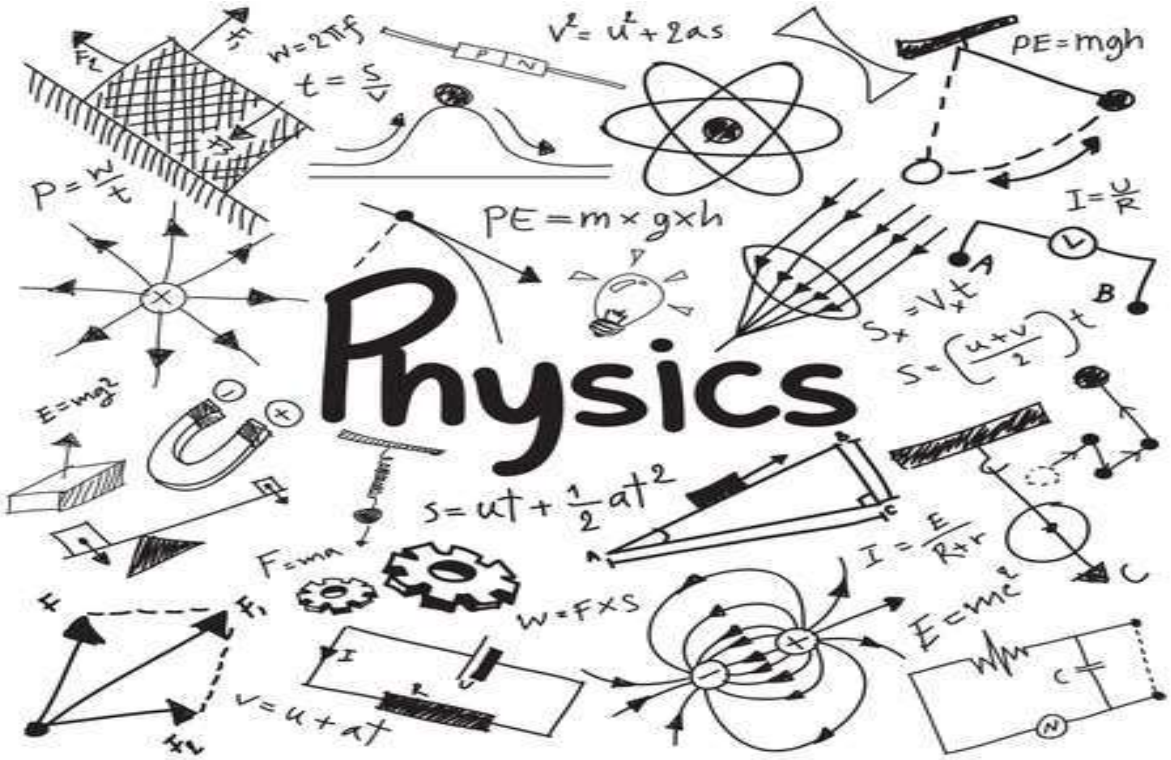
केन्द्रीय विद्यालय संगठन
KENDRIYA VIDYALAYA SANGATHAN

क्षेत्रीय कार्यालय रायपुर
REGIONAL OFFICE RAIPUR

अध्ययन सामग्री/**STUDY MATERIAL(2022-23)**

कक्षा **XII/CLASS XII**

भौतिकी/ **PHYSICS**



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DELETED TOPICS

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ELECTROSTATICS(ELECTRIC CHARGES AND FIELDS)

GIST

Charge- Charge is the property associated with matter due to which it produces and experiences electric and magnetic effect.SI unit of charge is coulomb.

One coulomb : It is that charge which when placed at a distance of 1m from an equal charge and similar charge in vacuum would repel it by a force of 9x109 N.

Properties of charges:

Like charges repel and unlike charges attract.

Charges are additive in nature i.e., Q= Q1+Q2+Q3 + ……..+Qn

Charges are quantized. i.e., Q= ± ne where n = 1,2,3,… & e=1.602 X10-19 C.

When any physical quantity exists in discrete packets rather than in continuous amount, the quantity is said to be quantised. Hence, charge is quantised.

Charge in a body is independent of its velocity.

Charge is conserved.

To measure charge gold leaf electroscopes are used.

Coulomb's law :

It states that the electrostatic force of interaction or repulsion acting between two stationary point charges is given by :

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

where, q_1 and q_2 are the stationary point charges and r is the separation between them in air or vacuum.

Also, $$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9 \text{ N-m}^2/\text{C}^2$$

where, ε_0 = permittivity of free space = 8.85419×10^{-12} $\text{C}^2/\text{N-m}^2$

The force between two charges q_1 and q_2 located at a distance r in a medium other than free space may be expressed as

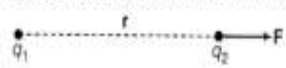
$$F = \frac{1}{4\pi\varepsilon} \cdot \frac{q_1 q_2}{r^2}$$

where, ε is **absolute permittivity** of the medium.

Now, $$\frac{F_{\text{vacuum}}}{F} = \frac{\frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}}{\frac{1}{4\pi\varepsilon} \cdot \frac{q_1 q_2}{r^2}} = \frac{\varepsilon}{\varepsilon_0} = \varepsilon_r$$

where, ε_r is called **relative permittivity** of the medium also called **dielectric constant** of the medium.

In vector form,



$$\mathbf{F} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{|\mathbf{r}|^2} \hat{\mathbf{r}} \quad \text{or} \quad |\mathbf{F}| = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_1 q_2}{r^2}$$

Electric field ($\vec{E}$) :- The strength of an electric field is measured by the force experienced by a unit positive charge placed at that point. The direction of field is given by the direction of motion of a unit positive charge if it were free to move.

$$\mathbf{E} = \lim_{q_0 \to 0} \frac{\mathbf{F}}{q_0}$$

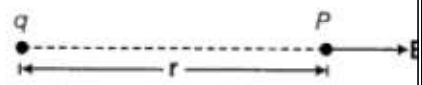
Here, $q_0 \to 0$, i.e. the test charge q_0 must be small, so that it does not produce its own electric field.

SI unit of electric field intensity (**E**) is N/C and it is a vector quantity.

Electric Field Intensity (EFI) due to a Point Charge

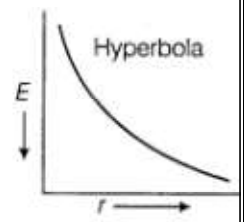
Electric field intensity at P is, then

$$\mathbf{E} = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{|\mathbf{r}|^2}\hat{\mathbf{r}}$$



The magnitude of the electric field at a point P is given by

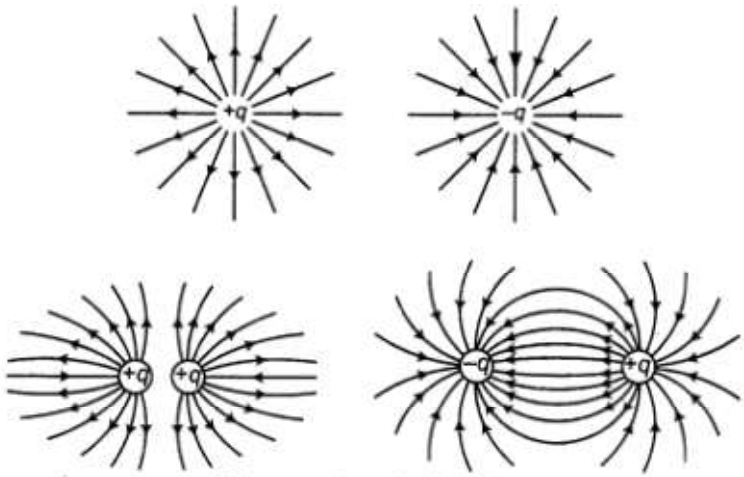
$$|\mathbf{E}| = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}$$



If $q > 0$, i.e. positive charge, then $\mathbf{E}$ is directed away from source charge. On the other hand if $q < 0$, i.e. negative charge, then $\mathbf{E}$ is directed towards the source charge.

$$\mathbf{E} \propto \frac{1}{r^2}$$

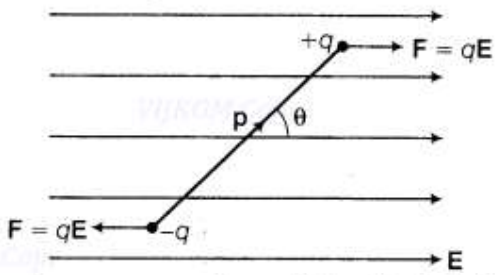
Electric field lines: It is the path straight or curved in electric field, such that tangent at any point of it gives direction of electric field at that point. Electric field lines are a way of pictorially mapping the electric field around a configuration of charge(s).
Properties of electric field lines:
Arbitrarily starts from +ve charge and end at –ve charge
Continuous, but never form closed loops
Tangent to elec. field line at any point gives direction of elec. field at that point.
Never intersect because at the point of intersection there will be two possible direction of elec. field which is not possible.
Relative closeness of the field lines represents the magnitude of the field strength.
Always normal to the surface of conductor.



Different electric field lines

Electric Dipole: Two equal and opposite charges separated by a small distance.
Dipole moment: The strength of an electric dipole is measured by a vector quantity known as electric dipole moment (p) which is the product of the charge (q) and separation between the charges (2l).
P= q x (2l)
It is a vector whose direction is from negative to the positive charge
Electric Field due to a Dipole : Electric field of an electric dipole is the space around the dipole in which the electric effect of the dipole can be experienced. It is a vector. SI unit: - Cm,
When l <<< r, | E_{axial} | = 2 | $E_{equitorial}$ |
Torque on an electric dipole placed in a uniform electric field (E) is given by

$\tau = \mathbf{p} \times \mathbf{E} \Rightarrow |\tau| = pE\sin\theta$



Minimum torque experienced by electric dipole in electric field, when $\theta = 0°$ or π

$$\tau = \tau_{min} = 0$$

Maximum torque $\tau = \tau_{max}$, when $\sin\theta = 1 \Rightarrow \theta = \pi/2$

$$\tau_{max} = pE$$

Dipole is in stable equilibrium in uniform electric field when angle between p and E is 0° and in unstable equilibrium when angle θ= 180°.
Net force on electric dipole placed in a uniform electric field is zero.
There exists a net force and torque on electric dipole when placed in non-uniform electric field.
Work done in rotating the electric dipole from θ1 to θ2 is W = pE (cos θ1 – cos θ2).
Work done in rotating the dipole from the position of stable equilibrium to unstable equilibrium, i.e. when θ1 = 0° and θ2 = π. W = 2 pE
Work done in rotating the dipole from the position of stable equilibrium to the position in which dipole experiences maximum torque, i.e. when θ1 = 0° and θ2 = 90°. W = pE
Electric flux. The electric flux through a small surface ts defined as the electric lines of force passing through that are when held normally to the lines of force.
Mathematically-- $\varphi = \vec{E}.\vec{\Delta S}$
where E is the electric field and AS is the area vector representing the elementary surface area.
Unit. In SI, unit of electric flux is (N m2 C-2).

Gauss' theorem. It states that the total outward electric flux through a closed surface is 1/ ϵ_o times the charge enclosed |by the closed surface.

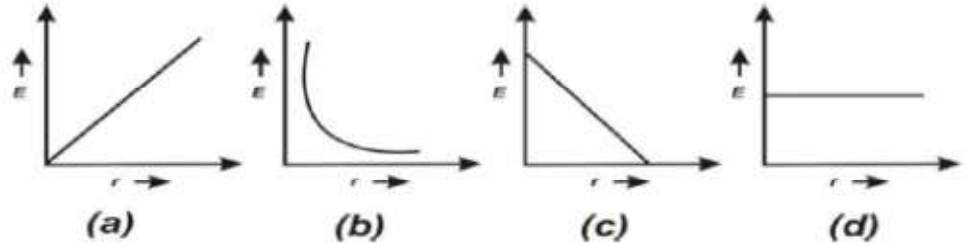
Mathematically : $\oint \vec{E}.\vec{dS} = \frac{q}{\epsilon_o}$ **where q is charge enclosed by the closed surface.**
Electric field due to infinitely long straight linear charge density λ
E = $\lambda / 2\pi\epsilon_o r$
where r is perpendicular distance of the observation point from the wire.
Electric field due to an infinite plane sheet of charge of surface charge density σ
Electric field between two infinite plane parallel sheets of charge of surface charge density σ and – σ :
E = $\sigma / 2\epsilon_o$

Practice questions

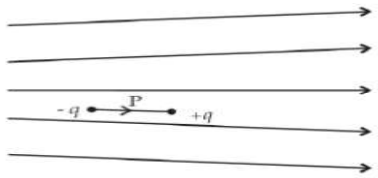
ONE MARK QUESTIONS)

1 The name electricity is coined from the Greek word :--
(a) elektron (b) as in (a) and meaning amber(c) electron(d) as in (c) and meaning smallest charged particle.
Ans (b)
2 Which of the following has highest mass :-
Neutral body (b) positively charged body (c) negatively charged body (d) All the above has equal mass.
Ans : (b)
3. A charge Q1 exerts some force on second charge Q2. If third charge Q3 is brought near them, then the force of Q1 exerted on Q2 :----

(a) Increases (b) Decreases (c) Remains same (d) Data incomplete
Ans : (c)
4.A thin straight infinitely long conducting wire having charge density λ (lambda) enclosed by a cylindrical surface of radius r and length l, its axis coinciding with the length of the wire. The expression for the electric flux through the surface of the cylinder is :--
(a) $\varepsilon_0 . \lambda l$ (b) $\lambda l / \varepsilon_0$ (c) $\varepsilon_0/\lambda l$ (d) zero
Ans (b)
5.The electric field due to a charge configuration with total charge zero
(a)is not zero (b) may or may not be zero (c) is zero (d) all the above are correct
Ans : (b)
6.Five charges + 1C, - 3C, +5Q, +7C and -10Q are kept inside a closed surface. What will be the outgoing flux through the surface.
26 V-m (b) 0 V-m (c) 10 V-m (d) 8 V-m
Ans : (b)
7.For a point charge, the graph between electric field versus distance is given by : -



Ans : (b)
8.If surface integral $\int E.ds = 0$ over a surface, then
(a) the electric field inside the surface and on it is zero.
(b) the electric field inside the surface is necessarily uniform.
(c) the number of flux lines entering the surface must be equal to the number of flux lines leaving it.
(d) all charges must necessarily be outside the surface.
(e) both(c) and (d)
Ans : (e) both(c) and (d)
Electric Field Lines
An electric field line in general is a curve drawn in such a way that the tangent to it at each point is in the direction of the electric field at that point. A field line is a space curve, i.e. a curve in three dimension. Electric field lines are thus used to pictorially map the electric field around a charge or a configuration of charges. The density of field lines is more near the charge. Away from the charge, the field is weak, so the density of field lines is less.
9. Electric field lines always move from
(a) higher to lower potential (b) lower to higher potential
(c) infinity to zero potential (d) None of the above
Ans : (a)
10.Figure shows electric field lines in which electric dipole P is placed as shown. Which of the following statement is correct?

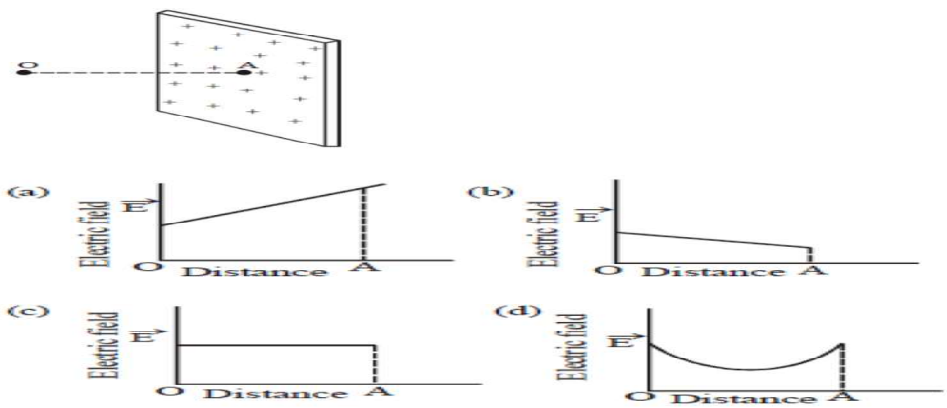


(a)The dipole will not experience any force (b)The dipole will experience a force towards right
(c) The dipole will experience a force towards left (d)The dipole will experience an upward force Ans : (c)
10 Choose the correct statement regarding electric lines of force.
(a) Emerges from negative charge and meet at positive charge.

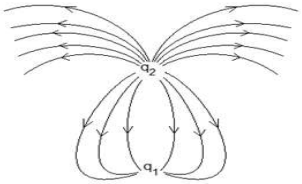
(b) A closely spaced region of electric lines of force represents strong electric field.
(c) Representation of field lines for a point charge and a solid sphere are same.
(d) They have physical nature
Ans : (b)
11 The spacing between two electric field lines indicates its
(a) charge (b) position (c) strength (d) None of the above
Ans : (c)

TWO MARK QUESTIONS

1.A uniformly charged conducting sphere of 2.4 m diameter has a surface charge density of 80.0 μC/m2. (a) Find the charge on the sphere. (b) What is the total electric flux leaving the surface of the sphere?
Hint- q= (Surface charge density x $4\pi R^2$), Use Gauss theorem to calculate flux
2.An infinite line charge produces a field of 9 × 104 N/C at a distance of 2 cm. Calculate the linear charge density.
Hint- E = $\lambda / 2\pi\epsilon_0 r$
3.A point charge of 2.0 μC is at the centre of a cubic Gaussian surface 9.0 cm on edge. What is the net electric flux through the surface?
Hint- Use Gauss law
4.Figure shows the part of an infinite plane sheet of charge. Which of the following graphs correctly shows the behavior of electric field intensity as we move from point O to A.



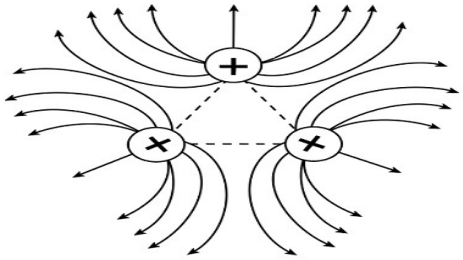
Ans : (c) (Electric field = $\sigma/2\varepsilon_0$, independent of distance)
5.If the electric field is given by ($6\hat{i} + 3\hat{j} + 4\hat{k}$) N/C, then find the flux through a surface of area 20m2 in the Y-Z plane.
Ans : 120 Nm2/C (flux = $20\hat{i} . 6\hat{i}$ =120)
5.Find the least coulomb force in nature for the charges placed 1 m apart.
Ans : 2.3 x 10-28 N (Hint : F = Ke2/ r2)
6.Write down the two limitations of coulombs law.
Ans : (i) applicable for point charges, not applicable when both charges in motion.
7.A shower of protons from outer space deposites equal charges +q from earth of mass M and moon of mass m, and the electrostatic repulsion then exactly counter balances the gravitational attraction. How large is the charge q?
Ans : here, electrostatic repusive force = gravitational attractive force
Kq2/ r2 = GMm/ r2 => q = $\sqrt{GMm/K}$
8.What is the magnitude of electric field that will balance the weight of an electron.
Ans : 5.6 x 10-11 N/C (Fg =Fe => mg = Ee => E = mg/ e)
9.Consider the situation shown in figure. What are the signs of q1 and q2. If the lines are drawn in proportion to the charge. What is the ratio of charge q1 to q2 ?



Ans : The way we have defined electric field lines is that they originate from positive charge or infinity and terminate on negative charge or infinity. So if we have a closer look of the diagram we can see they originate from q2 and terminate at q1. This means q2 is positive and q1 is negative. Ratio is 3 :8

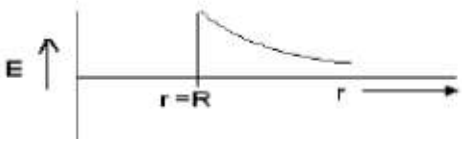
10.Three equal positive charges q are at the corners of an equilateral triangle. Sketch the field lines in the plane of the charges.

Ans :



11.Sketch the graph showing the variation of Electric field with the distance from the center of charged hollow sphere of radius R.

Ans :

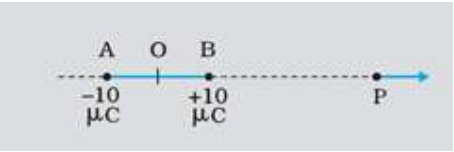


3 MARK QUESTIONS

1.Two positive ions carrying a charge q are separated by a distance d. If F is the force of repulsion between the ions, then find the number of electrons missing from each ions.

Ans : F = $\frac{kq^2}{d^2}$ **=> F=**$\frac{kn^2e^2}{d^2}$ **=> n =** $\sqrt{\frac{Fd^2}{ke^2}}$

2.Two charges ±10 µC are placed 5.0 mm apart. Determine the electric field at (a) a point P on the axis of the dipole 15 cm away from its centre O on the side of the positive charge, as shown in fig.



Ans : 2.6 x 105 N/C (Use formula E = 2Kp/ r3)

3. A system has two charges qA = 2.5 × 10-7 C and qB = –2.5 × 10-7 C located at points A: (0, 0, –15 cm) and B: (0,0, +15 cm), respectively. What are the total charge and electric dipole moment of the system?

Ans : 7.5 x 10-8 Cm.

Given A(0,0,−15cm) and B(0,0,15cm) AB = 30 cm

The total charge q on the dipole is

q=q_A**+** q_B**=2.5×10−7C−2.5×10−7C=0**

The electric dipole moment

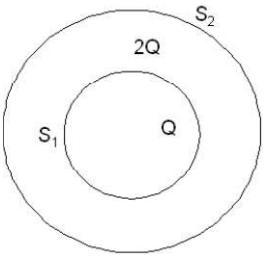
P = Any charge (qA× length of dipole (2a)

=2.5×10−7 C ×30×10−2 Cm

4. Three-point charges q, – 4q and 2q are placed at the vertices of an equilateral triangle ABC of side 'l' as shown in the figure. Obtain the expression for the magnitude of the resultant electric force acting on the charge q.

Ans : $2\sqrt{3}\ k\ \frac{q^2}{l^2}$ **(use principal of superposition of forces)**

5.S_1 and S_2 are two hollow concentric sphere enclosing charges Q and 2Q respectively as shown in the figure. (i)What is the ratio of the electric flux trough S_1 and S_2? (ii)How will electric flux through the sphere S_1 charge, if a medium of dielectric constant S is introduced in the space inside S1 in place of air?



Ans : (i) 1/3
(ii)=1/S th of its original value

6.Consider a uniform electric field E = 3 × 10^3 î N/C. (a) What is the flux of this field through a square of 10 cm on a side whose plane is parallel to the yz plane? (b) What is the flux through the same square if the normal to its plane makes a 60° angle with the x-axis?
Ans : (a) Electric field intensity, E=3×103N/C
Side of the square, s =10cm = 0.1m
Area of the square, A = 0.01m2
7.The plane of the square is parallel to the y-z plane. Hence, angle between the unit vector normal to the plane and electric field, θ =0^0
Flux (ϕ) through the plane is given by the relation,
ϕ=|E|Acosθ
= 3×103×0.01×cos0^0
= 30Nm2/C
(b) Plane makes an angle of 60^0 with the x-axis. Hence, θ=60^0
Flux, ϕ=|E|Acosθ
=3×103×0.01×cos60^0
=30x ½ =15Nm2/C
8.In a certain region of space, electric field is along the z-direction throughout. The magnitude of electric field is, however, not constant but increases uniformly along the positive z-direction, at the rate of 10^5 N/C per metre. What are the force and torque experienced by a system having a total dipole moment equal to 10–7 Cm in the negative z-direction ?

