{1}H \longrightarrow {}^{4}_{2}He + {}^{1}_{0}n + Q$$
Find the amount of energy released in the reaction.

Given :
$m\left({}^{4}_{2}He\right) = 4.002603\ u$
$m\left({}^{1}_{0}n\right) = 1.008665\ u$
$1\ u = 931\ MeV/c^2$
</td>
<td>MAIN</td>
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$m\left({}_{1}^{2}H\right)=2\cdot014102$ u

$m\left({}_{1}^{3}H\right)=3\cdot016049$ u

(b). Show that the nuclear density is independent of mass number.

SUGGESTIVE VALUE POINTS

Finding the amount of energy released	2
Showing the nuclear density is independent of mass number	1

$$\Delta m=\left[m({}_{1}^{2}H)+m({}_{1}^{3}H)\right]-\left[m({}_{2}^{4}He)+m({}_{0}^{1}n)\right]$$

$= (2.014102 + 3.016049) – (4.002603 + 1.008665)$

$= 0.018883u$

$Q = \Delta m \times 931$

$= 0.018883 \times 931$ MeV

$Q = 17.58$ MeV

$$\text{Nuclear density} = \frac{\text{Mass of nucleus}}{\text{Volume of nucleus}}$$

$$\rho=\frac{mA}{\frac{4}{3}\pi R^3}$$

$$R=R_0A^{1/3}$$

$$\rho=\frac{3m}{4\pi R_0^3}$$

Independent of mass number (A)

17. (a) Differentiate between Nuclear fission and nuclear fusion, discuss one example of each. MAIN

(b) Draw a graph of potential energy between a pair of nucleons as a function of their separation.

SUGGESTIVE VALUE POINTS

(a)	Differentiating between 'Nuclear fission' and 'Nuclear fusion' with example	1 + 1
(b)	Drawing the graph	1

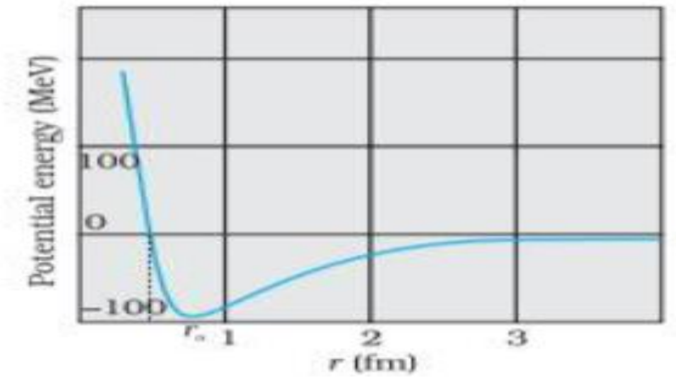
(a) **Nuclear fission** is the process of splitting up of a heavy nucleus into lighter ones with a release of energy.

$${}_{92}^{235}U+{}_{0}^{1}n \rightarrow {}_{92}^{236}U \rightarrow {}_{56}^{144}Ba+{}_{36}^{89}Kr+3\,{}_{0}^{1}n \text{ (or any other reaction)}$$

Nuclear fusion is the process of fusing of two lighter nuclei to form a heavier nucleus with the release of energy.

$${}_{1}^{1}H+{}_{1}^{1}H \rightarrow {}_{1}^{2}H+e^{+}+\nu+0.42\text{MeV} \text{ (or any other reaction)}$$

(b)



18. Give an example of fission reaction. Calculate the energy released by the fission of 1 kg of $_{92}U^{235}$ in kWh. The energy released per fission is 200 MeV. — COMP

SUGGESTIVE VALUE POINTS

• Example of fission reaction.	1
• Calculating the energy released by the fission of 1 kg of in kWh	2

• Example of fission reaction.

$$^{1}_{0}n + ^{235}_{92}U \rightarrow ^{144}_{56}Ba + ^{89}_{36}Kr + 3\,^{1}_{0}n$$

Or any other appropriate example of fission reaction.