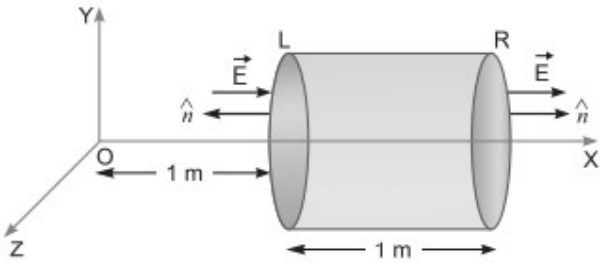
Ans :-- Dipole moment of the system, p=q×dl=−10-7 Cm

Rate of increase of electric field per unit length, dE =10^5 N/C
Force (F) experienced by the system is given by the relation,
F=qE
F=qdE/ dl ×dl
F= p x dE/ dl = 10^{-2} N n the negative z-direction i.e., opposite to the direction of electric field. Hence, the angle between electric field and dipole moment is 180o.
Torque (τ) is given by the relation,
τ = pEsin180^0= 0
Therefore, the torque experienced by the system is zero.
9.Two charges q and –3q are placed fixed on x-axis separated by distance 'd'. Where should a third charge 2q be placed such that, it will not experience any force?

Ans : $\frac{d}{2}$ +1) to the left of q.

Hint : K 2q2 / x2 = K 6 q2/ (x+d)2

10.A hollow cylindrical box of length 1m and area of cross-section 25 cm^2 is placed in a three-dimensional coordinate system as shown in the figure. The electric field in the region is given by $\vec{E}$ =50xi, where E is in NC^{-1} and x is in meters. Find (i) net flux through the cylinder (ii) charge enclosed by the cylinder.



Ans : (i) 0.125 Nm^2/ C
(ii) 1.107 x 10^{-12} C

11.Two small identical electrical dipoles AB and CD, each of dipole moment 'p' are kept at an angle of 120° as shown in the figure. What is the resultant dipole moment of this combination? If this system is subjected to electric field (E) directed along + X direction, what will be the magnitude and direction of the torque acting on this?
Hint : Use parallelogram law of vector addition for dipole moment. And then, τ = p x E
Derive an expression for time period of rotation of dipole in uniform electric field.
Derive an expression for the Field due to a uniformly charged infinite plane sheet.
Derive an expression for the field of an electric dipole for points on the equatorial plane.

5 MARK QUESTION

Two charged particles of masses 4m and m and having charges 3q and q are placed in uniform electric field, they are allowed to move for 2 second. Find the ratio of their kinetic energies.
Ans : K2 = 36 K1
Hint : Use equations of motion and K.E = ½ mv2

Chapter-02: Electrostatic Potential and Capacitance

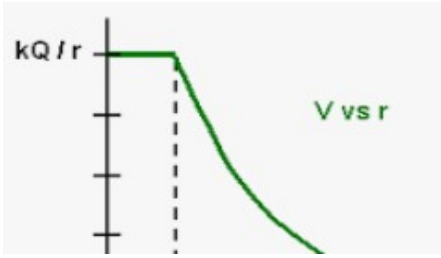
• Electrostatic Potential at a Point:

$$ElectricPotential(V) = \frac{Workdone(W)}{Charge(q)}$$

Its SI unit is volt (V) and 1V = 1 J/C.

• Electrostatic Potential due to a Charge at a Point:

$$V(r) = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$$



• **Electric potential at any point due to a system of n-point charges $q_1, q_2 \ldots\ldots q_n$ with position vectors $r_1, r_2 \ldots\ldots r_n$ the potential at a point P is given by the superposition principle,**

$$V(r) = \frac{1}{4\pi\varepsilon_0}\left(\frac{q_1}{r_1} + \frac{q_2}{r_2} + \frac{q_3}{r_3} + \cdots \ldots\ldots\ldots + \frac{q_n}{r_n}\right)$$

Where r_1 is the distance betweenq_1, and P, as and so on

• **The electric potential on the perpendicular bisector, i.e. in equatorial plane due to an electric dipole is zero.**

• **Potential Energy of a Charge q in an External Potential:**

$$U = q * V(r)$$

• **Potential Energy of a Dipole of Dipole Moment p in a Uniform Electric Field:**

$$U = -p.E = -pECos\theta$$

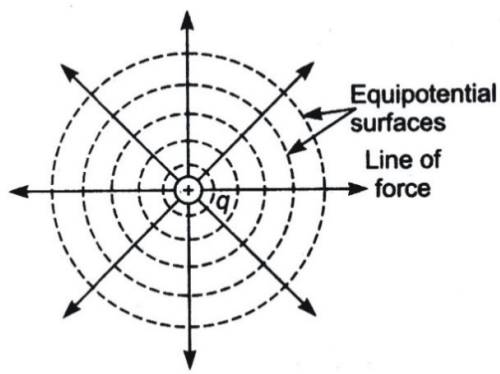
• **Equipotential Surface:**

An equipotential surface is a surface over which potential has a constant value.

a) For a point charge, concentric spheres centered at a location of the charge are equipotential surfaces.

b) The electric field E at a point is perpendicular to the equipotential surface through the point.

c) E is in the direction of the steepest decrease of potential.



• **Capacitance C of a System of Two Conductors Separated by an Insulator:**

It is defined as,

$$C = \frac{Q}{V}$$

Where Q and – Q are the charges on the two conductors V is the potential difference between them.

• **Capacitance is determined purely geometrically, by the shapes, sizes, and relative positions of the two conductors.**

• **SI unit of capacitance is farad (F).**

• **Capacitance C of a parallel plate capacitor (with vacuum between the plates):**

$$C = E_0\frac{A}{d}$$

where A is the area of each plate and d the separation between them.

• **For capacitors in the series combination:The total capacitance C is**

$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + \cdots \ldots\ldots$$

• **For capacitors in the parallel combination:**
The total capacitance C is

$$C = C_1 + C_2 + C_3 + \cdots$$

• **The energy U stored in a capacitor of capacitance C, with charge Q and voltage V:**

$$U = \frac{1}{2} Q * V = \frac{1}{2} C * V^2 = \frac{1}{2}\frac{Q^2}{C}$$

• **The electric energy density (energy per unit volume) in a region with electric field:**

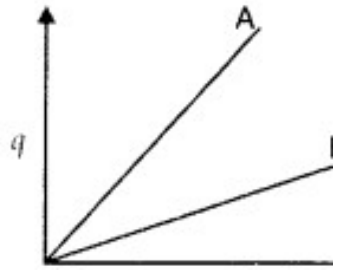
$$u = \frac{U}{A.d} = \frac{1}{2}\varepsilon_0 E^2$$

• **When the medium between the plates of a capacitor filled with an insulating substance:**
Changes observed are as follows:
(i). Polarization of the medium gives rise to a field in the opposite direction.
(ii).The net electric field inside the insulating medium is reduced.
(iii). Potential difference between the plates is thus reduced.
(iv). Capacitance C increases from its value when there is no medium (vacuum). Where K is the dielectric constant of the insulating substance.
• **Electrostatic Shielding: As we know that electrostatic field inside a conductor is zero, we use this properly to protect certain object from high electric fields by placing them inside a hollow conductor. This property is called electrostatic shielding.**

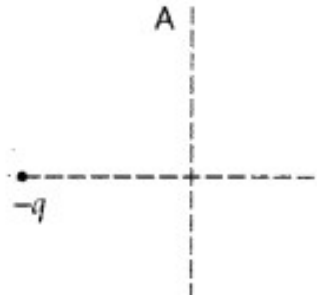
PRACTICE QUESTION

One Mark Question
1. Work done to bring a unit positive charge unaccelerated from infinity to a point inside electric field is called…….
Hint: Electric Potential
2. What is the direction of Electric field with respect to equipotential surface?
Hint: Normal/Perpendicular
3. A parallel plate capacitor C has a charge Q. The actual charges on the plates are
(a)Q,Q (b)Q,-Q (c)Q/2,-Q/2 (d) Q/2,Q/2
Hint: (b)
4. Electric field and electric potential inside a charged spherical shell
(a) E = 0; V = 0 (b) E = 0; V ≠ 0 (c) E ≠ 0; V = 0 (d) E ≠ 0; V ≠ 0
Hint: (b)
Two Mark Question
5. Why is there no work done in moving a charge from one point to another on an equipotential surface?
Hint: Potential Difference between any two points on equipotential is zero.
6. Why do the equipotential surfaces due to a uniform electric field not intersect each other?
Hint: They can't intersect each other because two different equipotential surface have different electric potential, so if they intersect then the point point of intersection will have two different potential at the same point which is not possible.
7. Two capacitor of capacitance $2\mu F$ are connected in series. What will be the equivalent capacitance?
Hint: $1\mu F$
8. Two conducting spheres A and B of radii a & b respectively are at the same potential. Calculate the ratio of surface charge densities of A and B.
Hint: b/a
9. Calculate the potential due to a dipole of dipole moment 3.5×10^{-11}C/m at a distance 0.5m from it
(a) On its axis
(b) On its perpendicular bisector
Hint: (a) 1.26 V (b) 0

10. Net capacitance of three identical capacitors in series is 1 μF. What will be their net capacitance if connected in parallel? Find the ratio of energy stored in the two configurations if they are both connected to the same source.
Hint: 9 μF, 1/9.
11. Two equal balls having equal positive charge 'q' coulombs are suspended by two insulating strings of equal length. What would be the effect on the force when a plastic sheet is inserted between the two?
Hint: The force would be reduced by a factor 'K'
12. The given graph shows variation of charge 'q' versus potential difference 'V' for two capacitors C1 and C2. Both the capacitors have same plate separation but plate area of C2 is greater than that of C1. Which line (A or B) corresponds to C1 and why?

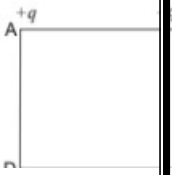


Hint: Line B correspond to C1
13. A charge 'q' is moved from a point A above a dipole of dipole movement 'p' to a point B below the dipole in equatorial plane without acceleration. Find the work done in the process.



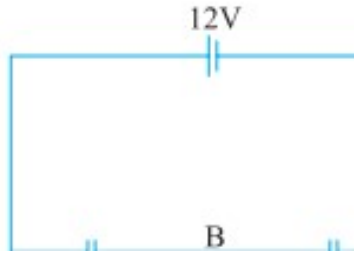
Hint: No work is done
[W = q V_{AB} = q × 0 = 0, since potential remains constant]
14. Why must the electrostatic potential inside a hollow charged conductor be the same at every point?
Hint: Inside the hollow charged conductor, electric field is zero
15. 15 identical mercury drops are charged to a same potential of 5 Volts. Assuming the drops to be of spherical shape, find the potential of the large drop, made up of the combination of all the charged drops.
Hint: 30.4 V

16.Four charges +q, – q, + q and – q are to be arranged respectively at the four corners of a square ABCD of side 'a'.
Find the work required to put together this arrangement.



Hint: $\frac{1}{4\pi\varepsilon_0}\frac{q^2}{a}\left(\sqrt{2}-4\right)$
17. A charge q_0 is brought to the Centre of the square, the four charges being held fixed. How much extra work is needed to do this?
Hint: 0
18. A cube of side b has a charge q at each of its vertices. Determine the potential and electric field due to this charge array at the centre of the cube.
Hint: $V = \frac{4q}{\sqrt{3}\pi\varepsilon_0 b}$, **0**
19. A charge of 8 mC is located at the origin. Calculate the work done in taking a small charge of –2 × 10^{-9} C from a point P (0, 0, 3 cm) to a point Q (0, 4 cm, 0), via a point R (0, 6 cm, 9 cm).
Hint: $W = 1.27J$

20. Find the potential at A and C in the following circuit :

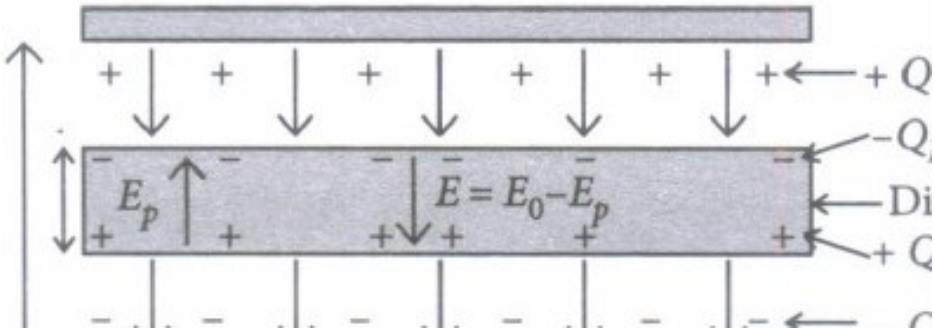


Hint: 10V, -2V

21. A point charge develops an electric field of 40 N/C and a potential difference of 10 J/C at a point. Calculate the magnitude of the charge and the distance from the point charge.

Hint: 2.9 × 10- C, 25 cm

A dielectric slab is a substance that does not allow the flow of charges through it but permits them to exert electrostatic forces on one another. When a dielectric slab is placed between the plates, the field ε_0 polarizes the dielectric. This induces charge $-Q_P$ on the upper surface and $+Q_P$ on the lower surface of the dielectric. These induced charges set up a field E_p inside the dielectric in the opposite direction of E_0as shown.



22. In a parallel plate capacitor, the capacitance increases from 4μF to 80μF on introducing a dielectric medium between the plates. What is the dielectric constant of the medium?

(a)10 (b) 20 (c)50 (d) 100

Hint: (b) 20

23. A parallel plate capacitor with air between the plates has a capacitance of 8 pF. The separation between the plates is now reduced half and the space between them is filled with a medium of dielectric constant 5. Calculate the value of capacitance of the capacitor in second case.

(a) 8pF (b) 10pF (c) 80pF (d) 100pF

Hint: (c) 80pF

24. A dielectric introduced between the plates of a parallel plate condenser

(a) Decreases the electric field between the plates (b) Increases the capacity of the condenser

(c) Increases the charge stored in the condenser (d) Increases the capacity of the condense

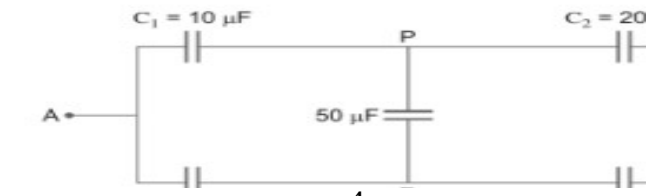
Hint: (d)

25. A parallel plate capacitor of capacitance 1 pF has separation between the plates is d. When the distance of separation becomes 2d and wax of dielectric constant x is inserted in it the capacitance becomes 2 pF. What is the value of x

(a) 2 (b) 4 (c) 6 (d) 8

Hint: (b)

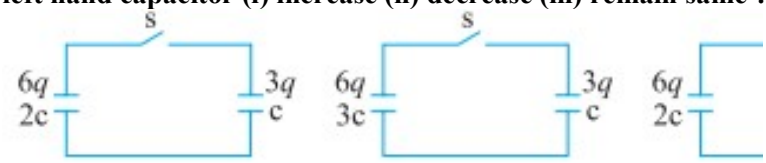
26. Calculate the equivalent capacitance between points A and B in the circuit below. If a battery of 10 V is connected across A and B, calculate the charge drawn from the battery by the circuit.



Hint: $C_{eq} = 10\mu F, Q = 10^{-4}C$

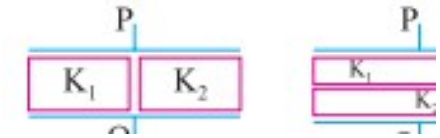
27. A cell of e.m.f. 'E' and internal resistance 'r' is connected across a variable resistor 'R'. Plot a graph showing the variation of terminal potential 'V' with resistance 'R'. Predict from the graph the condition under which 'V' becomes equal to 'E'.

28. Figure shows three circuits, each consisting of a switch and two capacitors initially charged as indicated. After the switch has been closed, in which circuit (if any) will the charges on the left hand capacitor (i) increase (ii) decrease (iii) remain same ?



Hint: 1 remains unchanged, 2 increases, 3 decreases.

29. You are given an air filled parallel plate capacitor. Two slabs of dielectric constants K1 and K2 having been filled in between the two plates of the capacitor as shown in Fig. What will be the capacitance of the capacitor of initial area was A distance between plates d

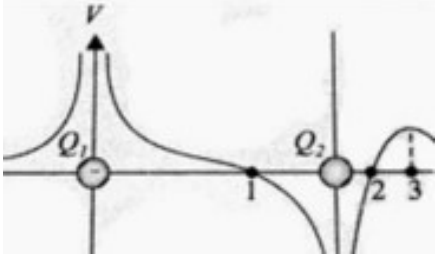


Hint: C1=(k1+k2)Co, C2= Co K1K2/(K1+K2)

30. Two metal spheres A and B of radius r and 2r whose centres are separated by a distance of 6r are given charge Q, are at potential V1 and V2. Find the ratio of V1/V2. These spheres are connected to each other with the help of a connecting wire keeping the separation unchanged, what is the amount of charge that will flow through the wire?

Hint: V1/V2 =7/4, q/3

The potential at any observation point P of a static electric field is defined as the work done by the external agent (or negative of work done by electrostatic field) in slowly bringing a unit positive point charge from infinity to the observation point. Figure shows the potential variation along the line of charges. Two-point charges Q1 and Q2 lie along a line at a distance from each other.



31. At which of the points 1, 2 and 3 is the electric field is zero?

(a) 1 (b) 2 (c) 3 (d) both (a) and (b)

Hint: (c)

32. The signs of charges Q1 and Q2 respectively are

(a) Positive and negative (b) negative and positive

(c) Positive and positive (d) negative and negative

Hint: (a)

33. Which of the two charges Q1 and Q2 is greater in magnitude?

(a) Q1 (b) Q 2 (c) cannot determine (d) same

Hint: (a)

34. Which of the following statement is not true?

(a)Electrostatic force is a conservative force.

(b) Potential at a point is the work done per unit charge in bringing a charge from infinity to that point in an electric field. (c)Electrostatic force is non-conservative.

(d)Potential is the ratio of work to charge.

Hint: (c)

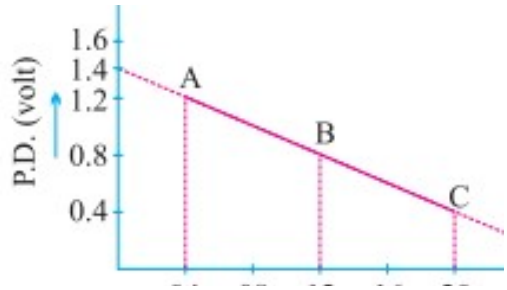
35. The current flowing through a conductor is 2mA at 50V and 3mA at 60V. Is it an ohmic or non-ohmic conductor? Give reason.

Hint: non-ohmic

36. Three concentric spherical metallic shells A < B < C of radii a, b, c (a < b < c) have surface densities σ, – σ and σ respectively. Find the potential of three shells A, B and C (ii). If shells A and C are at the same potential obtain relation between a, b, c.

Hint: c=a+b

37. Potential difference across terminals of a cell are measured (in volt) against different current (in ampere) flowing through the cell. A graph was drawn which was a straight line ABC. Using the data given in the graph. Determine (i) the emf. (ii) The internal resistance of the cell.

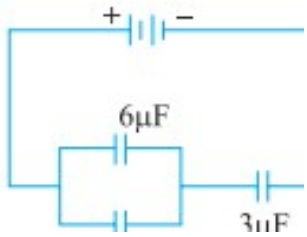


Hint: r = 5Ω emf = 1.4V

38. The charge passing through a conductor is a function of time and is given as q = $2t^2$ – 4t + 3 milli coulomb. Calculate (i) current through the conductor (ii) potential difference across it at t = 4 second. Given resistance of conductor is 4 ohm

Hint: I = 12A, V = 48 V

39. In the following arrangement of capacitors, the energy stored in the 6μF capacitor is E. Find: (i) Energy stored in 12 μF capacitors. (ii) Energy stored in 3μF capacitor. (iii) Total energy drawn from the battery.



Hint: (i)2E (ii) 18E (iii) 21E

CURRENT ELECTRICITY

Important Formulae

1. Electric current = $\frac{Charge}{Time}$ or I = $\frac{q}{t} = \frac{ne}{t}$

2. In case of an electron revolving in a circle of radius r with speed v, period of revolution is T = $\frac{2\pi r}{v}$

Frequency of revolution, v = $\frac{1}{T} = \frac{v}{2\pi r}$, Current, I = ev = $\frac{ev}{2\pi r}$

3. Ohm's law, R = $\frac{v}{I}$ or V = IR

4. Current in terms of drift velocity (V_d) is I = enAv_d

5. Resistance of a uniform conductor, R = $\rho \frac{l}{A} = \frac{ml}{ne^2\tau A}$

6. Resistivity or specific resistance, $\rho = \frac{RA}{l} = \frac{m}{ne^2\tau}$

7. Conductance = $\frac{1}{R}$

8. Conductivity = $\frac{1}{Resistivity}$ or σ = $\frac{1}{\rho} = \frac{l}{RA}$

9. Current density = $\frac{Current}{Area}$ or j = $\frac{I}{A}$ = env_d

10. Relation between current density and electric field,
j = σ E or E = ρ j

11. Mobility μ = $\frac{V_d}{E}$

12. Temperature coefficient of resistance, α = $\frac{R_2 - R_1}{R_1(t_2 - t_1)}$

13. EMF of a cell, E = $\frac{W}{q}$

14. For a cell of internal resistance r, the emf is E = V + Ir = I (R + r)

15. Terminal potential potential of a cell, V = IR = $\frac{E\,R}{R+r}$

16. Terminal p.d. when a current is being drawn from the cell, V = E – Ir

17. Terminal p.d. when the cell is being charged, V = E + Ir

18. Internal resistance of a cell, r = R [$\frac{E-V}{V}$]

19. For n cell in series, I = $\frac{nE}{R+nr}$

20. For n cells in parallel, I = $\frac{nE}{nR+r}$

21. Heat produced by electric current, H = I^2Rt joule = $\frac{I^2 Rt}{4.18}$ cal

22. Electric power, P = $\frac{W}{t}$ = VI = I^2R = $\frac{V^2}{R}$

23. Electric energy, W = Pt = VIt = I^2Rt

24. For a balanced Wheatstone bridge, $\frac{P}{Q} = \frac{R}{S}$,

If X is the unknown resistance $\frac{P}{Q} = \frac{R}{X}$ or X = $\frac{RQ}{P}$

25. Kirchhoff's law of electrical networks-

(i) Σ I = 0 (Junction Rule)

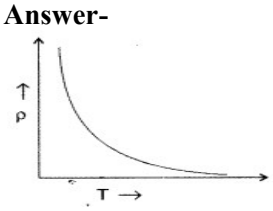
i.e. Total incoming current = Total outgoing current

(ii) Σ E = Σ IR (Loop Rule)

PRACTICE QUESTIONS

Q.1. Show on a graph the variation of resistivity with temperature for a typical semiconductor.

Answer-



Resistivity of a semi conductor decreases rapidly with temperature.

Q.2. Define the term 'Mobility' of charge carriers in a conductor.

Answer- Mobility of charge carriers is defined as the magnitude of the drift velocity per unit

electric field E.

$$\therefore \quad \mu = \left|\frac{V_d}{E}\right| = \frac{e\tau}{m}$$

Q.3. Write any two factors on which internal resistance of a cell depends.
Answer- The internal resistance of a cell depends on:
(i) distance (l) between electrodes.
(ii) area (A) of immersed part of electrode, and
(iii) nature and concentration of electrolyte.
Q.4. A resistance R is connected across a cell of emf e and internal resistance r. A potentiometer now measures the potential difference between the terminals of the cell as V. Write the expression for 'r' in terms of E, V and R.
Answer- r = $\left(\frac{E-V}{V}\right)R$
Understanding Based Problems (1X2, 2X4, 3X2)
Q.5. What happens to the power dissipation if the value of electric current passing through a conductor of constant resistance is doubled.
Answer- P = I^2 **R. When electric current is doubled** $I' = 2$ **I**
Power becomes $P' = I'$ **2R = 4** I^2 **R = 4P**
Q.6. What is the largest voltage you can safely put across a resistor marked 98 Ω - 0.5 W?

Answer- V = $\sqrt{PR}$ **= 7Volt.**
Q.7. When electrons drift in a metal from lower to higher potential, does it mean that all the free electrons of the metal are moving in the same direction?
Answer
No, only the drift velocities of the electrons are superposed over their random (haphazard) thermal velocities. The solid line shows the random path followed by a free electron in the absence of an external field. The electron proceeds from A to B, making six collisions on its path. The dotted curve shows how the random motion of the same electron gets modified when an electric field is applied.
Q.8. Define drift velocity. Write its relationship with relaxation time in terms of the electric field E applied to a conductor. A potential difference V is applied to a conductor of length L. How is the drift velocity affected when V is doubled and L is halved?
ANSWER: Drift velocity is defined as the average velocity with which the free electrons get drifted towards the positive end of the conductor under the influence of an external electric field applied. It is given by

$$v_d = \frac{eV\tau}{mL}$$

When V is doubled and L is halved, the drift velocity becomes 4 times.
Q.9. What is meant by drift velocity of free e' s. Derive ohm's law on the basis of the theory of electron drift.
ANSWER: Drift velocity - The average velocity with which free electrons of a conductor get driftedin a direction opposite to the direction of applied electric field.

$$v_d = \frac{eE}{m}\tau = \frac{eV}{ml}\tau$$

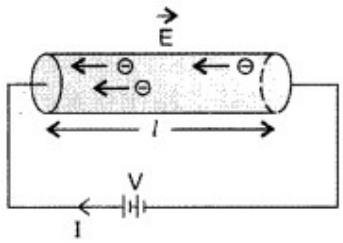
Current $I = neAv_d = \frac{ne^2A\tau}{ml}V \Rightarrow \frac{V}{I} = \frac{m}{ne^2\tau}\frac{l}{A}$
At a constant temperature, RHS of above equation is constant for a given conductor.

$$\therefore \frac{V}{I} = \frac{m}{ne^2\tau}\frac{l}{A} = \text{Constant (R)} \Rightarrow V \ \alpha \ I$$

Q.10. The I-V characteristics of a resistor are observed to deviate from a straight line for higher values of current as shown below. Why?

ANSWER: At higher values of current, large heat (i^2Rt) is produced which increases the temperature of resistor. Due to this its resistance increases and it becomes non-ohmic.

Q.11. Explain the term 'drift velocity' of electrons in a conductor. Hence obtain the expression for the current through a conductor in terms of 'drift velocity'
Answer:
Definition- Drift velocity is defined as the velocity with which free electrons in a conductor get drifted in a direction opposite to the direction of the applied field. Its unit is ms-1 and dimensions $[LT^{-1}]$

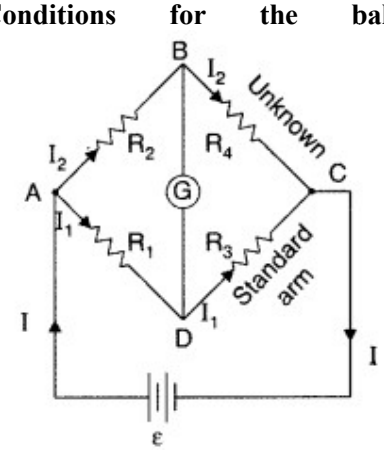


Expression : The magnitude of electric field set up across the conductor is given by
E = Vl
Let n be the number of free electrons per unit volume of the conductor. Then, total number of free electrons in the conductor = n × Volume of the conductor
Hence, Q = (nAl)e
Time taken by the charge to cross the conductor length l is given by

$$t = \frac{l}{v_d} \quad \text{where } [v_d \text{ is drift velocity of electrons}$$

$$\therefore \quad I = \frac{Q}{t} = \frac{nAle}{\frac{l}{v_d}} = neAv_d \quad \therefore \boxed{I = neAv_d}$$

Q.12. Use Kirchhoff's rules to obtain conditions for the balance condition in a Wheatstone bridge.
Answer-
Conditions for the balance condition in a Wheatstone bridge :



Applying Kirchhoff's loop rule to closed loop ADBA,

$$-I_1R_1 + 0 + I_2R_2 = 0 \quad (I_g = 0) \quad \ldots(i)$$

For loop CBDC,

$$-I_2R_4 + 0 + I_1R_3 = 0 \quad (I_g = 0) \quad \ldots(ii)$$

From equation, (*i*)

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

From equation, (*ii*)

$$\frac{I_1}{I_2} = \frac{R_4}{R_3} \quad \therefore \quad \frac{R_2}{R_1} = \frac{R_4}{R_3} \quad \text{or} \quad \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

This is the required balance condition in a Wheatstone bridge arrangement.
Application Based Problems (2X2, 3X3)

Q.13. Two conducting wires X and Y of same diameter across a battery. If the number density of electro in X is twice that in Y, find the ratio of drift velocity of electrons in the two wires.
Answer:

$$I = neA\, v_d \qquad \therefore \frac{v_{d_x}}{v_{d_y}} = \frac{n_y}{n_x}$$

$$\text{As } n_x = 2n_y \qquad \therefore \frac{v_{d_x}}{v_{d_y}} = \frac{1}{2}$$

Q.14. A battery of emf 6 V and internal resistance 2Ω is connected to a resistor. If the current in the circuit is 0.25 A, find
(i) the resistance of the resistors;
(ii) the terminal voltage of the battery.
Answer:

(*i*) **Given :** Current, I = 0.25 A, emf, $\bar{\varepsilon}$ = 6V,
internal resistance, $r = 2\ \Omega$

$$\text{As } I = \frac{\varepsilon}{r+R} \qquad \Rightarrow 0.25 = \frac{6}{2+R}$$

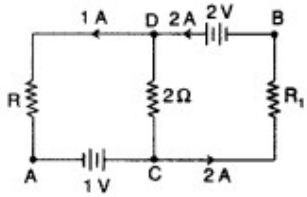
$$\Rightarrow 2 + R = \frac{600}{25} = 24$$

$\therefore$ ***Resistance,*** R = 24 – 2 = **22 Ω**

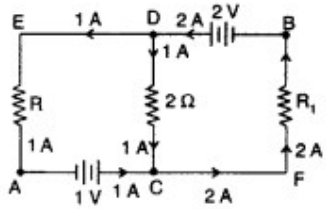
(*ii*) As V = IR $\qquad \therefore V = \frac{25 \times 22}{100} = \frac{22}{4} = 5.5$ V

$\therefore$ ***Terminal voltage,*** V = **5.5 V**

Q.15. In the given circuit, assuming point A to be at zero potential, use Kirchhoff's rules to determine the potential A at point B.



Answer:
Applying Kirchhoff's law by moving along ACDE,
we get,



Q.16. Estimate the average drift speed of conduction electrons in a copper wire of cross-sectional area 1.0 × 10 -7 m2 carrying a current of 1.5 A. Assume the density of conduction electrons to be 9 × 1028 m-3.

Answer:

Given : $A = 1.0 \times 10^{-7}\ m^2$, $I = 1.5\ A$,
$n = 9 \times 10^{28}\ m^{-3}$, $V_d = ?$
We know, $I = neAV_d$

$$\therefore \quad V_d = \frac{I}{neA} = \frac{1.5}{(9\times10^{28})\times(1.6\times10^{-19})(1.0\times10^{-7})}$$

$$\mathbf{V_d = 10.4 \times 10^{-4}\ m/s}$$

Q.17. Two cells of emfs 1.5 V and 2.0 V having internal resistance 0.2 Ω and 0.3 Ω espectively are connected in parallel. Calculate the emf and internal resistance of the equivalent cell.
Answer:
Given: E1 = 1.5 V, E2 = 2.0 V,

$r_1 = 0.2\ \Omega$, $r_2 = 0.3\ \Omega$

E = ?, r = ? (when two cells are connected in parallel)

$$E = \frac{E_1r_2 + E_2r_1}{r_1 + r_2}$$

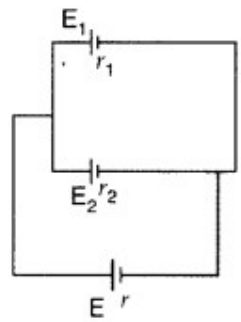
$$= \frac{1.5\times0.3 + 2\times0.2}{0.2+0.3}\ V$$

$$= \frac{0.45\times0.40}{0.5}\ V = \mathbf{1.7\ V}$$

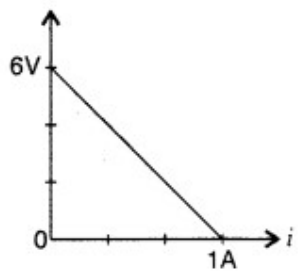
$$r = \frac{r_1r_2}{r_1+r_2}$$

$$= \frac{0.2\times0.3}{0.2+0.3}\ \Omega = \frac{0.06}{0.5}\ \Omega$$

$$= \mathbf{0.12\ \Omega}$$



Q.18. The plot of the variation of potential difference across a combination of three identical cells in series, versus current is as shown in the figure. What is the emf of each cell?



Answer
Total emf of three cells in series = P.D. corresponding to zero current = 6V
∴ The emf of each cell = $\frac{6}{3}$ = 2V

Q.19. Define current sensitivity and voltage sensitivity of a galvanometer. Increasing the current sensitivity may not necessarily increase the voltage sensitivity of a galvanometer. Justify.
Answer
Current sensitivity is defined as the deflection produced in the galvanometer when unit current is passed through its coil.

$$I_s = \frac{\theta}{I} = \frac{nBA}{k}\ \text{radian/ampere or division } A^{-1}$$

...where [n = Number of turns in the galvanometer.
k = Restoring couple per unit twist or torsional constant.

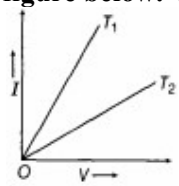
Voltage sensitivity is defined as the deflection produced in the galvanometer when unit voltage is applied across the coil of the galvanometer.

$$V_s = \frac{\theta}{V} = \frac{nBR}{kR} \text{ radian/volt or div. } V^{-1}$$

...where [R = Resistance of the coil

Since Vs = Is X R, increase in current sensitivity may not necessarily increase the voltage sensitivity. It may be affected by the resistance used.

Q.20. I-V graph for a metallic wire at two different temperatures T1 and T2 is as shown in the figure below. Which of the two temperature is lower and why?

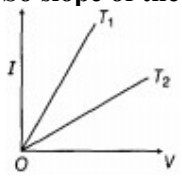


Answer

To solve this problem we will use ohm's law which states that V = I X R

1/ R = I/ V

So slope of the graph is inversely proportional to resistance. Consider the figure,



Since, slope of 1 > slope of 2.

I1/ V1 > I2/ V2 ⇒ V2/ I2 > V1/ I1

R2 > R1

∵ V/ I = R

Also, we know that resistance is directly proportional to the temperature.

as R2 > R1

Therefore, T2 > T1.

Q.21. A cell of emf E and internal resistance r is connected to two external resistances R1 and R2 and a perfect ammeter. The current in the circuit is measured in four different situations:

(i) without any external resistance in the circuit

(ii) with resistance R2 only

(iii) with R1 and R2 in series combination

(iv) with R1 and R2 in parallel combination

The currents measured in the four cases are 0.42A, 1.05A, 1.4A and 4.2A, but not necessarily in that order. Identify the currents corresponding to the four cases mentioned above.

Answer:

(i) $i = \frac{\varepsilon}{r}$; Hence $i = 4.2$ A

(ii) $i = \frac{\varepsilon}{R_1 + r}$; Hence $i = 1.05$ A

(iii) $i = \frac{\varepsilon}{r + R_1 + R_2}$; Hence $i = 0.42$ A

(iv) $i = \frac{\varepsilon}{r + \frac{R_1 R_2}{R_1 + R_2}}$; Hence $i = 1.4$ A

As $R_2 > R_1$, these resistances in increasing order are: r, $r + \frac{R_1 R_2}{R_1 + R_2}$, $r + R_1$, $r + R_1 + R_2$

The currents in decreasing order are :

4.2 A, 1.05 A, 0.42 A, 1.4 A.

Q.22. State the reason, why GaAs is most commonly used in making of a solar cell.

Answer- GaAs (gallium arsenide) is most commonly used in making of a solar cell because it absorbs relatively more energy from the incident solar radiation being of relatively higher absorption coefficient.

Q.23. Two wires of equal length, one of copper and the other of manganin have the same resistance. Which wire is thicker?

Answer:

As $R = \frac{\rho l}{A}$ $\therefore A = \frac{\rho l}{R}$

For both wires R and l are same and ρ copper < p manganin.

∴ A copper < A manganin

i.e. Manganin wire is thicker than copper wire.

Q.24. (a) Why do the 'free electrons', in a metal wire, 'flowing by themselves', not cause any current flow in the wire?

Define 'drift velocity' and obtain an expression for the current flowing in a wire, in terms of the 'drift velocity' of the free electrons.

(b) Use the above expression to show that the 'resistivity', of the material of a wire, is' inversely proportional to the 'relaxation time' for the 'free electrons' in the metal.

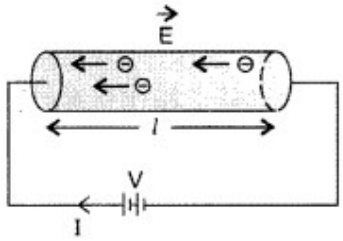
Answer:

(a) (i) The free electrons, in a metal, (flowing by themselves), have a random distribution of their velocities. Hence the net charge crossing any cross section in a unit time is zero.

(ii) The drift velocity equals the average (time dependent) velocity acquired by free electrons, under the action of an applied (external) electric field.

(iii) Expression for current in terms of drift velocity-

Definition : Drift velocity is defined as the velocity with which free electrons in a conductor get drifted in a direction opposite to the direction of the applied field. Its unit is ms-1 and dimensions [LT-1]



Expression : The magnitude of electric field set up across the conductor is given by E = Vl

Let n be the number of free electrons per unit volume of the conductor. Then, total number of free electrons in the conductor

= n × Volume of the conductor
Hence, Q = (nAl)e
Time taken by the charge to cross the conductor length l is given by

$$t = \frac{l}{v_d} \quad \text{where } [v_d \text{ is drift velocity of electrons}$$

$$\therefore \quad I = \frac{Q}{t} = \frac{nAle}{\frac{l}{v_d}} = neAv_d \quad \therefore \boxed{I = neAv_d}$$

(b) We know from above

$$I = -neA\, v_d; \qquad \ldots(i)$$

$$\text{Also we know, } v_d = \left(\frac{e\vec{E}}{m}\right)\tau \qquad \ldots(ii)$$

Putting the value of v_d in equation (*i*) from equation (*ii*) we have

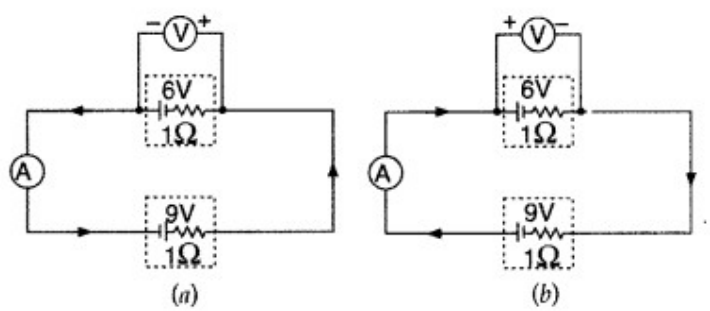
$$I = -neA\frac{eE}{m}\tau \qquad \left[\because E = \frac{V}{l}\right.$$

$$\text{or} \quad \frac{E}{I} = -\frac{m}{ne^2A\tau} \qquad \left[\because \rho = \frac{RA}{l}\right.$$

$$\rho = -\frac{m}{ne^2\tau}$$

$$\rho \propto \frac{1}{\tau}$$

Creativity Based Problems (2X2, 3X1)
Q.25. In the two electric circuits shown in the figure, determine the reading of ideal ammeter (A) and the ideal voltmeter (V).



Answer:
(i) In circuit (a)
Total emf = 15 V, Total Resistance = 2Ω

$$\text{Current, } i = \left(\frac{15}{2}\right)\text{A} = 7.5 \text{ A}$$

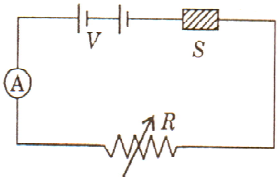
Potential difference between the terminals of 6 V battery
V = E – iR = [6 – (7.5 × 1) = -1.5 V
(ii) In circuit (b)
Effective emf = (9 – 6)V = 3V,
Total Resitance = 2Ω

$$\text{Current, } i = \left(\frac{3}{2}\right)\text{A} = 1.5 \text{ A}$$

Potential Difference across 6 V cell,
V = E – (- I)R = V + IR

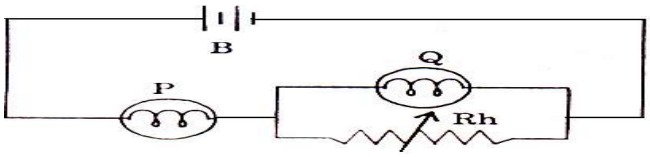
(∵ Current is in opposite direction to 6 V cell)
= 6 + 1.5 × 1 = 7.5 V

Q.26. Would you increase or decrease the value of R to keep the reading of ammeter constant, when semiconductor S is heated? Give reason.



A: When semiconductor S is heated, its resistance decreases. Therefore the effective resistance of circuit decreases and current tends to increase. To keep the reading of ammeter constant, the value of 'R' should be increased.

Q.27. B - Battery, P and Q - identical lamps, Rh - Rheostat
What will happen to the brightness of the lamps, if the resistance through the rheostat is increased? Why?



Answer- Battery voltage = Sum of potential drop across P and Q = Constant
On increasing the resistance through rheostat, the resistance of circuit increases and current in the circuit decreases. Therefore the brightness of lamp 'P' decreases but the brightness of lamp 'Q' increases because the potential difference across it increases due to the decrease in potential difference across lamp 'P'.

Q.28. The resistance of a metallic conductor increases due to
a. Change in dimensions of the conductor B.b. Change in carrier density
c. Increase in the number of collisions between the carriers
d. Increase in the rate of collisions between the carriers and vibrating atoms of the conductor
Answer
d) Increase in the rate of collisions between the carriers and vibrating atoms of the conductor
Explanation: When temperature increases, the thermal speed of the electrons increases as well as, the amplitude of vibration of the positive ions inside the metal conductor also increase, about their mean positions. Thus, the collisions between the electrons and the positive metal ions become more frequent and this decreases the relaxation time, t, leading to an increase in the resistivity of the conductor.

Q.29. According to Kirchhoff's Loop Rule
a. The absolute sum of changes in potential around any closed loop must be zero.
b. The algebraic sum of changes in potential around any closed loop must be zero.
c. The algebraic sum of changes in potential around any closed loop must be positive.
d. The algebraic sum of changes in potential around any closed loop must be negative.
Answer
b) The algebraic sum of changes in potential around any closed loop must be zero.
Explanation: Kirchhoff's loop rule is based on the principle of conservation of energy. Since work done in transporting a charge in a closed loop is zero. The algebraic sum (since potential differences can be both positive and negative) of potential differences around any closed loop is always zero.

Q.30. A steady current flows in a metallic conductor of non-uniform cross-section. Which of these quantities is constant along the conductor-
a. Current b. current density c. drift speed d. electric field
Answer
a) Current is constant along a conductor

Q.32. Figure shows two circuits in each having a galvanometer and a battery of 3 V. When the galvanometers in each arrangement do not show any deflection, obtain the ratio $R_1 : R_2$.

Answer- 1:6

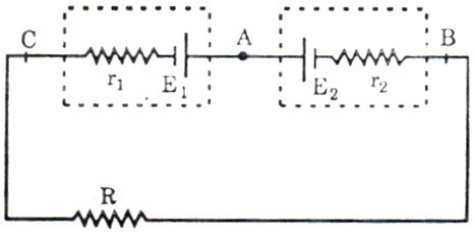
Q.33. Out of the two bulbs marked 25W and 100W, which one has higher resistance.

Answer- R = V2/P $\Rightarrow$ R α 1/P .

The bulb marked 25W has higher resistance than the bulb marked 100W.

Q.34. E1 = 2V, E2 = 4V, r1 = 1Ω, r2 = 2Ω, R = 5Ω

Calculate (i) current (ii) p.d. between B and A (iii) p.d. between A and C.



Answer- Net emf = E2 – E1 = 2V, Total resistance = R+ r1 + r2 = 0.25A

(i) I = 0.25A (ii) VAB = E2- Ir2 = 3.5V (iii) VAC = E1+ Ir1 = 2.25V

Q.35. A room has AC run for 5 hours a day at a voltage of 220V. The wiring of the room consists of Cu of 1 mm radius and a length of 10m. Power consumption per day is 10 commercial units. What fraction of it goes in the joule heating in the wires? What would happen if the wiring is made of Al of the same dimensions? [ρCu = 1.7 x 10-8 Ωm, ρAl = 2.7 x 10-8 Ωm]

Answer-

Power consumption = 2 units/ hour = 2kW = 2000 J/s

I = P/ V = 9A

Power loss in wire = I2R = I2ρl/ A = 4 J/ s = 0.2% of total power consumption

Power loss in Aluminium wire = 4 ρCu/ ρAl = 6.4 J/ s = 0.32 % of total power consumption

Q.36. Calculate the temperature at which the resistance of a conductor becomes 20% more than its resistance at 270C. The value of the temperature coefficient of resistance of the conductor is 2 x 10-4 / K.

Answer- $R_2 = R_1[1+\alpha(T_2 - T_1)] \Rightarrow R + 0.2R = R[1 + 2\times10^{-4}(T_2 - 300)] \Rightarrow T_2 = 1300K$

Q.37. Case Study Problem

Whenever an electric current is passed through a conductor, it becomes hot after some time. The phenomenon of the production of heat in a resistor by the flow of an electric current through it is called heating effect of current or Joule heating. Thus, the electrical energy supplied by the source of emf is converted into heat. In purely resistive circuit, the energy expended by the source entirely appears as heat. But if the circuit has an active element like a motor, then a part of energy supplied by the source goes to do useful work and the rest appears as heat. Joule's law of heating forms the basis of various electrical appliances such as electric bulb, electric furnace, electric press etc.

(i) Which of the following is correct statement?

(a) Heat produced in a conductor is independent of the current flowing.

(b) Heat produced in a conductor varies inversely as the current flowing.

(c) Heat produced in a conductor varies directly as the square of the current flowing.

(d) Heat produced in a conductor varies inversely as the square of the current flowing.