• No. of atoms in 1 kg of $^{235}_{92}U = \frac{6.023 \times 10^{23}}{235} \times 1000$

Total energy released by the fission of 1 kg of $^{235}_{92}U$

$$= \frac{6.023 \times 10^{26}}{235} \times 200 \text{ MeV}$$

$$= \frac{6.023 \times 10^{26}}{235} \times 200 \times 1.6 \times 10^{-13} \text{ J}$$

$$= \frac{6.023 \times 10^{26} \times 200 \times 1.6 \times 10^{-13}}{235 \times 3.6 \times 10^{6}} \text{kWh}$$

$$= 2.27 \times 10^{7} \text{ kWh}$$

19. Define binding energy (BE) of a nucleus. An unstable nucleus has mass number A = 240 and $\frac{BE}{A}$ = 7·6 MeV. It splits in two fragments, each of A = 120 with $\frac{BE}{A}$ = 8·5 MeV. Calculate the energy released. — COMP

SUGGESTIVE VALUE POINTS 3

<table>
<tr><td>20.</td><td>(a) Differentiate between isobars and isotones.

(b) Show that the nuclear density is independent of mass number A of a nucleus.

SUGGESTIVE VALUE POINTS

(a) Differentiating isobars and isotones 1
(b) Showing mass independence of nuclear density 2

(a) Nucleides with same mass number are called isobars.
Nucleides with same neutron number but different atomic numbers are called isotones.
(b) If R is the radius of nucleus, then its volume
$V = \frac{4}{3}\pi R^3$
As $R = R_o A^{\frac{1}{3}}$, $V = \frac{4}{3}\pi R_o^3 A$
Density of nucleus
$\rho = \frac{M}{V} = \frac{A}{\frac{4}{3}\pi R_o{}^3 A}$
$\rho = \frac{3}{4\pi R_o^3} = \text{constant}$
The nuclear density is independent of A.</td><td>BLIND

COMP</td></tr>
<tr><td>21.</td><td>What is thermonuclear fusion ?

Calculate the energy released in MeV in the fusion reaction given below :

${}^2_1H + {}^3_1H \longrightarrow {}^4_2He + n$

Given : $m({}^2_1H) = 2{\cdot}014102$ u, $m({}^3_1H) = 3{\cdot}016049$ u, $m({}^4_2He) = 4{\cdot}002603$ u,

$m_n = 1{\cdot}008665$ u, 1 u = 930 MeV/c^2

SUGGESTIVE VALUE POINTS

Defining thermonuclear fusion. 1
Calculating energy released in fusion reaction. 2

Thermonuclear fusion:
When two light nuclei fuse to form a larger nucleus, energy is released
Mass defect
$\Delta m = \left[m\left({}^2_1H\right) + m\left({}^3_1H\right)\right] - \left[m\left({}^4_2He\right) + m_n\right]$
$= (2.014102 + 3.016049) - (4.002603 + 1.008665)$
$\Delta m = 0.018883$ u
Energy released
$E = \Delta m \times 930$ MeV
$= 0.018883 \times 930$
$= 17.56$ MeV</td><td>COMP</td></tr>
</table>