(ii) If the coil of a heater is cut to half, what would happen to heat produced?

(a) Doubled

(b) Halved

(c) Remains same
(d) Becomes four times.
(iii) A 25 W and 100 W are joined in series and connected to the mains. Which bulb will glow brighter?
(a) 100 W (b) 25 W (c) Both bulbs will glow brighter (d) None will glow brighter
(iv) A rigid container with thermally insulated wall contains a coil of resistance 100 Ω, carrying 1 A. Change in its internal energy after 5 min will be
(a) 0 KJ (b) 10 kJ (c)20 kJ (d) 30 kJ
(v) The heat emitted by a bulb of 100 W in 1 min is
(a) 100 J (b) 1000 J (c) 600 J (d) 6000 J
Answer-
(i) c, (ii) b, (iii) b, (iv) d, (v) d

Q.38. Case Study Problem
According to Ohm's law, the current flowing through a conductor is directly proportional to the potential difference across the ends of the conductor i.e
$I \propto V \Rightarrow V/I = R$
where R is resistance of the conductor Electrical resistance of a conductor is the obstruction posed by the conductor to the flow of electric current through it. It depends upon length, area of cross-section, nature of material and temperature of the conductor.
We can write $R \propto l/A$ or $R=\rho l/A$
Where ρ is electrical resistivity of the material of the conductor.
(i) Dimensions of electric resistance is
(a) $[ML^2 T^{-2} A^{-2}]$ (b) $[ML^2T^{-3}A^{-2}]$ (c) $[M^{-1} L^{-2} T^{-1} A]$ (d) $[M^{-1}L^2T^2A^{-1}]$
(ii) If 1μA current flows through a conductor when potential difference of 2 volt is applied across its ends, then the resistance of the conductor is
(a) $2\times10^6\Omega$ (b) $3\times10^5\Omega$ (c) $1.5\times10^5\Omega$ (d) $5\times10^7\Omega$
(iii) Specific resistance of a wire depends upon
(a) length (b) cross-sectional area (c) mass (d) none of these
(iv) The slope of the graph between potential difference and current through a conductor is
(a) a straight line (b) curve
(c) first curve then straight line (d) first straight line then curve
(v) The resistivity of the material of a wire 1.0 m long, 0.4 mm in diameter and having a resistance of 2.0 ohm is
(a) $1.57\times10^{-6}\Omega m$ (b) $5.25\times10^{-7}\Omega m$ (c) $7.12\times10^{-5}\Omega m$ (d) $2.55\times10^{-7}\Omega m$
Answer-
Now, $\rho = RA/l = 2\times4\pi\times10^{-8}/1 = 2.55\times10^{-7}\Omega m$
(i) (b) (ii) (b) As $I = \varepsilon/(R+r)$
In first case, I = 0.5 A; R = 12 Ω
$0.5 = \varepsilon/(12+r) \Rightarrow \varepsilon = 6.0 + 0.5\,r$ ....(i)
In second case I = 0.25 A; R=25 Ω
$\varepsilon = 6.25 + 0.25\,r$ ...(ii)
From equation (i) and (ii), r = 1 Ω
(iii) (b) (iv) (a) Current in the circuit $I= \varepsilon/(R+r)$
Power delivered to the resistance R is P = I2R = E2R/ (R+r)2
It is maximum when dP/ dR = 0
dP/ dR = E2[(r+R)2−2R(r+R)]/ (r+R)4 = 0
or (r+R)2 = 2R(r+R) or R = r
(v) (b) For first case, $\varepsilon/(R+r) = 10/R$ ...(i)
For second case, $\varepsilon/(5R+r) = 30/5R$
Dividing (i) by (ii), we get r = 5R
From (i), $\varepsilon/(R+5R) = 10/R$,$\varepsilon = 60$ V

CHAPTER-4

(MOVING CHARGES AND MAGNETISM)

.Biot-Savart Law:

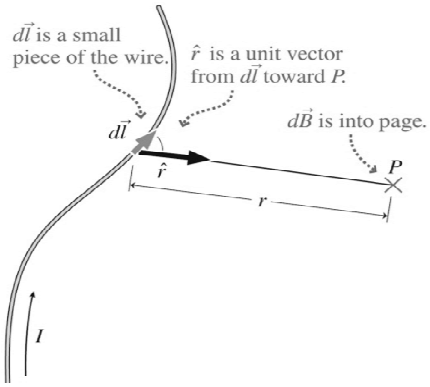
According to this law, the magnitude of magnetic field induction at a point due to a current element of length dl, carrying current I, at a distance r from the current element is given by

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{I d\vec{l} \times \vec{r}}{r^3}$$

Where μo is permeability of free space. Its value is 4π x 10^{-7}Wb/A-m

The magnitude of magnetic field is

$$B = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$$



Where Θ is the angle between current element Idl and position vector $\vec{r}$. The direction of magnetic field $\overrightarrow{dB}$ is perpendicular to the plane containing I$\overrightarrow{dl}$ and $\vec{r}$. the direction of $\overrightarrow{dB}$ is given by right hand screw rule or right hand thumb rule.

.Magnetic field induction at the centre of circular coil of radius r carrying current I:

$$B = \frac{\mu_0 nI}{2r}$$

The direction of magnetic field at the centre is perpendicular to the plane of coil.

5Magnetic field induction at a point on the axis of a circular coil carrying current is given by:

$$B = \frac{\mu_0 N I a^2}{2(a^2 + x^2)^{3/2}}$$

For N number of turns

Where a is the radius of the coil, x is the distance of the point on the axis, from the centre of coil

Ampere's circuital law:

It states that the line integral of magnetic field $\vec{B}$ along a closed path is equal to μo times the current(I) passing through the closed path.

$$\oint B.dl = \mu_0 I$$

Magnetic field induction at a point, at perpendicular distance 'a' from the axis of long linear conductor carrying current is given by:

$$B = \frac{\mu_0}{4\pi}\frac{2I}{a}$$

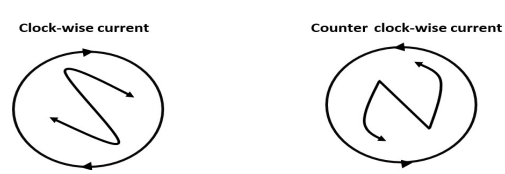
Solenoid: A solenoid consists of an insulated long wire closely wound in the form of a helix. Its length is very large as compared to its diameter.

At the axis of long solenoid, carrying a current I

B= μ_0 nI

Where n=number of turns per unit length.

Magnetic field at one end of solenoid Bend= μ_0 nI/2



Force on charge particle in electric field:

F=qE this force will act in direction of electric field. The Charge particle will describe a parabolic path if electric field is acting perpendicular or at some angle with initial direction of motion of particle.

Magnetic force on charge particle in magnetic field:

The force on charge particle moving with velocity $\vec{v}$ in the uniform magnetic field $\vec{B}$ is given by

$$\vec{F} = q\vec{v} \ x$$

=qvBsinΘ

This is known as magnetic Lorentz force. This force acts perpendicular to the plane containing $\vec{v}$ and $\vec{B}$, and is directed as given by right handed screw rule. If the moving charged particle is subjected to a perpendicular magnetic field, it describes a circular path and if moving charged particle is subjected to a magnetic field, making some angle with its initial direction of motion, it will describe a helical path.

When $\vec{v}$ is parallel to $\vec{B}$,then F=0

When $\vec{v}$ is perpendicular to $\vec{B}$,then $\vec{F}$ is maximum, i.e. F=qvB

10.Force on charge particle in simultaneous electric and magnetic field:

The total force on charge particle moving in simultaneous electric $\vec{E}$ and magnetic field $\vec{B}$ is given by

$$\vec{F} = \underbrace{q\vec{E}} + \underbrace{q\vec{v} \times \vec{B}}$$

This is called Lorentz force equation.

Force on current carrying conductor in magnetic field:

$\vec{F}$=I($\vec{l}$ X $\vec{B}$)

Magnitude of the force is

F=IlBsinΘ

Direction of force $\vec{F}$is normal to $\vec{l}$ and $\vec{B}$ given by Fleming's left hand rule. If Θ is zero($\vec{l}$ is parallel to $\vec{B}$) then magnetic force is zero.

Two long parallel conductors carrying currents in the same direction attracts each other and carrying currents in opposite direction, repel each other:

The force acting per unit length of each conductor is

$$f = \frac{F}{L} = \frac{\mu_0 I_1 I_2}{2\pi r}$$

If $I_1 = I_2 = 1$ A, $r = 1$ m, then

$$f = \frac{\mu_0}{\ } = 2 \times 10^{-}$$

Definition of ampere in SI system: 1 ampere is the current which when flowing in each of the two parallel wires in vacuum at separation of 1m from each other exert a force of

If $I_1 = I_2 = 1$ A, $r = 1$ m, then

$$f = \frac{\mu_0}{\ } = 2 \times 10^{-}$$

on each other.

Torque on coil of area A, having n turns, carrying current I, when suspended in magnetic field of strength B is given by

τ=nIBAsinα

where α is the angle which a normal drawn on the plane of the coil makes the direction of magnetic field.

Torque is minimum if the plane of coil is perpendicular to the direction of magnetic field, because α=0o

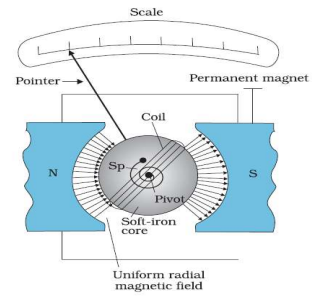
torque is maximum if the plane of the coil is parallel to the direction of magnetic field, because α=900

Radial magnetic field:

It is magnetic field in which plane of coil in all positions remain parallel to the direction of magnetic field.

Moving coil galvanometer:

A moving coil galvanometer is a device used to detect flow of current in a circuit. A moving coil galvanometer consists of a rectangular coil placed in a uniform radial magnetic field produced by cylindrical pole pieces. Torque on coil τ=nIBA where n is number of turns, A is area of coil. If k is torsional constant of material of suspended wire
Then for deflection Θ torque is τ=k Θ
For equilibrium nIBA= k Θ
Θ= nIBA/k
Clearly deflection in galvanometer is directly proportional to current.



Current sensitivity of galvanometer:
It is defined as deflection produced in galvanometer, when unit current flows through it.

$$\frac{\theta}{I} = \frac{nBA}{k}$$

Unit of current sensitivity is radA^{-1} or div A^{-1}

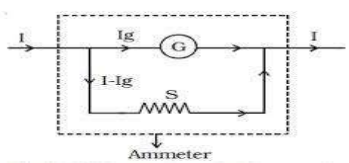
Voltage sensitivity of galvanometer:
It is defined as deflection produced in galvanometer when unit voltage is applied across two terminals of galvanometer.

$$\frac{\theta}{V} = \frac{nBA}{kR}$$

Unit of voltage sensitivity is rad.V^{-1} or div. V^{-1}

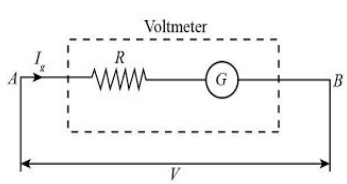
Shunt:
It is a low resistance wire connected in parallel with galvanometer or ammeter. It protects the galvanometer or ammeter from strong currents.

Conversion of galvanometer into ammeter:
A galvanometer can be converted into ammeter by using very small resistance in parallel with the galvanometer coil. The small resistance connected in parallel is called a shunt. If G is resistance of galvanometer, Ig is current in galvanometer for full scale deflection, then for conversion of galvanometer into ammeter of range I ampere, the shunt is given by
S=IgG/I-Ig



Conversion of galvanometer into voltmeter: A galvanometer can be converted into voltmeter by connecting high resistance (R) in series with the coil of galvanometer. If V volt is the range of voltmeter formed, then series resistance is given by

R=(V/Ig)-G



PRACTICE QUESTIONS ON MOVING CHARGES AND MAGNETISM

Q.Write the expression in vector form, for the Lorentz magnetic force $\vec{F}$ due to a charge moving with velocity $\vec{v}$ in a magnetic field $\vec{B}$.
Answer: $\vec{F}$=q($\vec{v}$ x $\vec{B}$)

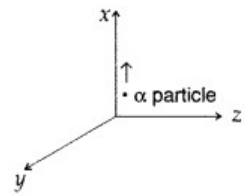
Q.Using the concept of force between two infinitely long parallel current carrying conductors, define one ampere of current.
Answer: "One ampere of current is the value of steady current, which when maintained in each of the two very long, straight, parallel conductors of negligible cross-section; and placed one

metre apart in vacuum, would produce on each of these conductors a force of equal to 2×10^{-7} newton per metre (Nm^{-1}) of length. "

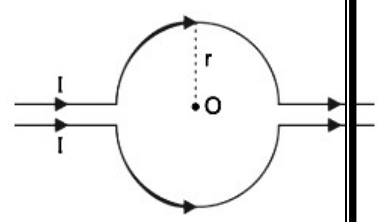
Q.Write the underlying principle of a moving coil galvanometer.
Answer: "A current carrying coil, in the presence of magnetic field, experiences a torque which produces proportionate deflection".
τ(torque) α Θ(deflection)
Q.State Biot Savart Law. Also write its mathematical expression.
Answer: The magnitude of magnetic field dB is proportional to the current I, the element length dl, and inversely proportional to the square of the distance r.

$$B = \frac{\mu_0}{4\pi}\frac{Idl\sin\theta}{r^2}$$

Q.A beam of a particles projected along +x-axis, experiences a force due to a magnetic field along the +y-axis. What is the direction of the magnetic field?



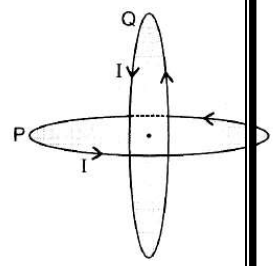
Answer: $\vec{F}=q(\vec{v} \times \vec{B})$, Direction of the magnetic field is towards negative direction of z-axis.
Q.What is the value of magnetic field at point O due to current flowing in the wire?
Answer: Zero, because the upper and lower current carrying conductors are identical, so the magnetic field caused by them will be equal and opposite.



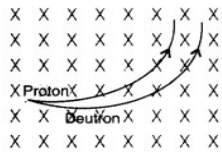
Q.An electron does not suffer any deflection while passing through a region of uniform magnetic field. What is the direction of the magnetic field?
Answer: Magnetic field will be in the line of the velocity of electron.
$\vec{F}=q(\vec{v} \times \vec{B})=0$ since v and B in same direction.

Q.A proton and a deuteron having equal momenta enter in a region of uniform electric field at right angle to the direction of the field. Find the ratio the radii of curvature of the path of the particle?
Answer: $q_d=q_p$
radius of circular path(r)=P/Bq
r α 1/q (for constant momentum(P))
so $r_p/r_d=q_d/q_p=q_p/q_p=1$
$r_p:r_d=1:1$
Q.A micro ammeter has a resistance of 100Ω and a full scale of 50μA. It it can be used as higher range ammeter or voltmeter provided resistance is added to it. Pick the correct range and resistance combinations.
50 V range and 10kΩ resistance in series.
10 V range and 200kΩ resistance in series.
5mA range with 1Ω resistance in parallel.
10mA range with 1Ω resistance in parallel.
Answer: b and c
Q.A circular current loop of magnetic moment M is in an arbitrary orientation in an external magnetic field B. The work done to rotate the loop by 300 about an axis perpendicular to its plane is
(a) MB (b)$\sqrt{3}$ MB/2 (c) $\frac{MB}{2}$ (d) Zero
Answer: d

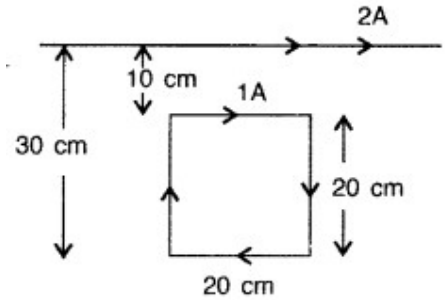
Q.In an ammeter 4% of the main current is passing through galvanometer. If the galvanometer is shunted with 5Ω resistance. Then the resistance of galvanometer will be
(a) 60Ω (b) 240Ω (c) 120Ω (d)480Ω
Answer: c
Q.A circular coil of 50 turns and radius 7cm is placed in a uniform magnetic field of 4T normal to the plane of the coil. If the current in the coil is 6A then total torque acting on the coil is
(a) 14.78N (b) 0N (c) 7.39N (d) 3.69N
Answer: b
Q.Two identical circular wires P and Q each of radius R and carrying current 'I' are kept in perpendicular planes such that they have a common centre as shown in the figure. Find the magnitude and direction of the net magnetic field at the common centre of the two coils.



Answer: B=μ0NI/√2R and tanΘ=1 ; Θ=45⁰
Q.A proton and a deuteron, each moving with velocity $\vec{V}$ enter simultaneously in the region of magnetic field $\vec{B}$ acting normal to the direction of velocity. Trace their trajectories establishing the relationship between the two.
Answer:



Q.Two long and parallel straight wires carrying current of 2A and 5A in the opposite directions are separated by a distance of 1cm. find the nature and magnitude of the force between them.
Answer: F=$\frac{\mu 0}{2\pi}\frac{I1I2}{a}$=20X10-5N(repulsive)
Q.Can a galvanometer as such be used for measuring the current? Explain.
Answer: (i) galvanometer has finite large resistance when connected in series increase the resistance of circuit and hence change the value of current in the circuit.
(ii) A galvanometer is a very sensitive device, it gives a full scale deflection for the current of order microampere.
Q.A particle of mass 10-3 kg and charge 5 pC enters into a uniform electric field of 2 × 105 NC-1, moving with a velocity of 20 ms-1 in a direction opposite to that of the field. Calculate the distance it would travel before coming to rest.
Answer: a=qE/m=103 ms-2
S=u2/2a=0.2m
Q.A square loop of side 20 cm carrying current of 1A is kept near an infinite long straight wire carrying a current of 2A in the same plane as shown in the figure.



Calculate the magnitude and direction of the net force exerted on the loop due to the current carrying conductor.
Answer: F=μ0I1I2l($\frac{1}{r1}$-$\frac{1}{r2}$)=5.3X10-7N
Direction of force is towards infinitely long straight wire.

Q.A proton and an alpha particle having the same kinetic energy are, in turn, passed through a region of uniform magnetic field, acting normal to the plane of the paper and travel in circular paths. Deduce the ratio of the radii of the circular paths described by them.

Answer: $r=\frac{\sqrt{2mE}}{qB}$

$m_\alpha=4m_p$

$q_\alpha=2q_p$

$r_p:r_\alpha::1:1$

Q.Two moving coil meter M1 and M2 having the following particulars:

R1=10Ω, N1=30, A1=3.6x10-3m2,B1=0.25T

R2=14Ω, N2=42, A2=1.8 x10-3m2,B2=0.50T

(the spring constant are identical for the two meters).Determine the ratio of (a) current sensitivity and (b) voltage sensitivity of M1 and M2.

Answer: current sensitivity, SC=NAB/C

Voltage sensitivity, SV=NAB/CR

(SC)M2/(SC)M1=1.4

(SV)M2/(SV)M1=1

Q.A straight horizontal conducting rod of length 0.45m and mass 60g is suspended by two vertical wires at its ends. A current of 5.0 A is setup in the rod through wires.

What magnetic field should be setup normal to the conductor in order the tension in the wire is zero?

What will be the total tension in the wires, if the direction of current is reversed keeping then magnetic field same as before? (neglect the mass of wires)

Answer: (a) if tension in the wire is zero, then the weight of rod and magnetic force on the rod must be equal and opposite.

BIL=Mg

B=0.26T

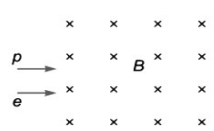
(b) When the direction of current is reversed, the magnetic force also reverses the direction: so thr net weight and magnetic force acts in the same direction

Total tension in the wireT=(T1+T2)=Mg+BIL=1.176N

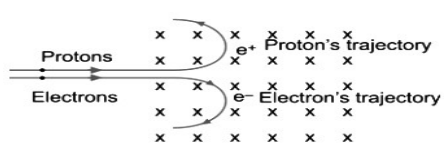
Q.An electron and proton enter a region of uniform magnetic field B with uniform speed v in a perpendicular direction.

Show the trajectory followed by two particles.

What is the ratio of the radii of the circular paths of electron to proton?



Answer: (a)



(b)r=mv/qB

r α m

$r_e/r_p=m_e/m_p=1/1840$

Q.The magnitude F of the force between two straight parallel current carrying conductors kept at a distance d apart in air is given by

$F=\mu_0 I_1 I_2/2\pi d$

Where I_1 and I_2 are the currents flowing through the two wires.

Use this expression, and the sign convention that the:

" force of attraction is assigned a negative sign and force of repulsion is assigned a positive sign."

Q.Draw graphs showing dependence of F on

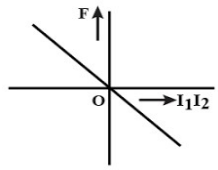
I_1I_2 when d is kept constant

d when the product I_1I_2 is maintained at a constant positive value.

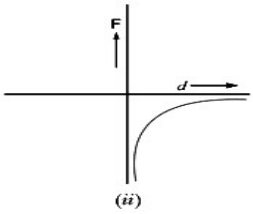
d when the product I_1I_2 is maintained at constant negative value.

Answer:

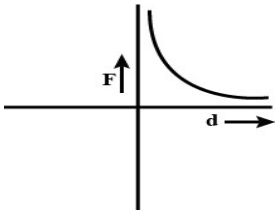
(i)



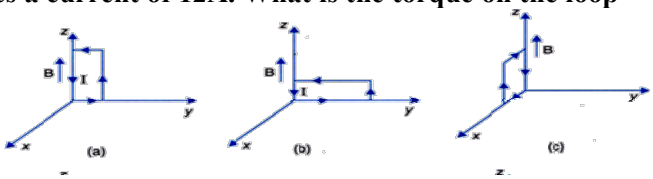
(ii)



(iii)



Q.A uniform magnetic field of 3000G is established along the positive Z-direction. A rectangular loop of side 10cm and 5cm carries a current of 12A. What is the torque on the loop in the different cases shown in figure.



Answer: $\vec{\tau}$=IABsinΘ$\hat{n}$

Angle between $\vec{A}$ and $\vec{B}$ is 900. $\vec{A}$ directed along X axis.

$\vec{\tau}$=1.8X10-2 Nm along negative y axis.

Angle between $\vec{A}$ and $\vec{B}$ is 900. $\vec{A}$ directed along X axis.

$\vec{\tau}$=1.8 Nm along negative y axis.

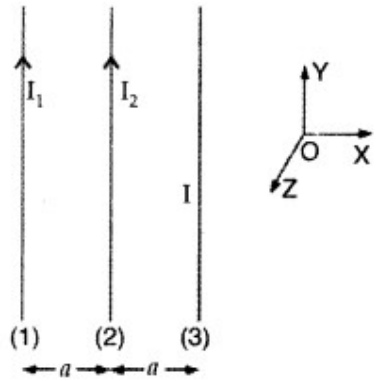
$\vec{A}$ directed along Y axis.

$\vec{\tau}$=-1.8X10-2 Nm along negative X axis.

Q. Three long straight parallel wires are kept as shown in the figure. The wire (3) carries a current I

(i) The direction of flow of current I in wire (3), is such that the net force, on wire (1), due to the other two wires, is zero.