CHAPTER- 14 ELECTRONICS

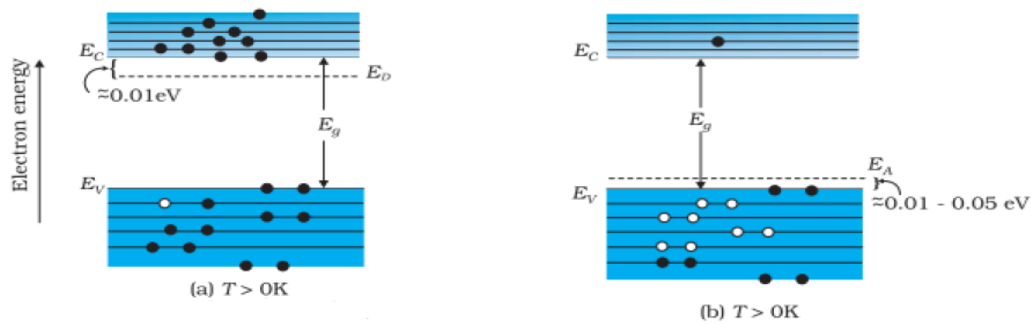
Q.N.	**SECTION (A) CARRY 1 MARK EACH**	CBSE 2025
1.	When a p-n junction diode is forward biased: (A) the barrier height and the depletion layer width both increases. (B) the barrier height increases and the depletion layer width decreases. (C) the barrier height and the depletion layer width both decrease. (D) the barrier height decreases and the depletion layer width increases. **APPROPRIATE OPTION** (C)	MAIN
2.	When the resistance measured between p and n ends of a p-n junction diode is high, it can act as a/an: **(A) resistor** (B) inductor **(C) capacitor** (D) switch **APPROPRIATE OPTION. (A)&(C)**	MAIN
3.	Which of the following is an electrical conductor at room temperature? (A) Sn (B) Mica (C) Si (D) C **APPROPRIATE OPTION. (C)**	MAIN
4.	Germanium crystal is doped at room temperature with a minute quantity of boron. The charge carriers in the doped semiconductors will be: (A) electrons only (B) holes only (C) holes and few electrons (D) electrons and few holes **APPROPRIATE OPTION. (C)**	MAIN
5.	A p-n junction diode is forward biased. As a result, (A) both the potential barrier height and the width of depletion layer decrease. (B) both the potential barrier height and the width of depletion layer increase. (C) the potential barrier height decreases and the width of depletion layer increases. (D) the potential barrier height increases and the width of depletion layer decreases. **APPROPRIATE OPTION. (A)**	MAIN
6.	The general purpose diode is normally used in – (A) beyond cut-in voltage region (B) before cut-in voltage region. (C) beyond the reverse saturation current region. (D) before the reverse saturation current region.	BLIND

	APPROPRIATE OPTION. (D)	
7.	Which of the following impurity atoms when doped in silicon, would produce a p-type semiconductor ? (A) Phosphorus (B) Arsenic (C) Antimony (D) Boron **APPROPRIATE OPTION. (D)**	BLIND
8.	Which of the following impurity atoms, when doped in silicon, would produce an n-type semiconductor? (A) Arsenic (B) Aluminium (C) Boron (D) Indium **APPROPRIATE OPTION. (A)**	BLIND COMP
9.	Which of the following statements is correct during formation of a p-n junction? (A) Initially the diffusion current is small and the drift current is large. (B) Initially the diffusion current and the drift current are equal to each other. (C) Finally, the diffusion current and the drift current are equal to each other. (D) Electrons move from p-region to n-region. **APPROPRIATE OPTION. (C)**	BLIND COMP
10.	**Assertion (A):** We cannot form a p-n junction diode by taking a slab of a p-type semiconductor and physically joining it to another slab of an n-type semiconductor. **Reason (R):** In a p-type semiconductor $\eta_e \gg \eta_h$ while in a n-type semiconductor $\eta_h \gg \eta_e$ **APPROPRIATE OPTION**. (C)	MAIN
11.	**Assertion (A):** In a semiconductor diode, the thickness of depletion layer is not fixed. **Reason (R):** Thickness of depletion layer in a semiconductor device depends upon many factors such as biasing of the semiconductor. **APPROPRIATE OPTION**. (A)	MAIN
12.	**Assertion (A):** n-type semiconductor is not negatively charged. **Reason (R):** Neutral pentavalent impurity atom doped in intrinsic semiconductor (neutral) donates its fifth unpaired electron to the crystal lattice and becomes a positive donor. **APPROPRIATE OPTION. (A)**	MAIN
13.	**Assertion (A):** The impurities in p-type Si are not pentavalent atoms. **Reason (R):** The hole density in valance band in p-type semiconductor is almost equal to the acceptor density.	MAIN