(ii) By reversing the direction of I, the net force, on wire (2), due to the other two wires, becomes zero. What will be the directions of current I, in the two cases? Also obtain the relation between the magnitudes of currents I1, I2 and I.



Answer:

Net force experienced by wire (1) can be zero only, when the current in wire (3) flows along $-\hat{j}$ i.e. downwards, it means that the forces acting on wire (1) due to wire (3) and wire (2) are equal and opposite.

$$\frac{\mu_0 I_1 I}{2\pi(2a)} = \frac{\mu_0 I_1 I_2}{2\pi(a)} \qquad \therefore \; I = 2I_2$$

(ii) When direction of current in wire (3) is reversed then current should be along +$\hat{j}$i.e. upwards.

For this case net force on wire (2) becomes zero, which means that the forces due to wire (1) and wire (3) are equal and opposite.

$$\frac{\mu_0 I_1 I_2}{2\pi a} = \frac{\mu_0 I_2 I}{2\pi(a)}$$

$$\therefore \; I = I_1 \qquad \Rightarrow \; I = I_1 = 2I_2$$

Q.A circular coil of 200 turns and radius 10 cm is placed in a uniform magnetic field of 0.5 T, normal to the plane of the coil. If the current in the coil is 3.0 A, calculate the

(a) total torque on the coil.

(b) total force on the coil.

(c) average force on each electron in the coil, due to the magnetic field.

Assume the area of cross-section of the wire to be 10-5 m2 and the free electron density is 1029/m3.

Answer: (a) As $\vec{B}$ is parallel to dipole moment $\vec{M}$

$\vec{\tau}$=BMsin00 =0

(b) As the forces on different parts of the coil appears in pairs, equal in magnitude and opposite in direction, net force on the coil is zero.i.e., F = 0

(c) F=BeVd

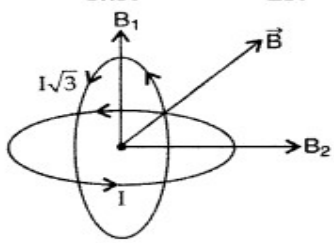
=BeI/neA=1.5X10-24N

Q.Two identical coils, each of radius 'R' and number of turns 'N' are lying in perpendicular planes such that their centres coincide. Find the magnitude and direction of the resultant magnetic field at the centre of the coils, if they are carrying currents 'I' and √3I respectively.

Answer:

$$B_1 = \frac{\mu_0 2\pi NI}{4\pi R} = \frac{\mu_0 NI}{2R}$$

$$B_2 = \frac{\mu_0 2\pi NI\sqrt{3}}{4\pi R} = \frac{\mu_0 NI\sqrt{3}}{2R}$$



So, **Resultant magnitude,**

$$\mathbf{B} = \sqrt{B_1^2 + B_2^2} = \frac{\mu_0 NI}{2R}\sqrt{1+3} = \frac{\mu_0 NI}{R}$$

and **Direction** is *clockwise*.

Q.A wire AB is carrying a steady current of 12A and is lying on the table. Another wire CD carrying 5A is held directly above AB at a height of 1 mm. Find the mass per unit length of the wire CD so that it remains suspended at its position when left free. Give the direction of the current flowing in CD with respect to that in AB. [Take the value of g = 10 ms-2]

ANSWER: Current in the wire AB (I1) = 12 A,

Current in wire CD (I2) = 5 A

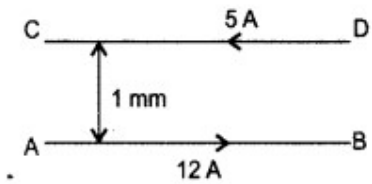
Separation between two wires (d) = 1 mm

= 10-3 m

Let 'm' be the mass of wire CD of length (L),

hence $\frac{m}{L} = ?$ $\quad F_{mag} = I(\vec{l} \times \vec{B})$

Now the magnetic field due to wire (AB) on wire (CD) is



$$\vec{B} = \frac{\mu_0}{4\pi} \times \frac{2I_1}{d}$$

$$F_{weight} = mg$$

To balance

$$F_{weight} = F_{mag} \qquad mg = I_2\,(\vec{L} \times \vec{B})$$

$$\frac{m}{L} = \frac{I_2 \times \vec{B}}{g} = \left(\frac{I_2}{g} \times \frac{\mu_0}{4\pi} \times \frac{2I_1}{d}\right)$$

$$= \frac{5}{10} \times \frac{\mu_0}{4\pi} \times \frac{2 \times 12}{1 \times 10^{-3}}$$

$$= \frac{5}{10} \times 10^{-7} \times \frac{2 \times 12}{10^{-3}}$$

$$= 1.2 \times 10^{-3}\ \text{kg m}^{-1}$$

Direction of current in CD should be opposite to that of AB.

Q. A closely wound solenoid of 2000 turns and cross sectional area 1.6 × 10-4 m2 carrying a current of 4.0 A is suspended through its centre allowing it to turn in a horizontal plane. Find (i) the magnetic moment associated with the solenoid, (ii) magnitude and direction of the torque on the solenoid if a horizontal magnetic field of 7.5 × 10-2 T is set up at an angle of 30° with the axis of the solenoid.

Answer: n=2000turns, A=1.6X10-4 m2

I=4.0 A, B=7.5X10-2T

Θ=300

Magnetic moment(M)

M=NIA=1.2Am2

magnitude of torque=MBsinΘ

48x10-3Nm

Q. A circular coil, having 100 turns of wire, of radius (nearly) 20 cm each, lies in the XY plane with its centre at the origin of co-ordinates. Find the magnetic field, at the point (0, 0, 20√3 cm), when this coil carries a current of($\frac{2}{\pi}$)A

Answer: N=100 turns

R=0.2m

I= ($\frac{2}{\pi}$)A

Z=0.2$\sqrt{3}$m

B=?

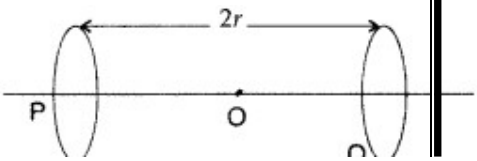
The plane of coil is XY plane and field point is on the Z axis.

Magnetic field on the axial point

B=μ0IR2N/2(R2+Z2)3/2

=25μT

Q.Two identical circular loops, P and Q, each of radius r and carrying current I and 21 respectively are lying in parallel planes such that they have a common axis. The direction of



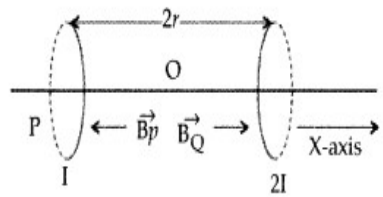
current in both the loops is clockwise as seen from O which is equidistant from both the loops. Find the magnitude of the net magnetic field at point O.

Answer:

Bp=μor2I/2(r²+r²)3/2=μ₀I/4√2r pointing towards P

BQ=μor2(2I)/2(r²+r²)3/2=μo2I/4√2r pointing towards Q

B= BQ- Bp= μoI/4√2r



Q. An ammeter of resistance 0.80 Ω can measure current upto 1.0 A.

(i) What must be the value of shunt resistance to enable the ammeter to measure current up to 5.0A?

(ii) What is the combined resistance of the ammeter and the shunt?

Answer:

Rg=0.80Ω , ig=1.0 A , i=5A

Shunt,S=(ig/i-ig)Rg=(1/5-1)0.80=0.20Ω

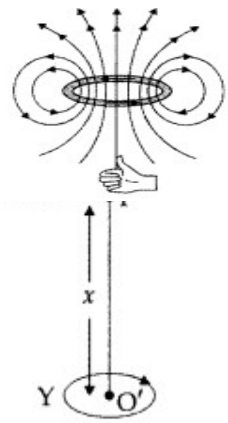
Combined resistance of ammeter and shunt,

1/Rcomb=1/Rg+1/S=1/0.80+1/0.20=50/8=0.16Ω

Q. (a) Draw the pattern of magnetic field lines for a circular coil carrying current. (b) Two identical circular loops X and Y of radius R and carrying the same current are kept in perpendicular planes such that they have a common centre at P as shown in the figure. Find the magnitude and direction of the net magnetic field at the point P due to the loops.

Answer:

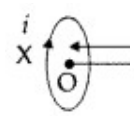
(a) Magnetic field lines :



(b) The magnetic field due to a circular coil at a point carrying current is given by

$$B = \frac{\mu_0 i R^2}{2(R^2 + x^2)^{3/2}}$$

Since these two circular coils are identical and carrying the same current,



$$B_X = B_Y = \frac{\mu_0 i R^2}{2(R^2 + x^2)^{3/2}} = B$$

Resultant magnetic field (BR)

$$= \sqrt{B_X^2 + B_Y^2} = \sqrt{B^2 + B^2} = B\sqrt{(1+1)} = \sqrt{2}B$$

$$= \frac{\sqrt{2}\mu_0 i R^2}{2(R^2 + x^2)^{3/2}}$$ **and making 45° with B_X or B_Y.**

Q. A multirange voltmeter can be constructed by using galvanometer circuit as shown in the figure. We want to construct a voltmeter that can measure 2V, 20V and 200V using a galvanometer of resistance 10Ω and that produces maximum deflection for current of 1mA. Find the value of R1, R2 and R3 that have to be used.

Answer: G=10Ω, Ig=1mA=10-3A

Case(i) V=2V

R1=(V/Ig)-G=1990Ω

(ii)V=20V

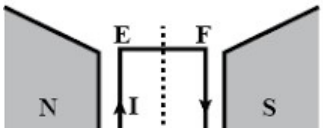
(R1+R2)=(20/10-3)-10=20k Ω

R2=18k Ω

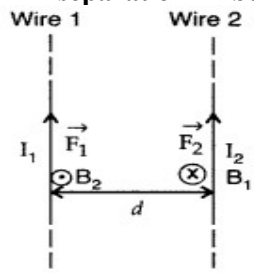
R1+R2+R3=180k Ω

R3=180k Ω

Q. a) Two straight long parallel conductors carry currents I1 and I2 in the same direction. Deduce the expression for the



force per unit length between them.
Depict the pattern of magnetic field lines around them.
(b) A rectangular current carrying loop EFGH is kept in a uniform magnetic field as shown in the figure.
(i) What is the direction of the magnetic moment of the current loop?
(ii) When is the torque acting on the loop
(a)maximum,
(b) zero?
Answer:
Consider two infinitely long parallel conductors carrying current I1 and I2 in the same direction.
Let d be the distance of separation between these two conductors.



$$B_1 = \frac{\mu_0 I_1}{2\pi d}$$

$$F_2 = I_2 \times l_2 \times B_1 \sin\theta \quad \{\sin\theta = 1\}$$

$$\Rightarrow \quad F_2 = I_2 \times l_2 \times \frac{\mu_0 \times I_1}{2\pi d}$$

Force per unit length,

$$F = \frac{\mu_0 I_1 I_2}{2\pi d}, \; B_2 = \frac{\mu_0 I_2}{2\pi d}$$

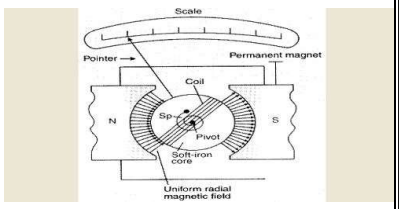
$$F_1 = I_1 \times l_1 \times B_2 \sin\theta \quad \{\sin\theta = 1\}$$

$$\Rightarrow \quad F_1 = \frac{\mu_0 I_1 I_2 l_1}{2\pi d}$$

$$\because \quad \text{Force per unit length, } F = \frac{\mu_0 I_1 I_2}{2\pi d}$$

Hence, force is attractive in nature.
(i) Magnetic moment will be out of the plane from the surface HEFG.
(ii) Torque
(A) Torque is maximum when M and B are perpendicular to each other.
(B) Torque is minimum when M and B are parallel o each other.

Q . Moving Coil Galvanometer



Moving coil galvanometer operates on Permanent Magnet Moving Coil (PMMC) mechanism and was designed by the scientist D'arsonval.
Moving coil galvanometers are of two types
(i) Suspended coil
(ii) Pivoted coil type or tangent galvanometer.
Its working is based on the tact that when a current carrying coil is placed in a magnetic field, it experiences a torque This torque tends to rotate the coil about its axis of suspension in such a way that the magnetic flux passing through the coil is maximum.

Now answer these questions-

(i) A moving coil galvanometer is an instrument which
(a) is used to measure emf (b) is used to measure potential difference
(c) is used to measure resistance
(d) is a deflection instrument which gives a deflection when a current flows through its coil

(ii) To make the field radial in a moving coil galvanometer.
(a) number of turns of coil is kept small (b) poles are of very strong magnets
(c) magnet is taken in the form of horse-shoe(d) poles are cylindrically cut

(iii) The deflection in a moving coil galvanometer is
(a) directly proportional to torsional constant of spring

(b) directly proportional to the number of tarns in the coil
(c) Inversely proportional to the area of the coil
(d) inversely proportional to the current in the coil
(iv) In a moving coil galvanometer, having a coil of -turns of area A and carrying current I is placed in a radial field of strength B.The torque acting on the coil is
(a) NA2B2I (b) NABI2 (0) NABI (d) NABI

(v) To increase the current sensitivity of a moving coil galvanometer, we should decrease
(a) strength of magnet (b) torsional constant of spring
(c) number of turns in coil (d) area of coil

Answers: (1) d (ii)d (iii) b (iv) d (v)b

Q. Motion of Charged Particle Inside Magnetic Field
A charged particle moving in a magnetic field experiences a force that is proportional to the strength of the magnetic field, the component of the velocity that is perpendicular to the magnetic field and the charge of the particle.
This force is given by $\vec{F}$=q($\vec{v}$ x $\vec{B}$) where q is the electric charge of the particle, v is the instantaneous velocity of the particle, and B is the magnetic field (in tesla).
The direction of force is determined by the rules of cross product of two vectors.
Force is perpendicular to both velocity and magnetic field. Its direction is same as vxB if q is positive and opposite of v x B if q is negative.
The force is always perpendicular to both the velocity of the particle and the magnetic field that created it.
Because the magnetic force is always perpendicular to the motion, the magnetic field can do no work on an isolated charge. It can only do work indirectly, via the electric field generated by a changing magnetic field.

Now answer these questions-

(i) When a magnetic field is applied on a stationary electron, it
(a) remains stationary (b) Spins about its own axis
(c) Moves in the direction of the field
(d) Moves perpendicular to the direction of the field.

(ii) A proton is projected with a uniform velocity v along the axis of a current carrying solenoid, then
(a) The proton will be accelerated along the axis (b) The proton path will be circular about the axis
(c) The proton moves around helical path
(d) The proton will continue to move with velocity v along axis.

iii) A charged particle experiences magnetic force in the presence of magnetic field. Which of the following statement is correct ?
(a) The particle is stationary and magnetic field is perpendicular.
(b) The particle is moving and magnetic field is perpendicular to the velocity.
(c) The particle is stationary and magnetic field is parallel.
(d) The particle is moving and magnetic field is parallel to velocity.

(iv) A charge g moves with a velocity 2 ms-1 along x-axis in a uniform magnetic field $\vec{B}$=

($\hat{i}$+2$\hat{j}$+3$\hat{k}$) T, then charge will experience a force
(a) in z-y plane (b) Along -y axis (c) Along +z axis, (d) Along -z axis

(v) Moving charge will produce

(a) Electric field only (b) Both electric and magnetic field (c) Magnetic field only (d) None of these.

Answers: (i) a (ii) d (iii) b (iv) a (v) c

Magnetism and Matter

Magnetic dipole: An arrangement of two unlike poles of equal strength and separated by a small distance is called a magnetic dipole. In SI, the unit of magnetic pole strength is ampere metre (A.m).

Magnetic Dipole Moment: The product of the pole strength of either magnetic pole and the magnetic length of the magnetic dipole is called its magnetic dipole moment. The SI unit of magnetic dipole moment is ampere-metre2 (A m2).

Current loop and a magnetic dipole: A current loop of area A carrying current I behave as a magnetic dipole having magnetic dipole moment:

m = I.A

Torque on a magnetic dipole in a magnetic field: When a magnetic dipole of magnetic dipole moment m is placed in a uniform magnetic field of strength B making an angle θ with the direction of the magnetic field, it experiences a torque, which is given by

$\tau = m \times B = mB\sin\theta$

potential energy stored in a magnetic dipole on rotating inside a magnetic field: The work done in rotating a magnetic dipole against the torque acting on it when placed in a magnetic field is stored inside the magnetic dipole in the form of its potential energy. When the magnetic dipole is rotated from its initial position θ1, to the final position θ2, then the potential energy stored is given by

$U = mB(\cos\theta_2 - \cos\theta_1)$

Magnetic intensity. It is defined as the ratio of magnetic induction in a vacuum to the absolute magnetic permeability of free space. It is given by

$H = \frac{B_0}{\mu_0}$

Where $\mu_0 = 4\pi \times 10^{-7}$ tesla metre/ampere is the absolute permeability of vacuum. Magnetic intensity is also known as H-field or magnetising field strength. The unit of magnetic intensity i.e. A/m is also equivalent to N /m^2 T or N/Wb or J/m^{-3} T

Intensity of magnetisation. It is defined as the magnetic dipole moment developed per unit volume

$M = \frac{m_{net}}{V}$

In SI, the unit of intensity of magnetisation is ampere/metre (A/m).

Magnetic induction. It is defined as the number of magnetic lines of induction (magnetic field lines inside the material) crossing per unit area normally through the magnetic material. If H is the strength of the magnetising field, then magnetic induction is given by

$B = \mu_0 (H + M)$

In SI, the unit of the strength of magnetising field is ampere/ metre (A/ m) and that of magnetic induction is tesla (T) or weber /metre^2 (Wb/ m^2)

Magnetic susceptibility. The magnetic susceptibility of a material is defined as the ratio of the intensity of magnetisation (M) and the strength of magnetising field (H). It is given by

$\chi_m = \frac{M}{H}$

It has no units.

Magnetic permeability. The magnetic permeability of a material is defined as the ratio of the magnetic induction (B) of the material to the strength of magnetising field (H). It is given by

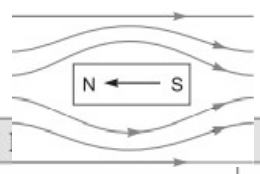
$\mu_m = \frac{B}{H}$

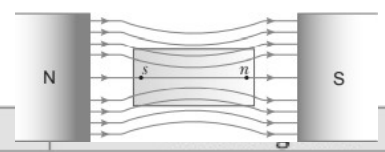
In SI, the unit of magnetic permeability is tesla metre/ ampere (T m/ A).

Diamagnetic substances. Those substances, which when placed in a magnetic field are feebly magnetised in a direction opposite to that of the magnetising field.

Paramagnetic substances. Those substances, which when placed in a magnetic field are feebly magnetised in the direction of the magnetising field.

Ferromagnetic substances. Those substances, which when placed in a magnetic field are strongly magnetised in the direction of the magnetising field.





		Paramagnetic	
1	$-1 \le \chi < 0$	$0 < \chi < \varepsilon$	$x \gg 1$
2	$0 \le \mu_r < 1$	$1 \le \mu_r < (1 + \varepsilon)$	$\mu_r \gg 1$
3	$\mu < \mu_0$	$\mu > \mu_0$	$\mu \gg \mu_0$

Practice questions

Q.The relative permeability of a magnetic material is 0.9. Name the type of magnetic materials it represents.

Ans. Diamagnetic.

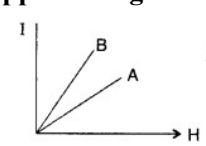
Q.The susceptibility of a magnetic material is 1.9×10^{-5}. Name the type of magnetic materials it represents.

Ans. Paramagnetic.

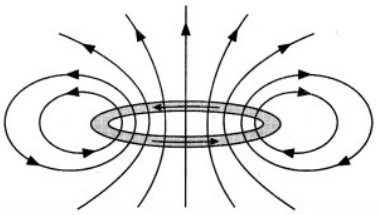
Q. The figure shows the variation of intensity of magnetisation versus the applied magnetic field intensity, H, for two magnetic materials A and B:

Identify the types of materials.

Ans. A is paramagnetic, and B is ferromagnetic.



Q.Draw the magnetic field lines due to a circular loop of area A carrying current I.
Ans. The magnetic field lines due to a circular loop of area A and current I, are shown in the figure.



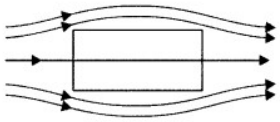
Q.Why does a paramagnetic sample display greater magnetisation (for the same magnetizing field) when cooled? Why is diamagnetism, in contrast, almost independent of temperature?

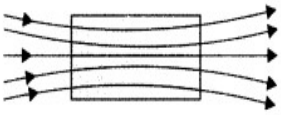
Ans. The thermal motion reduces at a lower temperature, and the tendency to disrupt the alignment of the dipoles decreases. The dipole moment induced is always opposite to the magnetizing field. Therefore, the internal motion of the atoms due to the temperature will not affect the material's magnetism.

Q.For which class of materials is magnetic susceptibility positive and negative? Why?

Ans. Paramagnetic materials' magnetic susceptibility is slightly positive as these materials get slightly magnetised in the magnetic field. For diamagnetic materials, magnetic susceptibility is slightly negative as these materials repel the magnetic field lines. For ferromagnetic materials, magnetic susceptibility is very high as these materials get highly magnetised in the magnetic field and could retain their magnetisation.

Q.Depict the behaviour of magnetic field lines near (i) diamagnetic and (ii) paramagnetic substances.
Ans. Diamagnetic repels the field lines while paramagnetic material attracts the field lines. That's why the relative permeability of diamagnetic materials is slightly less than 1, and the relative permeability of paramagnetic materials is slightly more than 1. Paramagnetic materials increase the magnetic field by a small amount, while diamagnetic materials reduce the magnetic field by a small amount.

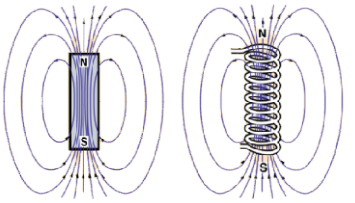




Ans: Diamagnetic, Paramagnetic

Q.Explain the sense in which the solenoid acts like a bar magnet.

Ans. A current-carrying solenoid is analogous to a bar magnet because a magnetic field develops along its axis, i.e., along its length, joining the north and south poles. The same is depicted in the figures:



Bar Magnet Solenoid

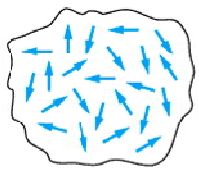
Q.Why magnetic field lines are nearly normal to the surface of a ferromagnet? What is the effect of the magnetic field on the permeability of ferromagnetic materials? Would the maximum possible magnetisation of a paramagnetic sample be of the same order of magnitude as the magnetisation of a ferromagnet?

Ans. A ferromagnetic material's permeability is always much larger than one. Hence, magnetic field lines are nearly normal to the surface of such materials at every point. The permeability

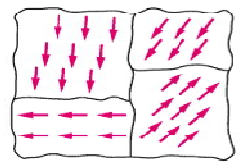
of ferromagnetic materials depends of the applied magnetic field. It is greater for a lower field and lesser for a higher field. The maximum possible magnetisation of a paramagnetic sample can be of the same order of magnitude as the magnetisation of a ferromagnet, but this requires high magnetising fields for saturation.

Q.How are ferromagnetic materials different from paramagnetic materials? Why soft iron core is used in a moving coil galvanometer? What will happen if we put an aluminium or a copper core instead of a soft iron core?

Ans. Ferromagnetic materials have a domain structure instead of all the spins being random, as in paramagnetic materials. All the spins in a single domain are aligned in a particular direction, so the magnetic field is very high on magnetisation. We put a soft iron core inside the galvanometer to increase the magnetic field several times, so the deflection on the needle of the galvanometer is large. Aluminium is a paramagnetic material, and copper is diamagnetic material. So, if we put aluminium core, the magnetic field will be very low; hence, the deflection will be low. Copper is diamagnetic material, so the magnetic field is further lowered.



Paramagnetic Material



Ferromagnetic Material

Q. A circular coil of N turns, and radius R carries a current I. It is unwound and rewound to make another coil of radius R/2; current I remain the same. Calculate the ratio of the magnetic moments of the new coil and the original coil.

Ans. m1:m2 = 1:2. Hint: Magnetic moment m = NIA. The first coil is rewound to make the second coil. So the number of turns N2 = N1/2. Similarly, A2 = 4.A1.

Q.A short bar magnet placed with its axis at 30° with a uniform external magnetic field of 0.25 T experiences a torque of magnitude equal to 4.5×10–2J. What is the magnitude of the magnetic moment of the magnet?
Ans. 0.36 J/T. Hint: $\tau = mBsin\theta$ **so** $m = \frac{\tau}{Bsin\theta}$

Q.A closely wound solenoid has 2000 turns per m. If the solenoid is 40 cm long, has an area of cross-section 2.5×10–4 m2, and carries a current of 3.0 A. What is its associated magnetic moment?
Ans. 0.6 J/T. Hint: m = NIA and N = n × l = 800.

Q.Two wires of the same length are shaped into a square and a circle if they carry the same current. Calculate the ratio of the magnetic moment.
Ans. m1:m2 = π:4. Hint: Magnetic moment m = IA. Both coils have the same length. So, 4a = 2πr. So, a = πr/2. As/Ac = π:4.

Q.A solenoid has a core of material with a relative permeability of 400. The solenoid windings are insulated from the core and carry a current of 2A. If the number of turns is 1000 per metre, calculate (a) H, (b) M, (c) B and (d) the magnetising current Im.
Ans. H = nI = 2×103 A/m, B = μrμ0H = 1.0 T, M = (B – μ0H)/μ0 = 8×105 A/m, B = μ0n (I+Im) so Im = 794 A.

Q.A domain in ferromagnetic iron is in the form of a cube of side length 1μm. Estimate the number of iron atoms in the domain and the maximum possible dipole moment and magnetisation of the domain. The atomic mass of iron is 55 g/mole, and its density is 7.9 g/cm3. Assume that each iron atom has a dipole moment of 9.27×10–24 A.m2.

Ans. V = 10–12 cm3. Hence, the number of atoms in the domain is N = ρV×NA/A = 8.65×1010 atoms. Maximum possible dipole moment when all the atomic moments are perfectly aligned. mmax = N×μ = (8.65×1010) × (9.27×10–24) = 8.0 ×10–24 A.m2. Mmax = mmax/V = 8.0 ×105 A/m.

Q.A short bar magnet placed with its axis at 30° with an external field of 800 G experiences a torque of 0.016 Nm. (a) What is the magnetic moment of the magnet? (b) What is the work done in moving it from its most stable to the most unstable position? (c) The bar magnet is replaced by a solenoid of cross-sectional area 2×10–4 m2 and 1000 turns but of the same magnetic moment. Determine the current flowing through the solenoid.
Ans. m = 0.40 Am2, Hint: $\tau = mBsin\theta$, The most stable position is θ = 0° and most unstable position is θ = 180° so W = Um (θ = 180°) – Um (θ = 0°) = 2mB = 0.064 J, m = NIA so I. = 2A.

Q.A short bar magnet of magnetic moment 0.9 J/T is placed with its axis at 60° to a uniform magnetic field. It experiences a torque of 0.063 Nm. Calculate the strength of the magnetic field. What orientation of the bar magnet corresponds to the equilibrium position in the magnetic field?
Ans. $\tau = mBsin\theta$, so B = 0.081 T, for equilibrium position, the torque on the needle must be zero. But the m and B can't be zero; hence, the angle between m and B i.e., θ must be zero when the magnet aligns itself parallel to the field.

Q.A circular coil of 16 turns and a radius of 10 cm carrying a current of 0.75 A rests with its plane normal to an external field of magnitude 5.0×10–2 T. The coil is free to turn about an axis in its plane perpendicular to the field direction. When the coil is turned slightly and released, it oscillates about its stable equilibrium with a frequency of 2.0 s–1. What is the moment of inertia of the coil about its axis of rotation?
Ans. m = NIA = NIπr2 = 0.377 J/T, frequency is given as: $\nu = \frac{1}{2\pi}\sqrt{\frac{I}{mB}}$, so I = $\frac{mB}{4\pi^2\nu^2}$ = 1.2 ×10–4 kg.m2

Q.A small compass needle of magnetic moment 'm' is free to turn about an axis perpendicular to the direction of uniform magnetic field 'B'. The moment of inertia of the needle about the axis is 'I'. The needle is slightly disturbed from its stable position and then released. Prove that it executes simple harmonic motion. Hence deduce the expression for its time-period.

Ans. Torque on the needle:

$$\vec{\tau} = \vec{m} \times \vec{B} = mBsin\theta$$
$$\vec{\tau} = I\vec{\alpha}$$
$$I\vec{\alpha} = -mBsin\theta$$
$$I\frac{d^2\theta}{dt^2} = -mBsin\theta$$

For small angle sinθ = θ

$$\frac{d^2\theta}{dt^2} = \frac{-mB\theta}{I}$$

Which represents the Simple Harmonic Motion with time-period of

$$T = 2\pi\sqrt{\frac{mB}{I}}$$

Q.A circular coil is placed in the uniform magnetic field of strength 0.10T normal to the plane of the coil. If the current in the coil is 5.0A. Find. (a) Total torque on the coil, (b) the total force on the coil, (c) average force on each electron due to magnetic field (The coil is made of copper wire of cross-sectional area, and free electron density in copper is 1029/m3).
Ans. B = 1.0 T, I = 5A, θ = 0°, τ = $mBsin\theta$ = 0, F = 0, Fav = q (v×d), I = neAvd, so Fav = IB/nA = 5×10–25 N

Q.The magnetic field produced by a solenoid is 50 G, and a material with a relative permeability of 400 is inserted inside the solenoid. Then the magnetic field will be?
Ans. B = $\mu_r\mu_0$H = 2 T

Q.The volume of a domain is 10 μm3. If all the spins in the domain are aligned, and the net magnetic moment of the domain is 7×10–12 A.m2. The magnetisation of the material will be?
Ans. M = m_{net}/V = 7×105 A/m.

Q.On quadrupling the moment of inertia of a magnet, its frequency of oscillation will be.
Ans. Half, Hint: ν = $\frac{1}{2\pi}\sqrt{\frac{I}{mB}}$

Q.The magnetic field strength due to a short bar magnet directed along its equatorial line at a distance r is B. What is its value at the same distance along the axial line?
Ans. 2B, Hint: the axial field is double that of the equatorial field.

Q.A 5.0 cm long bar magnet with its axis at 30° with an external field of 800 G experiences a torque of 0.016 Nm. What is the magnitude of the equatorial and axial fields due to a bar magnet at 50 cm from its mid-point?
Ans. m = 0.40 Am2, Hint: τ = $mBsin\theta$. Now the equatorial field $B_E = \frac{\mu_0 m}{4\pi r^3}$, BE = 3.2×10–7 T and the axial field $B_A = \frac{2\mu_0 m}{4\pi r^3}$, BA = 6.4×10–7 T.

Q.What is the susceptibility and permeability of a perfectly diamagnetic substance?
Ans. A perfectly diamagnetic material fully opposes the magnetic field lines; hence, the magnetic field B inside the material is always zero. B = μ0(H+M) = 0, so M = –H, magnetic susceptibility χ_m = M/H = –1, and magnetic permeability μ_0 = 1+χ_m = 1–1 = 0.

Q.A monoenergetic (18 keV) electron beam initially in the horizontal direction is subjected to a horizontal magnetic field of 0.04 G normal to the initial direction. Estimate the up or down deflection of the beam over 30 cm (me = 9.11×10–31 kg).
Ans. E = 18 keV = 2.88 ×10–15 J. B = 0.04 G, me = 9.11×10–31 kg, d = 30 cm. From $E = \frac{1}{2}m_e v^2$, v = 7.96 ×107 m/s. The magnetic force balances with the centripetal force; hence, $qVB = \frac{m_e v^2}{r}$, so r = 11.32 m, deflection x = r (1 – cosθ), sinθ = d/r = 0.3/11.32 = 0.026, x = [1 – {1 – (0.026)2}1/2] = 3.83 mm.

Q.Gauss' law for magnetism: By analogy to Gauss' law of electrostatics, we can write Gauss' law of magnetism as $\phi_B = \vec{B}.\overrightarrow{dS} = m_{in}.\mu_0$ where $\vec{B}.\overrightarrow{dS}$ is the magnetic flux, and min is the net pole strength inside the closed surface. We do not have an isolated magnetic pole in nature. At least none has been found till date. The smallest unit of the source of the magnetic field is a magnetic dipole, where the net magnetic pole is zero. Hence, the net magnetic pole enclosed by any closed surface is always zero. Correspondingly, the flux of the magnetic flux through any closed surface is zero.
Now answer these questions-
(i)The net magnetic flux through any closed surface kept in a magnetic field is:
(a)Zero (b) $\frac{\mu_0}{4\pi}$ (c) $4\pi\mu_0$ (d) $\frac{4\mu_0}{\pi}$

Ans. Zero

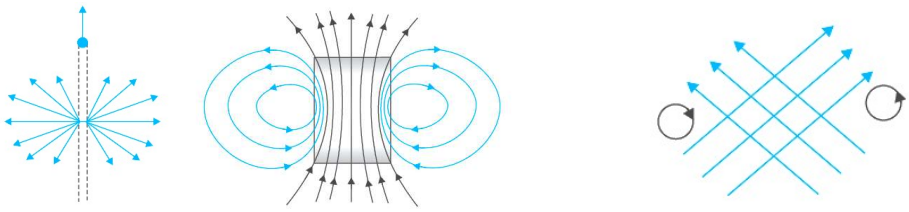
(ii)A closed surface S encloses a magnetic dipole moment 2m.l. The magnetic flux emerging from the surface is
(a)μ_0m (b) Zero (c) 2μ_0m (d) μ_0/ m
Ans. Zero

Q.Which of the following is not a consequence of Gauss' law?
(a)The magnetic poles always exist as, unlike pairs of equal strength
(b)If several magnetic lines of force enter a closed surface, then an equal number of lines of force must leave that surface
(c)There are abundant sources or sinks of the magnetic field inside a closed surface
(d)Isolated magnetic poles do not exist
Ans. (c) There are abundant sources or sinks of the magnetic field inside a closed surface

Q.The surface integral of a magnetic field over a surface
(a)is proportional to the mass enclosed (b)is proportional to the charge enclosed
(c) is equal to its magnetic flux through that surface (d) is zero
Ans. (c) is equal to its magnetic flux through that surface

Q.A magnetic dipole is under the influence of two magnetic fields. The angle between the field directions is 60°, and one of the fields has a magnitude of 1.2×10–2 T. If the dipole comes to stable equilibrium at an angle of 15° with this field, what is the magnitude of the other field?
Ans. B1 = 1.2 × 10–2 T, B2 =? θ = 60° At stable equilibrium, θ1 = 15°, θ2 = 45°, mB1.sinθ1 = mB2.sinθ2 so B2 = mB1sinθ1/m.sinθ2 = 4.39 ×10–3 T

Q.Below three figures are shown, which show magnetic field lines. Some are depicted correctly, while others are depicted wrongly. With reasons, explain which is/are correct and which is/are not.



Ans. (a) Wrong. Magnetic field lines can never emanate from a point, as shown in figure (b) Right; these are field lines outside and inside a bar magnet, (c) Wrong. Magnetic field lines (like electric field lines) can never cross each other.

ELECTROMAGNETIC INDUCTION

The phenomenon of inducing emf/current when the magnetic flux linked with the coil changes called ELECTROMAGNETIC INDUCTION.

Magnetic Flux

Magnetic flux -The number of magnetic field lines crossing a surface normally is called magnetic flux (ΦB) linked

It is a scalar quantity.

Magnetic flux is denoted by ΦB or Φ. SI Unit is Weber (Wb).

Mathematically:

ΦB = BA

B=magnetic field vector, A= area vector

Area vector =In case of magnetic

ΦB = BA cos θ

Where θ=angle between magnetic field and area vector.

Direction of area vector is determined by the normal to the area vector.

FARADAY'S LAW:-

First Law-According to this law the magnetic flux linked with the coil changes, an emf is induced in the coil linked with the flux.Relative motion between coils induces the electric current.

Second law: -According to the second law the magnitude of the induced emf in the coil is directly proportional to the rate of change of magnetic flux linked with the coil.

Mathematically:-.

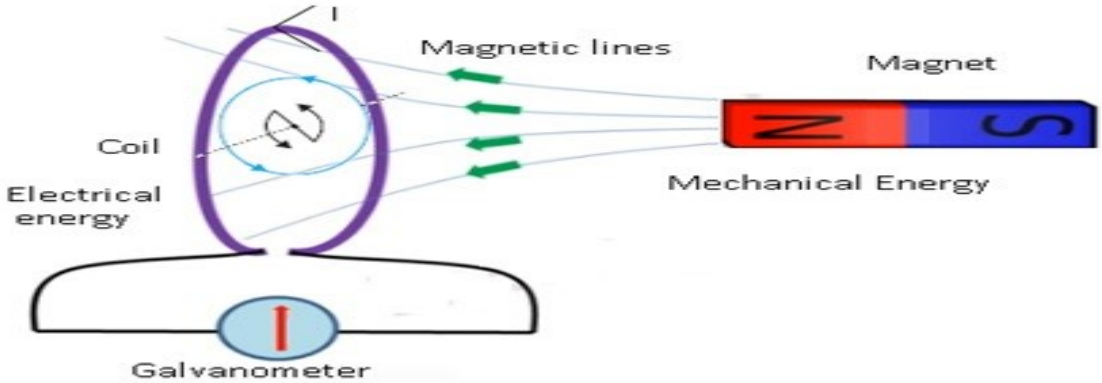
e=(dΦ/dt)

If a coil has N number of turns;Then e = N(dΦ/dt)

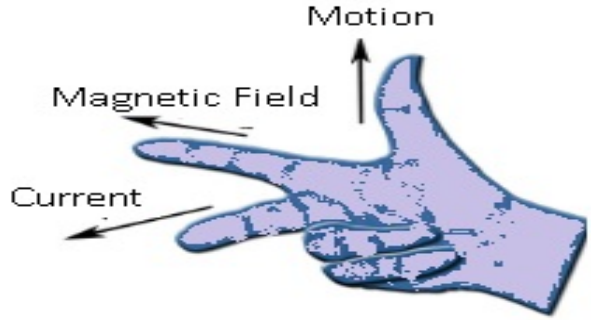
Lenz's law:-

It gives direction of induced current which always opposes the change of magnetic flux responsible for its production.

Lenz's law and energy conservation.



Direction of Induced current: Fleming's right hand rule



Induction

Induction is defined as current production in the coil due to the change in magnetic flux in itself or another coil.

Types of Induction:-

Self-induction-

There will be change in the magnetic flux in the coil itself because of which a current will be induced in itself.

It is denoted by L.

Mutual induction-

There are 2 coils,if there is change in the magnetic flux in one coil then the magnetic field is induced in the second coil.

It is denoted by M.

Inductance:-

It is the property of coil of inducing emf by itself called coefficient of self-induction or self-inductance.

It is a scalar quantity.SI unit is Henry(H). It depends on Geometry of the coil & Nature of the material on which it is wound.

Self-inductance of a long solenoid

Case 1:- core of the solenoid has air.

=>L = (μ_0N2A)/length

Case 2:- core of the solenoid is made of material which has permeability μr.

=>L= (μ_0 μ_r N2 A)/length

Coefficient of self-induction. ---The coefficient of self-induction or simply self-inductance (L) of a coil is numerically equal to the magnetic flux () linked with the coil, when a unit current flows through it.

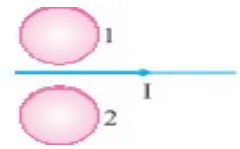
Mathematically: Ø=LI The self-inductance of a coil ts also numerically equal to the induced e.m.f. produced in the coil, when the rate of change of current in the coil is unity.
Mathematically e=-L *dI*/dt
The self-inductance of a coil also numerically equal to the induced e.m.f. produced in the coil, when the rate of change of current in the coil is unity.
Coefficient of mutual induction---. The coefficient of mutual induction or simply mutual inductance (M) of the two coils is numerically equal to the magnetic flux (p) linked with one coil, when a unit current flows through the neighbouring coil.
Mathematically- Ø = MI
The mutual inductance of two coils is also numerically equal to the induced emf. produced in one coil, when the rate of change of current is unity in the other coil.
Mathematically - e= -M *dI*/ *dt*
Unit. In SI, the unit of mutual inductance is henry (H).
Motional E.M.F.----- When a conductor of length / moves with a velocity v in a magnetic field B, so that magnetic field is perpendicular to both the length of the conductor and its direction of motion, the magnetic Lorentz force on the conductor gives rise to emf. across the two ends of the conductor.
Mathematically: e = Blv
Energy stored in an inductor. When a current! flows through an inductor of self-inductance L, the energy stored in the inductor is given by U=1/2 LI^2

Practice questions

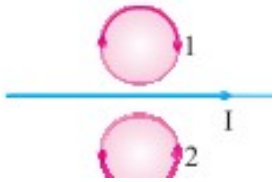
Q. An electric current flows in a horizontal wire from East to West. What will be the direction of magnetic field due to current at a point (i) North of wire; (ii) above the wire.

Ans. (i) Going into the plane of the paper. (ii) Going out of the plane of paper

2. What is the direction of induced currents in metal rings 1 and 2 seen from the top when current I in the wire is increasing steadily?

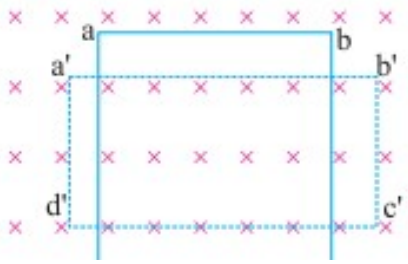


Ans.



Q. In an inductor L, current passed I0 and energy stored in it is U. If the current is now reduced to I0/2, what will be the new energy stored in the inductor?
Ans. U/4

Q A square loop a, b, c, d of a conducting wire has been changed into a rectangular loop a′, b′, c′, d′ as shown in figure. What is the direction of induced current in the loop?



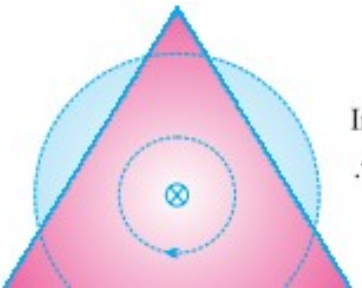
Ans. Clockwise

Q. A long straight wire with current i passes (without touching) three square wire loops with edge lengths 2L, 1.5L and L. The loops are widely spaced (so as do not affect one another). Loops 1 and 3 are symmetric about the long wire. Rank the loops according to the size of the current induced in them if current i is (a) constant and (b) increasing

Ans. (a) No induced current (b) Current will be induced only in loop 2

Q.A current carrying wire (straight) passes inside a triangular coil as shown in figure. The current in the wire is perpendicular to paper inwards. Find the direction of induced current in the loop if current in the wire is increasing with time.

Ans.



Induced emf =

∴ Induced cu

Magnetic field line are tangential to the triangular plane θ = 90º so φ = 0

Q. Mention True/False against sentances A and B.

A Self inductance of the coil Increases when an iron core is introduced in the core of the coil.

Ans True

B The rate of change of magnetic flux through a coil is maximum when a magnet is held stationary near the coil.

Ans. False

Q. If both the number of terms and core length of an inductor is doubled keeping other factors constant.Self Inductance will become

A Unaffected. B. doubled C. Halved D. quadrupled

Ans. B

Q.Henry is the SI unit of ----

A. Self-inductance B. Resistance C. Magnetic flux D. Capacitance

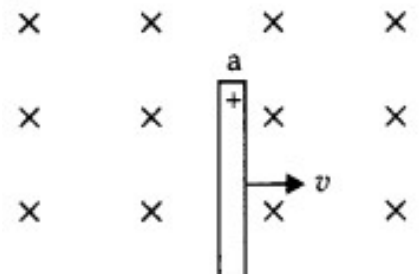
Ans.Self inductance

Q. State Lenz's law. Explain by giving examples that Lenz's law is a consequence of the law of conservation of energy.

Answer:
It states that the direction of induced emf in a coil is such that it opposes the cause of its production. Lenz's law is a consequence of the law of conservation of energy. To show it, let us consider a bar magnet pushed towards a conducting loop. When N-pole moves towards the loop, the face of the loop facing the North Pole develops north polarity as per Lenz's law so as to oppose the motion of the magnet.
Again, when N-pole moves away from the loop, the nearby face develops south polarity, thus opposing the motion of the magnet away from the loop. It means that the motion of the magnet is automatically opposed every time. Hence, some work is to be done on the magnet to move it and this mechanical work is transformed into electrical energy. Thus, the conservation law of energy is followed

Q. (a) State Faraday's laws of electromagnetic Induction.
Answer:
Faraday's Laws of electromagnetic induction
First law: Whenever the magnetic flux (inked with a circuit (or coil) changes, an emf is induced in the circuit. The induced emf lasts so Long as the change in the magnetic flux continues.
Second law:
The magnitude of induced emf in the circuit (or coil) is directly proportional to the rate of change of magnetic flux linked with the circuit.
i.e. $e = -d\phi/dt$

(b) Derive an expression for the emf induced across the ends of a straight conductor of length I moving at right angles to a uniform magnetic field B with a uniform speedy.
Answer:
Let a conductor ab of Length l be placed in a magnetic field $\vec{B}$ shown by (x) directed towards the reader. When the conductor moves with velocity v perpendicular to B, the force on any free electron of this conductor is given



$F = e\,vB \sin 90° = evß$
When this electron moves across the Length of the conductor, the work done by the electron
$W = F \times l = evBl$
After some time when all the free electrons are shifted towards the end b, the end b becomes negative and end a becomes positively charged.
Hence the net induced emf in the conductor
$E=evBl/e=Blv$

Q. Why does the acceleration of a magnet falling through a long solenoid decrease?
Ans. It decreases because of the opposing induced emf produced in the solenoid due to the rate of change of magnetic flux.

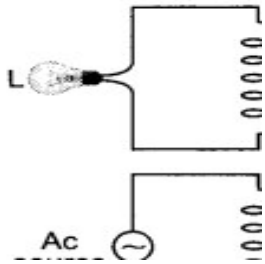
Q. A magnet is moved towards a coil and an electric charge is induced in it. If the resistance of the coil is increased, how will the induced charge change?
Ans. On increasing the resistance of the colt, the magnitude of induced charge decreases

Q. An air-core solenoid is connected to an ac source and a bulb. If an iron core Is inserted in the solenoid, how does the brightness of the bulb change? Give reasons for your answer.
Ans. Insertion of an iron core In the solenoid increases its inductance. This in turn increases the value of inductive reactance. This decreases the current and hence the brightness of the bulb

Q. An induced current has no direction of its own, comment.
Ans. Yes, it is perfectly correct to say that an induced current has no fixed direction of its own. The direction of induced current depends upon the change in magnetic flux because in accordance with Lenz's law the induced current always opposes the change in magnetic flux.