	APPROPRIATE OPTION. (B)	
14.	**Assertion (A):** A hole is an apparent free particle with effective positive electronic charge. **Reason (R):** A hole is not necessarily a vacancy left behind by an electron in the valence band. **APPROPRIATE OPTION. (C)**	MAIN
15.	**Assertion(A):** The electrical conductivity of a pure Ge crystal increases with increase in its temperature. **Reason (R):** The number of electrons excited by thermal excitation from the valence band to the conduction band, in a semiconductor, increases with increase in temperature **APPROPRIATE OPTION. (A)**	COMP
	SECTION (B) EACH QUESTION CARRY 2 MARKS	
16.	A p-type Si semiconductor is made by doping an average of one dopant atom per 5×10^7 silicon atoms. If the number density of silicon atoms in the specimen is 5×10^{28} atoms m^{-3}, find the number of holes created per cubic centimetre in the specimen due to doping. Also give one example of such dopants. **SUGGESTIVE VALUE POINTS -** Finding the number of holes — 1 One example — 1 1 dopant atom for 5×10^7 Si atoms and number density of Si atoms $= 5\times10^{28}\ \frac{\text{atoms}}{m^3}$ *(given)* No. of holes created per $m^3 = \frac{5\times10^{28}}{5\times10^7} = 10^{21}$ Number of holes created per cubic centimeter $= \frac{10^{21}}{10^6} = 10^{15}$ Any one example of dopant - Aluminium / Indium / Gallium	MAIN
17.	The threshold voltage of a silicon diode is 0.7 V. It is operated at this point by connecting the diode in series with a battery of V volt and a resistor of 1000 Ω. Find the value of V when the current drawn is 15 mA.	MAIN

	SUGGESTIVE VALUE POINTS Finding the value of V. 2 $V - V_o = IR$ $V - 0.7 = (15\times10^{-3}) \times 1000$ $V = 15.7$ volt	
18.	In an intrinsic semiconductor, carrier's concentration 5×10^8 /m^3. On doping with impurity atoms, the hole concentration becomes 8×10^{12} /m^3. (a) Identify (i) the type of dopant and (ii) the extrinsic semiconductor so formed. (b) Calculate the electron concentration in the extrinsic semiconductor. **SUGGESTIVE VALUE POINTS** (a) (i) Identifying the type of dopant ½ (ii) Identifying the type of extrinsic semiconductor ½ (b) Calculating the electron concentration 1 (a) (i) Trivalent (ii) p – type semi conductor (b) Electron concentration $n_e = \frac{n_i^2}{n_h}$ $n_e = \frac{(5\times10^8)^2}{8\times10^{12}}$ $n_e = 3.125\times10^4 m^{-3}$	MAIN
19.	In an n-type semiconductor electron-hole combination is a continuous process at room temperature. Yet the electron concentration is always greater than the hole concentration in it. Explain. **SUGGESTIVE VALUE POINTS** Explanation for higher electron concentration in n-type semiconductor in comparison to hole concentration 2 In a doped semiconductor the total number of conduction electrons is due to the electrons contributed by donors and those generated intrinsically, while the total number of holes is only due to the holes from the intrinsic sources.	MAIN
20.	Draw energy band diagrams of n-type and p-type semiconductors at temperature T > 0 K. Show the donor/acceptor energy levels with the order of difference of their energies from the bands. **SUGGESTIVE VALUE POINTS**	MAIN

Drawing Energy band diagram of	
n type semiconductor	½
p type semiconductor	½
Showing donor/acceptor energy level	½+½



SECTION (C) EACH QUESTION CARRY 3 MARKS

21. **(a)** Draw circuit arrangement for studying V-I characteristics of a p-n junction diode. — MAIN

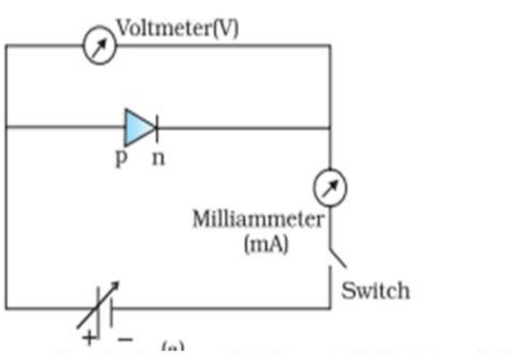
(b) Show the shape of the characteristics of a diode.