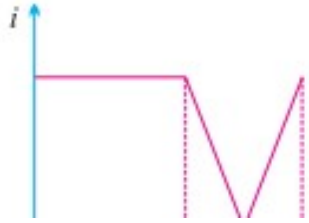
Q. In the given diagram a coil B is connected to a low voltage bulb L and placed parallel to another coil A as shown. Explain the following observations

(i) Bulb lights, and
(ii) Bulb gets dimmer if coil B is moved upwards.

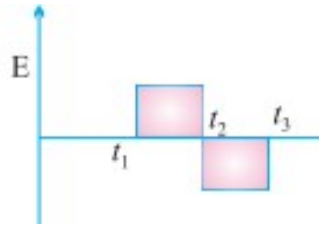


Answer:
(a) When ac is applied across coil A an induced emf is produced in coil B due to mutual induction between the two coils. This makes the lamp light up.
(b) When coil B is moved upwards the mutual induction and hence induced emf in coil B decreases. This makes the lamp dimmer.

Q. (i) A wire in the form of a tightly wound solenoid is connected to a DC source and carries a current. If the coil is stretched so that there are gaps between successive elements of the spiral coil, will the current increase or decrease? Explain.
(ii)A solenoid is connected to a battery so that a steady current flows through it. If an iron core is inserted into the solenoid, will the current increase or decrease? Explain
Answer
(i)The current will increase. As the wires are pulled apart the flux will leak through the gaps. Lenz's law demands that induced e.m.f. resist this decrease, which can be done by an increase in current .(ii) The current will decrease. As the iron core is inserted in the solenoid, the magnetic field increases and the flux increases. Lenz's law implies that induced e.m.f. should resist this increase, which can be achieved by a decrease in current.
Q. The current i in an induction coil varies with time t according to the graph Draw the graph of induced e.m.f. with time.



Ans.



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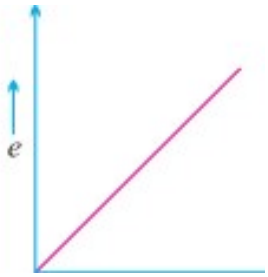
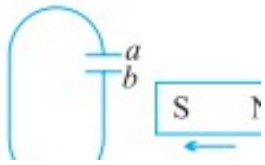
Q. A conducting rod held horizontally along East-West direction is dropped from rest at certain height near Earth's surface. Why should there be an induced e.m.f. across the ends of the rod? Draw a graph showing the variation of e.m.f. as a function of time from the instant it begins to fall.

Ans. Hint : e = BlV and V = gt



Q. Predict the polarity of the capacitor in the situation described in the figure below



Ans. Plate a will be positive with respect to 'b'. When the observer is looking from the side of moving bar magnet

Q. A circular coil rotates about its vertical diameter in a uniform horizontal magnetic field. What is the average emf induced in the coil?

Ans. Zero

Q. A square loop of side 12 cm with its sides parallel to X and Y-axis is moved with a velocity of 8 cm/s in positive x-direction. Magnetic field exists in z-directions.

(i) Determine the direction and magnitude of induced emf if the field changes with 10-3 Tesla/cm along negative z-direction.

(ii) Determine the direction and magnitude of induced emf if field changes with 10-3 Tesla/s along +z direction.

Ans. (i) Rate of change of flux = induced emf = (0.12)2 × 10-3× 8 = 11.52 × 10-5 Wb/s in +z direction.

Rate of change of flux = induced emf = (0.12)2 × 10-3 × 8 = 11.52 × 10-5 Wb/s in –z direction

Q. Magnetic flux linked with each turn of a 25 turns coil is 6 milliweber. The flux is reduced to 1 mWb in 0.5s. Find induced emf in the coil.

Ans. Induced emf $\varepsilon = -N\frac{d\emptyset}{dt} = 0.25\ volt$

Q.The magnetic flux linked with a closed circuit of resistance 8Ω varies with time according to the expression φ = (5t2 – 4t + 2) where φ is in millI weber and t in second. Calculate the value of induce current at t = 15 s.

Ans. E=−dϕ/dt=2V

Q. Show that the induced charge does not depend upon rate of change of flux.

Ans. $dq = \frac{N}{R}d\emptyset$

Q. A wire in the form of a tightly wound Solenoid is connected to a DC source, and carries a current. If the coil is stretched so that there are gaps between successive elements of the spiral coil, will the current increase or decrease? Explain?

Ans. When the coil is stretched so that there are gaps between successive elements of the spiral coil i.e. the wires are pulled apart which lead to the flux leak through the gaps. According to Lenz's law, the e.m.f. produced must oppose this decrease, which can be done by an increase in current. So, the current will increase.

Q. If the self-inductance of an air-core inductor increases from 0.01 mH to 10 mH on introducing an iron core into it, what is the relative permeability of the core used?

Answer:

We know that $\mu = L/L_0 = 10/0.01 = 1000$

Three Marks Question

Q. (a) Obtain the expression for the magnetic energy stored in a solenoid in terms of the magnetic field B, area A and length l of the solenoid.

(b) How is this magnetic energy per unit volume compared with the electrostatic energy per unit volume stored in a parallel plate capacitor?

Answer:

The magnetic field stored in a solenoid is given by the expression $U = -\frac{1}{2} Ll2$.

But for a solenoid $B = \mu_0 nl$

or

$l = B / \mu_0 n$

Substituting in the above expression we have

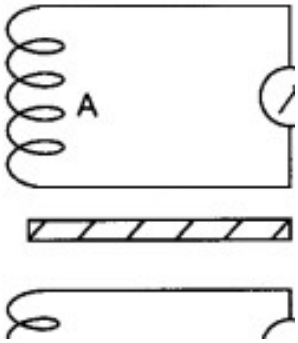
$U = 1/2 \times (\mu_0 n_2 A_l)(B/ \mu_0 n)2$as $L = \mu_0 n_2 A_l$

$U = 1/2 B_2 A_l / \mu_0$

We know that the energy stored per unit volume in a parallel plate capacitor is $UE = ½ \varepsilon_0 E^2$

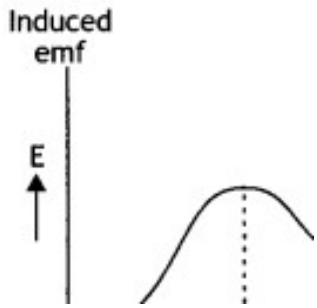
It is clear that in both cases the energy stored per unit volume is proportional to the square of the field intensity.

Q. A coil A is connected to a voltmeter V and the other coil B to an alternating current source D. If a large copper sheet C is placed between the two coils, how does the induced emf in coil A change due to current in coil B. Justify your answer.



Answer:

In the absence of sheet C, an induced emf is set up in coil due to mutual induction phenomenon when an alternating current is passed through coil B.



However, when induced copper sheet C is placed, eddy currents are set up in the sheet due to a change in flux.
Thus, now coil A has a positive effect due to coil B and a negative effect due to eddy currents in C. Consequently, the flux of coil A and hence the induced emf in coil A is decreased, i.e. the reading of voltmeter V is reduced.

ALTERNATING CURRENT

Alternating Current (AC) It is the current which varies in both magnitude as well as direction alternatively and periodically.

$I = I_m \sin \omega t$ where, I_m = peak value or maximum value of AC.

Alternating voltage:- It is the voltage which varies in both magnitude as well as direction alternately and periodically.

$V=V_m \sin \omega t$ where V_m = peak or maximum value of voltage.

The symbol used to represent the AC source in a given circuit as shown in figure

Average or Mean Value of current and voltage :

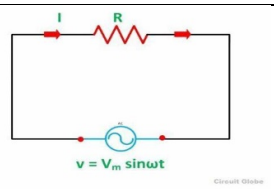
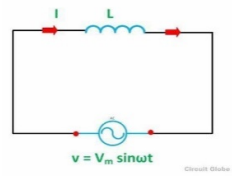
Average current	Average voltage
$I_{avg} = \frac{\int I\,dt}{\int dt}$ For a full cycle of ac source $I_{avg} = \frac{\int_0^T I\,dt}{\int_o^T dt}$ $= \frac{\int_0^T I_m \sin\omega t}{\int_0^T dt}$ $=0$ For a half cycle of ac source $I_{avg} = \frac{\int_0^{T/2} I\,dt}{\int_o^T dt}$ $= \frac{\int_0^{T/2} I_m \sin\omega t}{\int_0^T dt}$ $=2I_m/\pi$ $=0.637I_m$	$V_{avg} = \frac{\int V\,dt}{\int dt}$ For a full cycle of ac source $v_{avg} = \frac{\int_0^T V\,dt}{\int_o^T dt}$ $= \frac{\int_0^T V_m \sin\omega t}{\int_0^T dt}$ $=0$ For a half cycle of ac source $V_{avg} = \frac{\int_0^{T/2} V\,dt}{\int_o^T dt}$ $= \frac{\int_0^{T/2} V_m \sin\omega t}{\int_0^T dt}$ $=2V_m/\pi$ $=0.637V_m$

RMS Value of AC It is defined as the value of AC over a complete cycle which would generate same amount of heat in a given resistors that is generated by steady current in the same resistor and in the same time during a complete cycle.

RMS Current	RMS Voltage

Irms= $\sqrt{\frac{\int_0^T I^2\,dt}{\int_0^T dt}}$ = Im/ √2 =0.707 Im RMS Current is same for half or full cycle of AC	Vrms= $\sqrt{\frac{\int_0^T V^2\,dt}{\int_0^T dt}}$ = Vm/ √2 =0.707 Vm RMS Voltage is same for half or full cycle of AC

AC Through pure Resistor ,Inductor and Capacitor:-

Pure Resistor	Pure Inductor	Pure Capacitor
 I = Im sin ωt Im =Vm /R R-Resistance potential and current are in same phase Average power=Pav =I2rms /R Resistance does not depends on frequency	 I = Im sin (ωt-π/2) Im =Vm /XL XL-Inductive Reactance Potential leads current by 900 Average power= Pav =0 Inductive Reactance depends on frequency	I = Im sin (ωt+π/2) Im =Vm /XC XC- Capacitive Reactance Current leads potential by 900 Average power= Pav =0 Capacitive Reactance depends on frequency

Inductive Reactance (X_L) The opposing nature of inductor to the flow of current is called Inductive reactance.

$$X_L = \omega L = 2\pi f L$$

ω=Angular frequency

f = Linear frequency

L =Inductance of inductor

7. Capacitive Reactance (Xc) The opposing nature of capacitor to the flow of alternating current is called capacitive reactance.

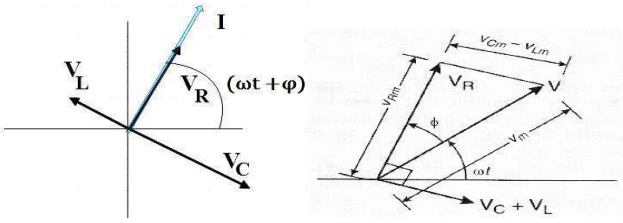
$$Xc = 1/\omega C = 1/2\pi f C$$

C= Capacitance of capacitor

L-C-R Series circuit:-

Alternating voltage = $V=V_m \sin \omega t$

Alternating current=I = I_m sin (ωt+∅)
∅ Is the angle between potential and current
Potential due to resistor ,capacitor and inductor are V_R = IR,V_C = IX_C and V_L= IX_L
Maximum potential due to resistor ,capacitor and inductor are VR_m =I_mR,V_{Cm} =$I_m X_C$ and V_{Lm}= $I_m X_L$
The phasor diagram of L-C-R circuit is



From the phasor diagram

$$v_m = \sqrt{V_{Rm}^2 + (V_{Cm} - V_{Lm})2}$$

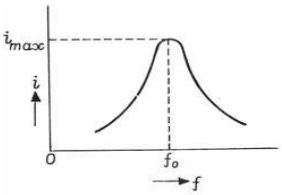
Impedance of L-C-R circuit is Z=Vm/Im = $\sqrt{R^2 + (X_C - X_L)^2}$

Phase angle:- Tan ∅ = $\frac{V_c - V_L}{V_R} = \frac{X_c - X_L}{R}$

Power factor of L-C-R circuit is cos∅

Resonance:-

If X_L=Xc ,then Impedance is minimum i.e Z=R and current passing through is maximum(Im) and the circuit is in resonance



Angular resonance frequency =$\omega_0 = \frac{1}{\sqrt{LC}}$

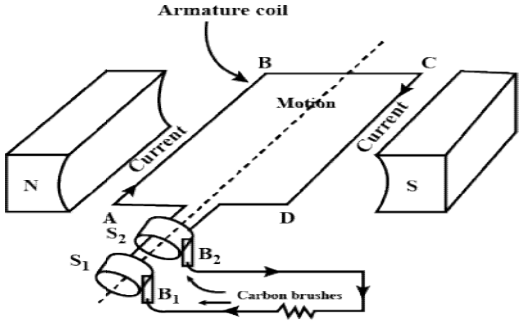
Linear resonance frequency=f0 =$\frac{1}{2\Pi\sqrt{LC}}$

Average power through AC circuit =P_{avg} =V_m I_m cos∅ /2
=V_{rms} I_{rms} cos∅
= I^2_{rms} Z cos∅

Watt less current(or) Idle current:-The average power consumed over a complete cycle in a purely inductive or purely capacitive circuit is zero,and thus the corresponding alter nating current referred as watt less current.

AC Generator:- AC generator is used to converts mechanical energy into electrical energy

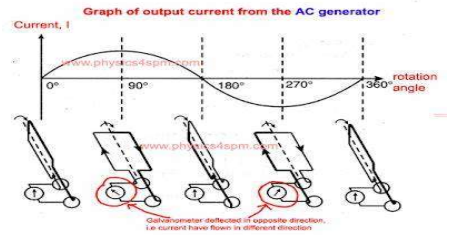
Principle:- AC generator working on the principle of Faraday's law of electromagnetic



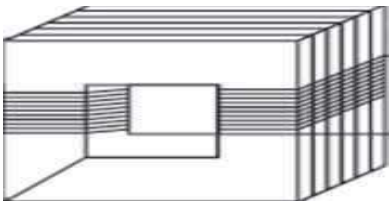
induction

The induced emf in an ac generator e=-Ndϕ/dt = -Nd(BAcosθ)/dt
e=$e_0$sinωt (e_0=Maximum emf=NBAω)
The induced emf changes alternately.so that emf is known as alternating emf

The induced current $I=e/R=I_0\sin\omega t$ **Io=Maximum current**



Transformer: Transformer is a device which is used to convert high potential low current into low potential high current and vice versa
Principle: The transformer works on the principle of mutual induction.



whenever the amount of magnetic flux linked with a coil changes, an e.m.f is developed in another coil.
The number of windings in primary and secondary of a trans former are NP and NS.
The induced emf in secondary coil ES =-NSdØ/dt
The back emf develops in primary EP = - NP dØ/dt
Transformer ratio = Es/Ep=Ns/Np
$=V_S/V_P$ = Ns/Np **($E_S=V_S$ and $E_P=V_P$)**
If the transformer is ideal, then input and out power is same
$P_{in} = P_{out}$
Transformer ratio= $V_S/V_P=I_P/I_S$= Ns/Np
step-up transformer:- Ns>Np and Vs>Vp (Is<Ip)
step-down transformer Ns<Np and Vs<Vp(Is>Ip)
Efficiency of a transformer $=\eta = \frac{P_0ut}{p_{1n}} * 100$
For an ideal transformer efficiency is 100% and other transformers < 100%.

Practice questions

Q.The phase difference between voltage and current in a capacitor in an ac circuit is
(A) $\frac{\pi}{2}$ (B) π (C) 0 (D)$\pi/3$
A:- (A)$\frac{\pi}{2}$
Q. Define the term watt less current?
A:- The average power consumed over a complete cycle in a purely inductive or purely capacitive circuit is zero,and thus the corresponding alter nating current referred as watt less current.

Q.The phase angle in L-C-R circuit is 900,then power factor becomes
A:- Zero

Q.The graph between inductive reactance and angular frequency of pure inductor circuit is
(A) Straight line (B)Parabola (C)Hyperbola (D)Rectangular hyperbola
A: Straight line

Q. At resonance of L-C-R circuit,the value of impedance is_____
A : Minimum

Q.In an a.c. circuit, the voltage and current are represented by V = 200 sin (100 π t)V I = 25 sin (100 π t + π/3)A .Find out the impedance of the circuit ?

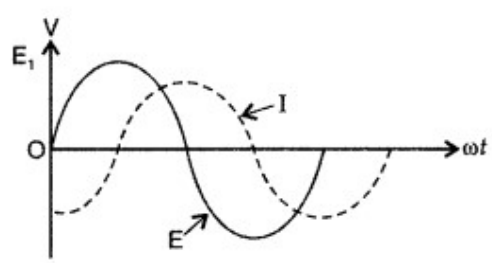
A: 8Ω
Hint :$Z=V_m/I_m$
Q. What is the voltage applied across the resonant circuit if the ac voltage across resistance R, inductance L and capacitance C is 5 V, 10 V and 10 V respectively.
(A)10V (B)15V (C) 5V (D) 20V
A :5V

Q. A power transmission line feeds input power at 2300 V to a step-down transformer with its primary windings having 4000 turns. The output power is delivered at 230 V by the transformer. If the current in the primary of the transformer is 5 A and its efficiency is 90%, the output current would be

(A) 25A (B) 50A (C) 45A (D) 30A
A : C
Hint: $\eta = Po/Pi = (V_0I_0=V_iI_i)$

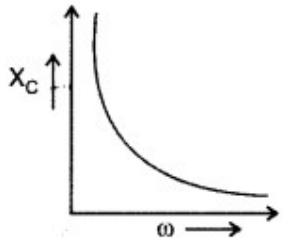
Q. An alternating voltage V(t) = 220 sin100πt volts is applied to a purely resistive load of 50Ω.Find out time taken for the current to rise from half of the peak value ?
A: 3.3ms
Hint $I=I_m\sin\omega t$
Q. What is the peak value of the voltage of an electric lamp connected to a 220 V, 50 Hz supply
(A)220V (B)311V (C) 211V (D)230V
Ans: B
Hint : $I_{rms} =I_m/\sqrt{2}$

Q. An alternating voltage is connected in series with a resistance r and an inductance L. If the potential drop across the resistance is 200 volt and across the inductance is 150 volt, the applied voltage is_____
A: 250 V Hint : $v = \sqrt{V_R^2 + (V_C - v_L)2}$ V_C =0
Q. Mention the two characteristic properties of the material suitable for making core of a transformer
A:- Characteristic properties of material suitable for core of a transformer :
1)It should have high permeability
2)It should have low hysteresis loss.
3)It should have high resistivity
Q. When an ac source is connected across an ideal inductor, show on a graph the nature of variation of the voltage and the current over one complete cycle?
Ans:-



Q. Plot a graph showing variation of capacitive reactance with the change in the frequency of the AC source?
A:- Graph showing a variation of xc capacitive reactance with the change in frequency of AC

source.

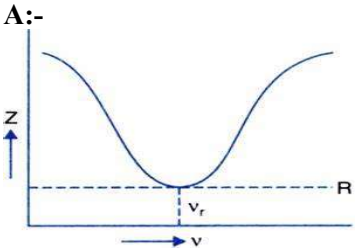


Q.Explain the different energy losses in a transformer?
A:- (i) Flux Leakage: There is always some flux leakage; that is, not all of the flux due to primary passes through the secondary due to poor design of the core or the air gaps in the core. It can be reduced by winding the primary and secondary coils one over the other.
(ii) Resistance of the windings: The wire used for the windings has some resistance and so, energy is lost due to heat produced in the wire . In high current, low voltage windings, these are minimized by using thick wire.
(iii) Eddy currents: The alternating magnetic flux induces eddy currents in the iron core and causes heating. The effect is reduced by using a laminated core.
(iv) Hysteresis: The magnetization of the core is repeatedly reversed by the alternating magnetic field. The resulting expenditure of energy in the core appears as heat and is kept to a minimum by using a magnetic material which has a low hysteresis loss

Q.The ratio of primary and secondary wsindings of a transformer are 2:50 and primary voltage is 5V.Find out its secondary voltage?
A:-125V Hint:-VS/VP=NS/NP

Q. Why is the use of a.c. voltage preferred over d.c. voltage? Give two reasons.
A: a.c. voltage is preferred over d.c. voltage because of following reasons :
1)it can be stepped-up or stepped-down by a transformer.
2)carrying losses are much less.

Q.Draw the graph of impedance and frequency of a L-C-R circuit ?
A:-



Q.The phase angle of L-C-R circuit is 900, then find out the power factor and average power in ac source?
A:- power factor =cos∅ =0
Average power =V_{rms} I_{rms} cos∅ =0

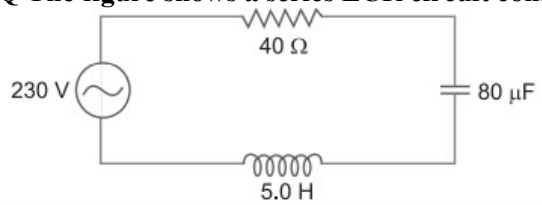
Q.The maximum voltage of ac source is 10V and linear frequency of a source is 60HZ ,Then write the equation of Instantaneous ac source and find the value of average value of ac source?
A:-V =10 sin120πt ,V_{avg}=2V_m/π =6.36V
Q. A light bulb is rated at 100W for a 220 V supply. Find (a) the resistance of the bulb; (b) the peak voltage of the source?
A:- R=V_2/P = 484Ω , V_m =$\sqrt{2}$ V_{rms} =311V

Q.The maximum value of alternating emf is 50V,then find out alternating emf at i)t=T/4 ii)t=T/6 and iii) t=T/12 ?
A;- i)50V ii)25$\sqrt{3}$ V iii)25V Hint: V =Vmsinωt

Q.An inductor of inductive reactance 40Ω and capacitor of capacitive reactance 70Ω and resistor of resistance 40Ω connected in an ac source,then find out impedence of the circuit?
A:- Z= $\sqrt{R^2 + (x_C - x_L)^2}$ **=50Ω**

Q. A 15.0 µF capacitor is connected to 220 V, 50 Hz source. Find the capacitive reactance and the rms current?
A:- $X_C = 1/\omega C$ **=212.3Ω ,** $I_{rms} = V/X_C$ **=1.04A**

Q The figure shows a series LCR circuit connected to a variable frequency 230 V source.



a)Determine the source frequency which drives the circuit in resonance.
b)Calculate the impedance of the circuit and amplitude of current at resonance
(Evaluation based)
A:- $f = 1/2\,\pi\sqrt{LC}$ **=25/π HZ Z=R=40Ω** $I_{max}=V_{max}/R$ **=8.1A**

Q. At a hydroelectric power plant, the water pressure head is at a height of 300 m and the water flow available is 100 m3 s-1. If the turbine generator efficiency is 60%, estimate the electric power available from the plant (g= 9.8 m s-2).