(c) Mention two information that you can get from these characteristics.

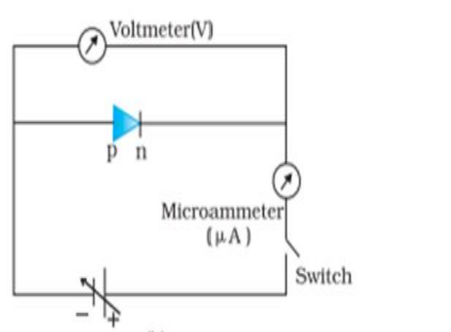
SUGGESTIVE VALUE POINTS

a) Circuit Arrangement for studying V–I characteristics.	1
b) Showing the shape of characteristic curves.	1
c) Two informations from the characteristics	½ + ½

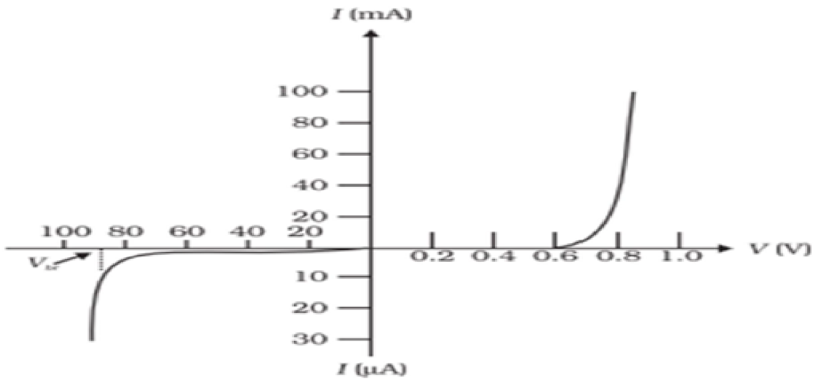
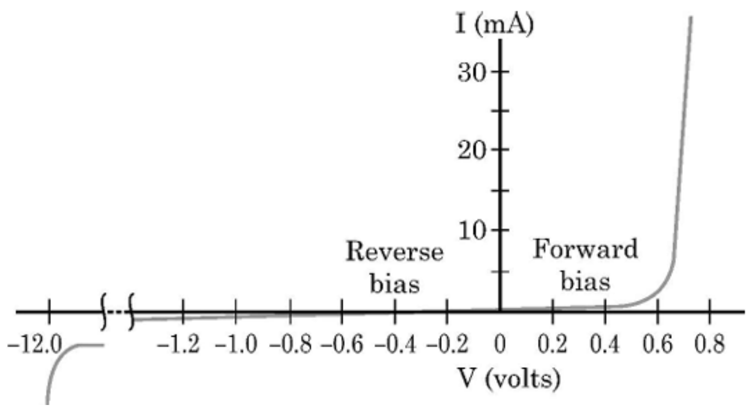
a)



Circuit diagram for forward characteristics



Circuit diagram for Reverse characteristics

	b)  Note: Please do not deduct marks for not writing values. c) Any two information Knee voltage / reverse saturation current / Breakdown voltage / very low resistance in forward biasing / very high resistance in Reverse biasing.	
22.	(a) What are majority and minority charge carriers in an extrinsic semiconductor? (b) A p-n junction is forward biased. Describe the movement of the charge carriers which produce current in it. (c) The graph shows the variation of current with voltage for a p-n junction diode.  Estimate the dynamic resistance of diode at – 0.6V. **SUGGESTIVE VALUE POINTS**	MAIN

(a) Defining majority and minority charge carries in an extrinsic semiconductor	½+½
(b) Describing movement of the charge carriers when pn-junction diode is forward biased	1
(c) Estimating Dynamic resistance	1

(a) In an extrinsic semiconductor, the charge carriers whose number density is large are known as majority charge carriers.

In an extrinsic semiconductor, the charge carriers whose number density is small are known as minority charge carriers.

(b) Due to the applied forward voltage, electrons from n-side cross the depletion region and reach p-side. Similarly, holes from p-side cross the junction and reach the n-side. Due to the movement of these charge carriers current is produced.

(c) At V = -0.6 volt, I = 0, so dynamic resistance is infinite.

23. (a) Draw the energy-band diagrams for conductors, semiconductors and insulators at T = 0 K. How is an electron-hole pair formed in a semiconductor at room temperature?

(b) Carbon and silicon both, are members of IV group of periodic tables and have the same lattice structure. Carbon is an insulator whereas silicon is a semiconductor. Explain.

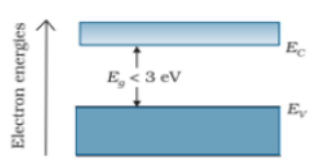
MAIN

SUGGESTIVE VALUE POINTS

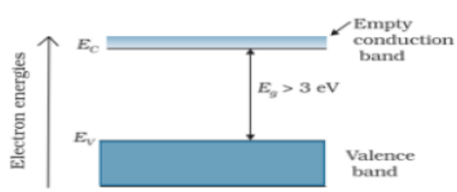
a)	Drawing energy band diagrams	½ + ½ + ½
	Formation of electron hole pair	½
b)	Explanation	1

(a)

CONDUCTORS



SEMICONDUCTORS



INSULATORS

At room temperature, thermal energy is sufficient for electrons to make them free from the bonds and create a vacancy called hole. Hence electron hole pair is formed.

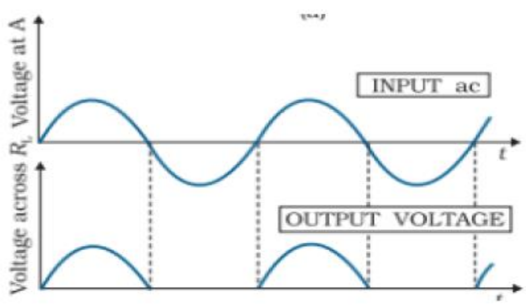
	(b) The valence electron in carbon and silicon lie in the second and third orbit respectively. So, the energy required to take out an electron will be less for silicon as compared to carbon. Hence number of free electrons for conduction in silicon are significant but negligibly small for carbon	
24.	Differentiate between half-wave and full-wave rectification. With the help of a circuit diagram, explain the working of a full-wave rectifier.	MAIN

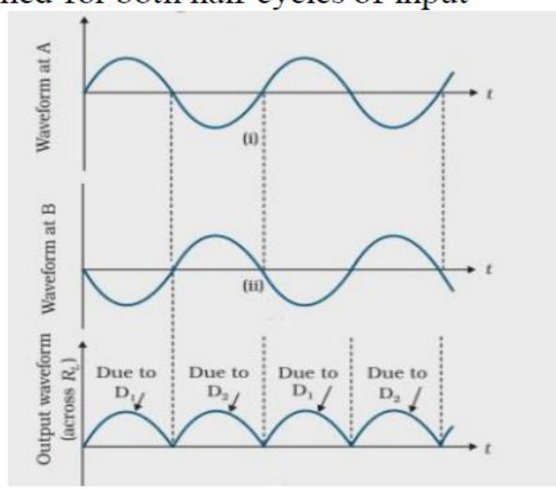
SUGGESTIVE VALUE POINTS

Difference between half wave and full wave rectification	1
Working of full wave rectifier	2

In half wave rectification there is output in one half of input cycle, whereas in full wave rectification, output is obtained for both half cycles of input (positive and negative)

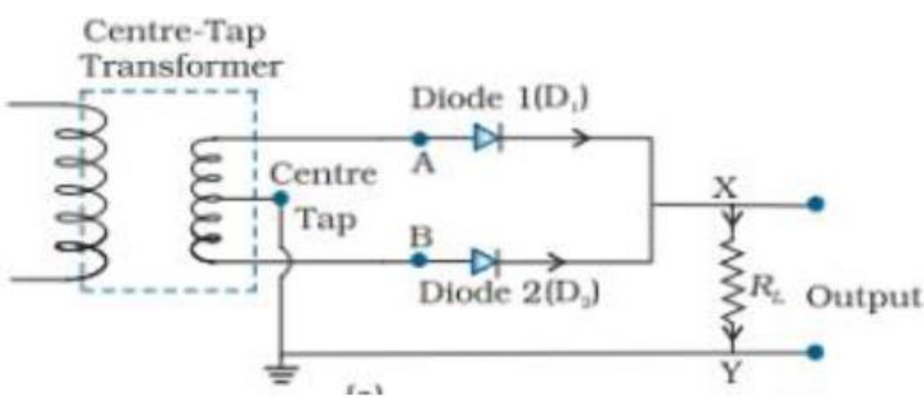
Alternatively





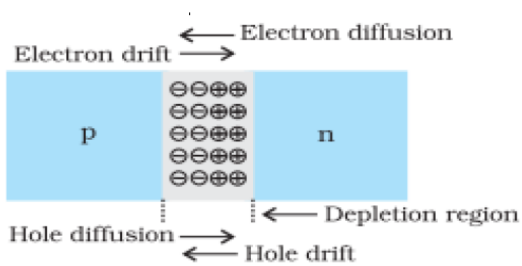
Half wave Rectification

Full wave Rectification



WORKING

Suppose the input voltage to A with respect to the centre-tap at any instant is positive. At that instant, voltage at B being out of phase will be negative. So, diode D1 gets forward biased and conducts (while D2 being reverse biased is not conducting). Hence, during this

	positive half cycle we get an output current (and output voltage across the load resistor RL). In the course of ac cycle when the voltage at A becomes negative with respect to course of ac cycle when the voltage at A becomes negative with respect to centre tap, the voltage at B would be positive. In this part of the cycle diode D_1 would not conduct but diode D_2 would, giving an output current and output voltage (across R_L) during the negative half cycle of the input ac.	
25.	Explain the process of formation of ‘depletion layer’ and ‘potential barrier’ in a p-n junction region of a diode, with the help of a suitable diagram. Which feature of junction diode makes it suitable for its use as a rectifier? **SUGGESTIVE VALUE POINTS** Explaining the formation of depletion layer and potential barrier 1+1 Feature of junction diode for its use as rectifier 1 When an electron diffuses from n-side to p-side, it leaves behind an ionized donor on n side. Similarly, when a hole diffuses from p-side to n-side, it leaves behind an ionized acceptor on p side. This space charge region consisting of immobile ions on either side of the junction is known as depletion layer. As diffusion process continues width of depletion layer increases and consequently strength of electric field increases across the junction and thus the drift current. The potential that prevents the movement of electron from n region into p region is called potential barrier.  **<u>Note</u> : Award 1 mark if formation of depletion layer is shown with the help of above diagram.** Diode allows current to pass only when it is forward biased as resistance is small whereas in reverse bias resistance is very large. **Alternatively**: Diode is unidirectional.	MAIN
	SECTION (D) EACH QUESTION CARRY 4 MARKS	

26.	Extrinsic semiconductors are made by doping pure or intrinsic semiconductors with suitable impurity. There are two types of dopants used in doping, Si or Ge, and using them p-type and n-type semiconductors can be obtained. A p-n junction is the basic building block of many semiconductor devices. Two important processes occur during the formation of a p-n junction: diffusion and drift. When such a junction is formed, a 'depletion layer' is created consisting of immobile ions -cores. This is responsible for a junction potential barrier. The width of a depletion layer and the height of potential barrier changes when a junction is forward-biased or reverse-biased. A semiconductor diode is basically a p-n junction with metallic contacts provided at the ends for application of an external voltage. Using diodes, alternating voltages can be rectified. (i) Which of the following is a donor impurity atom for Ge? (A) Boro (B) Antimony (C) Aluminium (D) Indium **APPROPRIATE OPTION (B)** (ii) When a pentavalent atom occupies the position of an atom in the crystal lattice of Si, four of its electrons form covalent bonds with four silicon neighbours, while the fifth remains bound to the parent atom. The energy required to set this electron free is about: (A) 0 .5 ev (B) 0 .1 eV (C) 0 .05 eV (D) 0. 01 Ev **APPROPRIATE OPTION. (C)** (iii) During formation of a p-n junction: (A) a layer of negative charge on n-side and a layer of positive charge on p-side appear. (B) a layer of positive charge on n-side and a layer of negative charge on p-side appear. (C) the electrons on p-side of the junction move to n-side initially. (D) initially diffusion current is small and drift current is large. **APPROPRIATE OPTION. (B)** (iv) (a) In reverse-biased p-n junction: (A) the drift current is of the order of few mA. (B) the applied voltage mostly drops across the depletion region. (C) the depletion region width decreases. (D) the current increases with increase in applied voltage. **APPROPRIATE OPTION. (B)**	MAIN

	OR (b) The output frequency of a full-wave rectifier with 50 Hz as input frequency is: (A) 25 Hz (B) 50 Hz (C) 100 Hz (D) 200 Hz **APPROPRIATE OPTION. (C)**	
27.	According to the band theory of solids, a semiconductor has a valence band and a conduction band separated by a gap, known as energy band gap. Pure semiconductors are called intrinsic semiconductors. At room temperature, some electrons from the valence band can acquire enough energy to cross the band gap and enter the conduction band. The number of conduction electrons is equal to the number of holes is an intrinsic semiconductor. The number of charge carriers can be changed by doping of a suitable impurity in a pure semiconductor. Such semiconductors are known as extrinsic semiconductors. These are of two types (n-type and p-type). A p-n junction is the basic building block of semiconductor devices. Two important processes occur during formation of a p-n junction: diffusion and drift. A 'depletion layer' is formed in a p-n junction. This is responsible for a junction potential barrier. A semiconductor diode is basically, a p-n junction with metallic contacts provided at the ends for the application of an external voltage. A diode can be forward-biased or reverse-biased. The barrier height and the depletion layer width in a p-n junction changes depending on the nature of the biasing. (i) (a) Which of the following statements is not true? (A) The resistance of an intrinsic semiconductor decreases with the increase of temperature. (B) Doping pure Si with trivalent impurities gives p-type semiconductors. (C) The majority charge carriers in n-type semiconductors are holes. (D) A p-n junction can act as a semiconductor diode. **APPROPRIATE OPTION. (C)** **OR** (b) In a unbiased p-n junction: (A) the diffusion current is zero everywhere. (B) the drift current is zero everywhere. (C) the electric potential is zero everywhere. (D) the drift current and the diffusion current cancel each other **APPROPRIATE OPTION. (D)**	COMP

	(ii) The impurity atoms with which pure Ge should be doped to convert it into an n-type semiconductor, is: (A) Boron (B) Phosphorous (C) Aluminium (D) Indium **APPROPRIATE OPTION. (B)** (iii) The energy band gap in Ge at 0 K is about: (A) 0·72 eV (B) 1·1 eV (C) 3·0 eV (D) 5·4 Ev **APPROPRIATE OPTION. (A)** (iv) In a p-n junction diode under reverse bias, the barrier height: (A) is reduced and the depletion layer width decreases. (B) is reduced and the depletion layer width increases. (C) increases and the depletion layer width also increases. (D) increases and the depletion layer width decreases. **APPROPRIATE OPTION. (C)**	