A: Height of water pressure head, h = 300 m
Volume of water flow per second, V = 100 m3 /s
Efficiency of turbine generator n = 60% = 0.6
Acceleration due to gravity, g = 9.8 m/s2
Density of water, ρ = 10 3 kg/m3
Electric power available from the plant = η × hρgV
= 0.6 × 300 × 10 3 × 9.8 × 100
= 176.4 × 10 6 W = 176.4 MW

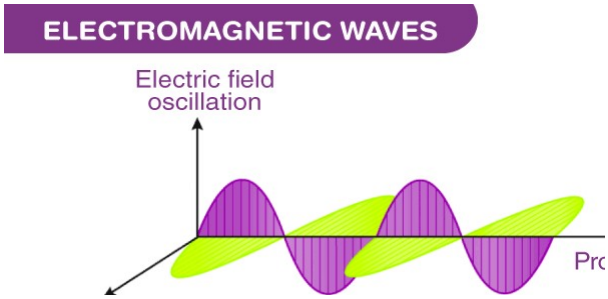
Q. A small town with a demand of 800 kW of electric power at 220 V is situated 15 km away from an electric plant generating power at 440 V. The resistance of the two wire line carrying power is 0.5 Ω per km. The town gets power from the line through a 4000-220 V step-down transformer at a sub-station in the town
(a) Estimate the line power loss in the form of heat.
(b) How much power must the plant supply, assuming there is negligible power loss due to leakage?
(c) Characterise the step up transformer at the plant.

Ans: Total electric power required, P = 800 kW = 800 × 10 3 W
Supply voltage, V = 220 V Voltage at which electric plant is generating power,
V‘ = 440 V Distance between the town and power generating station,
d = 15 km
Resistance of the two wire lines carrying power = 0.5 Ω/km
Total resistance of the wires, R = (15 + 15)0.5 = 15 Ω
A step-down transformer of rating 4000 − 220 V is used in the sub-station.
Input voltage, V_1 **= 4000 V**
Output voltage, V_2 **= 220 V**
Rms current in the wire lines is given as:
(a) Line power loss = I^2R **= (200) 2 × 15 = 600 × 10 3 W = 600 kW**

(b) Assuming that the power loss is negligible due to the leakage of the current: Total power supplied by the plant = 800 kW + 600 kW = 1400 kW
(c) Voltage drop in the power line = IR = 200 × 15 = 3000 V
Hence, total voltage transmitted from the plant = 3000 + 4000 = 7000 V Also, the power generated is 440 V.
Hence, the rating of the step-up transformer situated at the power plant is 440 V − 7000 V.
Q.A transformer is essentially an a.c. device. It cannot work on d.c. It changes alternating voltages or currents. It does not affect the frequency of a.c. It is based on the phenomenon of mutual induction. A transformer essentially consists of two coils of insulated copper wire having a different number of turns and wound on the same soft iron core. The number of turns in the primary and secondary coils of an ideal transformer is 2000 and 50 respectively. The primary coil is connected to the main supply of 120 V and the secondary coil is connected to a bulb of resistance 0.6Ω
(i) The value of voltage across the secondary coil is
(a)5V (b)2V (c)3V (d) 10V
(ii) The value of current in the bulb is
(a) 7 A (b) 15 A (c) 3 A d) 5 A
(iii) The value of current in the primary coil is
(a) 0.125 A (b) 2.52 A (c) 1.51 A (d) 3.52 A
(iv) Power in primary coil is
(a) 20W (b) 5W (c) 10 W (d) 15W
(v) Power in secondary coil is
(a) 15W (b) 20W (c) 7 W (d) 8W
Ans:- (i) c (ii)d (iii)a (iv)d (v)a
Hints:- $V_S / V_P = N_S / N_P = I_P / I_S$ $P_{in} = VpIp$ $P_{out} = V_S I_S$

ELECTROMAGNETIC WAVES

Displacement current is the current, which arises due to time rate of change of electric flux (p,) in some part of the electric circuit.
Mathematically- $I_D = \epsilon_o \, d\phi_B / dt$
When a capacitor is charged or a charged capacitor is allowed to discharge, the electric flux between the plates of the capacitor changes with time and it gives rise to displacement current between the plates.
The conduction and displacement currents are entirely different from each other. However, displacement current produces magnetic field in the same manner, as the conduction current does.
The displacement current is always equal to the conduction current.
Modified Ampere circuital law states that the line integral of magnetic field B over a closed path is equal to μo, times the sum of the conduction current (I) and the displacement current (I,) threading the closed path.
Mathematically- $\oint \vec{B} . \vec{dl} = \mu_o (I_C + \epsilon_o \, d\phi_B / dt)$
It is also known as Ampere-Maxwell's circuital law.
Following four equations, which describe the laws of electromagnetism, are called Maxwell's equations
$\oint \vec{E} . \vec{dS} = q / \epsilon_o$ (Gauss's law in electrostatics)
$\oint \vec{B} . \vec{dS} = 0$ (Gauss's law in magnetism)
$\oint \vec{E} . \vec{dl} = - d\phi_B / dt$ (Faraday's law of electromagnetic induction)
$\oint \vec{E} . \vec{dl} = \mu_o I$ (Ampere-Maxwell's circuital law)
Maxwell's equations are mathematical formulation of Gauss' law in electrostatics, Gauss' law in magnetism, Faraday's law of electromagnetic induction and Ampere's circuital law.



propagation, constitute electromagnetic waves.

***The direction of propagation of an electromagnetic wave is given by the cross product of electric field and magnetic field vectors**

***The electromagnetic waves are transverse in nature.**

***The velocity of electromagnetic waves in free space is given by c = 1 /√$\mu_o \in_o$ = 3 x 108 m/s**

***In a material medium, velocity of electromagnetic waves is given by v = 1/ √$\mu \in$**

***The ratio of the amplitudes of electric and magnetic fields is constant and it is equal to velocity of the electromagnetic waves in free space.**

Mathematically- E_0 /B_0 = c

***The energy in electromagnetic waves is divided equally between the electric and magnetic field vectors.**

***The electric vector of an electromagnetic wave is responsible for its optical effect. For this reason, the electric vector is also called light vector.**

***The energy transported by electromagnetic waves is given by U = hν = hc /λ**

where U is energy transported by electromagnetic waves in a given time and c is speed of electromagnetic waves in free space.

***The momentum transported by electromagnetic waves is given by p= U /c = $h\nu$/ c = h/ λ**

The intensity of electromagnetic waves i.e. energy crossing per second per unit area of a surface normally is given by I = 1/ 2 $\in o$ Eo 2

***When electromagnetic waves strike a surface, they exert pressure on the surface.**

***The orderly distribution of electromagnetic waves (according to wavelength or frequency) in the form of distinct groups, having widely differing properties, is called electromagnetic spectrum.**

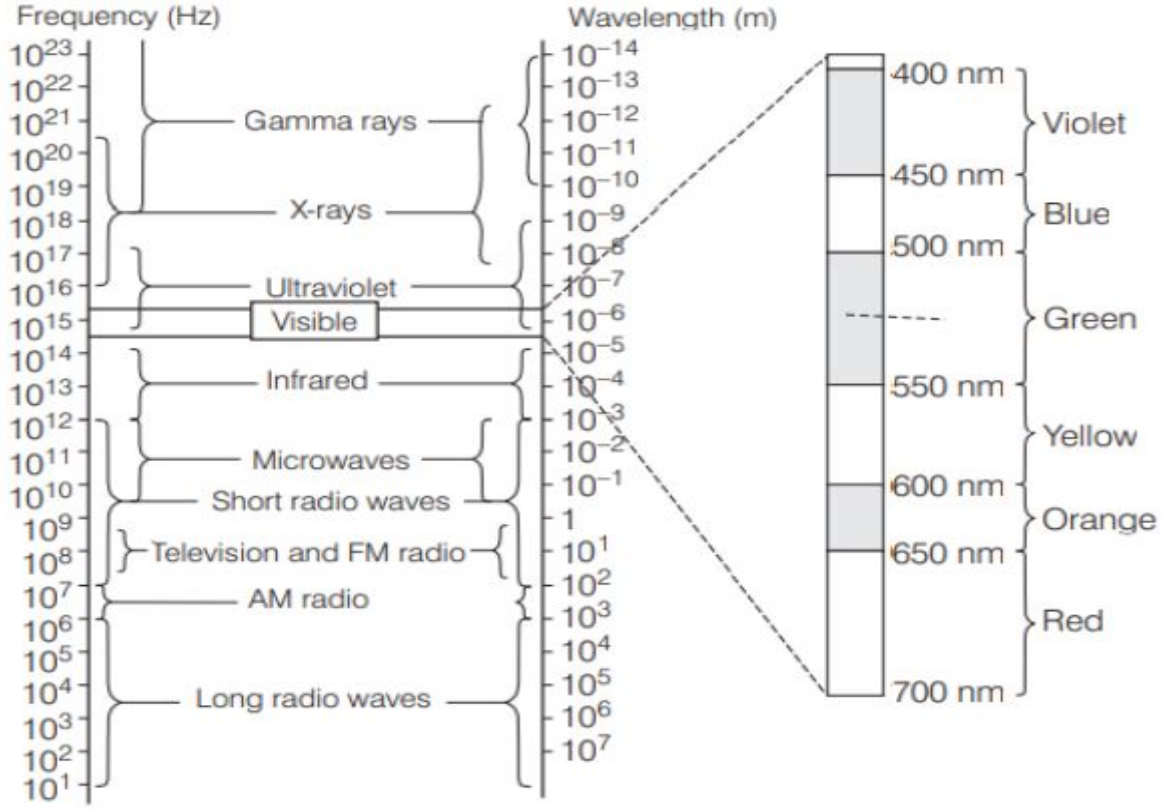
***The main parts of electromagnetic spectrum are namely- γ-rays, X-rays, ultra-violet rays, visible light, infrared rays, microwaves and radio waves.**

***The frequency of electromagnetic waves is its inherent characteristic. When an electromagnetic wave travels from one medium to another, its wavelength changes but frequency remains unchanged.**

***All the types of electromagnetic waves travel with the same speed in free space**

The orderly arrangement of EM waves in increasing or decreasing order of wavelength l and frequency n is called electromagnetic spectrum. The range varies from 10^{-12} m to 10^4 m, i.e. from γ-rays to radio waves.

Electromagnetic wave spectrum is shown below



Uses of Electromagnetic Spectrum

***γ-rays are highly penetrating; they can penetrate thick iron blocks. Due to high energy, they are used to initiate some nuclear reactions. γ-rays are produced in nuclear reactions. In medicine, they are used to destroy cancer cells.**
***X-rays are used in medical diagnostics to detect fractures in bones, tuberculosis of lungs, presence of stone in gallbladder and kidney. They are used in engineering to check flaws in bridges. In physics X-rays are used to study crystal structure.**
***Ultraviolet rays provide vitamin D. These are harmful for skin and eyes. They are used to sterilise drinking water and surgical instruments. They are used to detect invisible writing, forged documents, finger prints in forensic lab and to preserve food items.**
***Infrared rays are produced by hot bodies and molecules. These waves are used for long distance photography and for therapeutic purposes.**
***Radio waves are used for broadcasting programmes to distant places. According to frequency range, they are divided into following groups**
Medium frequency band or medium waves 0·3 to 3 MHz
Short waves or short frequency band 3 MHz — 30 MHz
Very high frequency (VHF) band 30 MHz to 300 MHz
Ultrahigh frequency (UHF) band 300 MHz to 3000 MHz
***Microwaves are produced by special vacuum tubes, namely; klystrons, magnetrons and gunn diodes. Their frequency range is 3 GHz to 300 GHz. They are used in RADAR systems for aircraft navigation and microwave used in homes.**

Practice questions

Q If λx, , λv represents wavelength of X-Rays, microwaves & visible rays then
(a) $\lambda m > \lambda x > \lambda v$ (b) $\lambda m > \lambda v > \lambda x$ (c) $\lambda v > \lambda x > \lambda m$ (d) $\lambda v > \lambda m > \lambda x$
ANS-B
Q In EM spectrum minimum wavelength is of:
(a) gamma rays (b) radio waves (c) visible rays (d) microwave.

ANS-A
Q Human body radiate
(a) microwave (b) X-rays (c) infrared rays (d) gamma rays.
ANS-C
Q Shorter the wavelength of an electromagnetic waves ,…….. energy it carries.
ANS- More [E=hc/λ]
Q Waves used to transmit cellular telephone message are…….
ANS- microwaves
Q If the earth did not have atmosphere, would its average surface temperature be higher or lower than what it is now?Explain.
ANS- lower because of absence of green house gases
Q A plane electromagnetic wave of frequency 25 MHz travels in free space along the x-direction. At a particular point in space and time$\vec{E} = 6.3\hat{j}$ V/m. What is $\vec{B}$ at this point ?
[HINT E/B=C]
ANS- TRUE
Q What does the displacement current $I_D = \varepsilon_0 \frac{dE}{dt}$ signify ?
Ans- It signifies that the changing electric field can give rise to a magnetic field.

Q i)A radio can tune in to any station in the 7.5 MHz to 12 MHz band. What is the corresponding wavelength band?
ii) A charged particle oscillates about its mean equilibrium position with a frequency of 109 Hz. What is the frequency of the electromagnetic waves produced by the oscillator?
[ANS i) Radio wave ii) frequency will be same it will not change,10^9 Hz.

Q i) Arrange the following electromagnetic waves in order of increasing frequency : Y -rays, microwaves, infrared rays and Ultraviolet rays
ii) Which of the following has the shortest wavelength : Microwaves, Ultraviolet rays, X-rays [Ans.
[Ans.i) Microwaves, infrared rays, Ultraviolet rays, Y - rays, ii) X-rays]
Q . State any four properties of electromagnetic waves.
[Ans. (i) do not require any material medium for their propagation (ii) transverse in nature (iii) do not get deflected by electric or magnetic fields (iv) same speed in vacuum for all waves]
Q Name the following constituent radiations of electromagnetic spectrum which
(i) are used in satellite communication/in radar and geostationary satellite
(ii) are used for studying crystal structure of solids
(iii) are similar to the radiations emitted during decay of radioactive nuclei.
(iv) used for water purification/ are absorbed from sunlight by ozone layer.
Ans. (i) microwaves (ii) x- rays (iii) - rays (iv) UV rays

Q In an electromagnetic wave the oscillating electric field having a frequency of 3 X1010 HZ and an amplitude of 30 V/m propagates in the positive x-direction.
(i) what is the wavelength of electromagnetic wave.
(ii) write down the expression to represent the corresponding magnetic field.
ANS

$$\lambda = \frac{c}{f} = \frac{3\,X\,10^8}{3\,X\,10^{10}} = 10^{-2}\ m \qquad \text{(ii)}\ B_0 = \frac{E_0}{c} = \frac{30}{3\,X\,10^8} = 10^{-7}\ T$$

$$\omega = 2\pi f = 2\pi\,X3\,X\,10^{10} = 6\pi\,X\,10^{10}\ \text{rad/s}\ \ \&\ \ K = \frac{2\pi}{\lambda} = \frac{2\pi}{10^{-2}} = 2\pi \times 10^2\ m^{-1}$$

$$B = B_0 \sin(\omega t - Kx) = 10^{-7} \sin(6\pi\,X\,10^{10}\,t - 2\pi\,\text{X}\,10^2\,x)\ ]$$

Q Which segment of electromagnetic waves has highest frequency ? How are these waves produced ? Give one use of these waves.
[Ans. γ-rays,Production : these are produced by Radioactive decay of the nucleus,
Use : used in medicine to destroy cancer cells]

Q What role does infra radiation play in (i) maintain the Earth's warmth, and (ii) Physical therapy ?
ANS-(i) Infrared radiations are absorbed by the earth's surface and radiated as longer wavelength infrared radiations. These radiations are trapped by green house gases such as CO2 and maintain the Earth's warmth. (ii) Infrared radiations are easily absorbed by the water molecules present in the body. After absorption, their thermal motion increases causes heating which is used as physical therapy

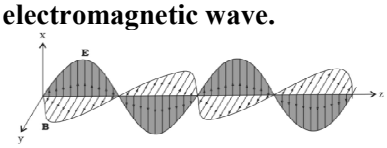
Q Identify the electromagnetic waves whose wavelength vary as and also write one use for each
10^{-11}m <λ < 10^{-14}m ii) 10^{-5}m <λ < 10^{-6}m
ANS- i) X-rays/$_\gamma$-rays used for medical purposes/ nuclear reactions
(ii) Infrared/ visible used for muscular treatment/ vision

Q Why is the thin ozone layer on the top of stratosphere is crucial for human survival ? Identify to which part of electromagnetic spectrum does this radiation belong and write one important application of the radiation.
ANS- Because ozone layer absorbs ultraviolet radiation coming from the sun and thus prevent these radiations from reaching the earth which causes Cancer.
Identification : Ultraviolet radiations, Application : Water purification/ forensics

Q Which em waves lie near the high frequency end of visible part of em spectrum ? Give its one use. In what way This component of light has harmful effects on humans ?
[Ans. used in LASIK eye surgery, UV lamps to kill germs in water (water purification) UV rays causes Skin Cancer/Sunburn/ harms eyes when exposed to direct UV rays]

Q . Do the electromagnetic waves carry energy and momentum ? How can we show that em waves carry momentum ?
ANS- [Yes, Electric charges present on a plane, normal to the direction of propagation of an em wave can be set and sustained in motion by the electric and magnetic fields of the electromagnetic wave. The charges thus acquire energy and momentum from the waves. If the total energy transferred to a surface in time is U, then the magnitude of the total momentum delivered to this surface (for complete absorption) is, p=$\frac{U}{c}$]

Q13 ENERGY ASSOCIATED WITH EM WAVES AND RADIANT PRESSURE
We know that in a region of free space with electric field E, there is an energy density ($\varepsilon_0 E^2/2$). Similarly, associated magnetic field B, magnetic energy density ($B^2/2\mu_0$). As electromagnetic wave contains both electric and magnetic fields, there is a non-zero energy density associated with it. Now consider a plane perpendicular to the direction of propagation of the electromagnetic wave.



If there are, on this plane, electric charges, they will be set and sustained in motion by the electric and magnetic fields of the electromagnetic wave. The charges thus acquire energy and momentum from the waves. This just illustrates the fact that an electromagnetic wave (like other waves) carries energy and momentum. Since it carries momentum, an electromagnetic wave also exerts pressure, called radiation pressure.
Write the expression which shows total energy associated with electromagnetic wave.
What do you mean by radiant pressure?
Is there any external energy required in sustaining electromagnetic waves in motion?
An em wave exerts pressure on the surface on which it is incident. Justify.
[ANS- iv) em waves carry momentum p=$\frac{U}{C}$ energy (hv) hence they exert a radiation pressure,p=f/a, f=$\frac{1}{a}\frac{dp}{dt}$

Q i)Which of the following, if any, can act as a source of em waves? Give reason.
a) a charge moving with a constant velocity.
b) a charge at rest.
c) a charge moving in a circular orbit.
ii) When can a charge acts as a source of em wave ?
Ans: i) C. Circular motion is an accelerated motion and accelerated charge produces em waves. when charge is either accelerated or oscillating.

QWrite two applications each of
a) microwaves b) infrared waves c)radio waves.

Q In a plane em wave, the electric field oscillates sinusoidally at a frequency of 2.0 X 10^{10} HZ and amplitude 48 V/m.
(i) what is the wavelength of the wave ?
(ii) what is the amplitude of oscillating magnetic field ?
(iii) show that the average energy density of the $\vec{E}$ field equals the average energy density of $\vec{B}$ the field.
[ANS- i)$\lambda=\frac{C}{n}$, ii)$B_0=\frac{E_0}{C}$ iii) $u_e=\frac{1}{2}\varepsilon_0 E^2$ by putting value E=Bc

Q Which constituent radiations of electromagnetic spectrum is used -
(i) in Radar
(ii) in photographs of internal parts of human body/as a diagnostic tool in medicine
(iii) for taking photographs of sky, during night and fog conditions.
(iv) has the largest penetrating power
Give reason for your answer in each case.
Ans- (i) microwaves because they go straight and are not absorbed by the atmosphere
(ii) x- rays because they can penetrate light elements (flesh)
(iii) Infrared rays, because they penetrate fog and are not absorbed by the atmosphere
(iv) γ-rays as they have the highest frequency and hence highest energy]

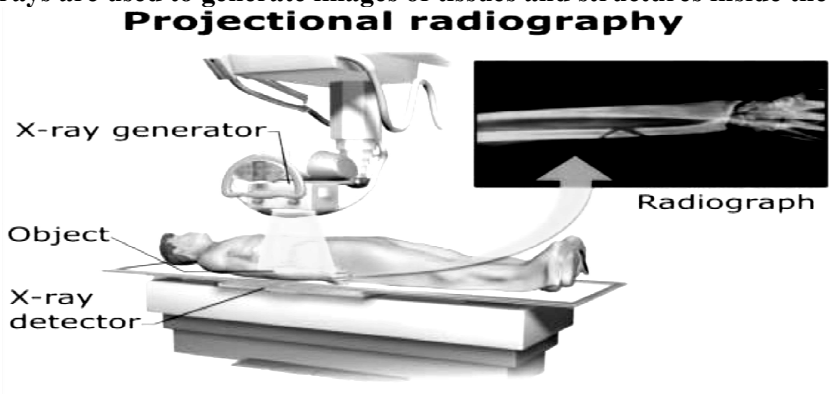
Q7 How are infrared rays produced ? Why are these referred to as " heat waves? Write their three important uses.Name the radiations which are next to these radiations in the electromagnetic spectrum having (a) shorterwavelength (b) longer wavelength.
ANS- Production : Infrared waves are produced by hot bodies due to the vibrations of their atoms/molecules.
Infrared rays are called heat waves because they produce heat when they fall on any object.
Uses : (i) in photography during fog (ii) treating muscular strain (iii) in remote controls of electronic devices
Radiations : (a) Visible light (b) Microwaves
Q a)Which physical quantity is same for x-rays of wavelength 10-10 m, red light of wavelength 6800 A0 and radio waves of wavelength 500 m?
b) Show that for em waves, the average energy density of electric field equals the average energy density of magnetic field.
ANS: a) speed in vacuum,
b)$U_E= 1/2\epsilon_0 E^2$, $U_B= 1/2\mu_0 B^2$,
using E= cxB and $c=1/\sqrt{\mu_0\epsilon_0}$,
$U_E=U_B$

Q The magnetic field in a plane electromagnetic wave is given by
By = (2×10^{-7}) T sin $(0.5\times10^3x+1.5\times10^{11}t)$
(a) What is the wavelength and frequency of the wave?
(b) Write an expression for the electric field.
[ans-(a) $\lambda=\frac{2\Pi}{k}$,$\nu=\frac{1}{T}$ (b)$E_0=B_0C$, $E_Z= 60\sin(0.5\ X\ 10^3x + 1.5X10^5t)$ V/m]

Q Suggest reasons, why

(a) food in metal containers cannot be cooked in a microwave oven.
(b) an empty glass container does not get hot in a microwave oven.
(C) Why are microwaves found useful for the radar systems in aircraft navigation ?
ANS- In a microwave oven, the frequency of microwaves is selected to match the resonance frequency of water molecules, so that the energy from the waves is transferred efficiently to the kinetic energy of the molecules. This raises the temperature of any food containing water.
(a) The atoms of the metallic container are set into forced vibrations by the microwaves. Due to this, energy of the microwaves is not efficiently transferred to the metallic container. Owing to this, food in metallic containers cannot be cooked in a microwave oven.
(b) The molecules of the glass container do not respond to the frequency of microwaves. Due to this, energy from the microwaves is not transferred to the glass container and hence it does not get hot in a microwave oven.
(C) Due to short wavelength, microwaves have high penetrating power with respect to atmosphere and are not diffracted by the obstacle in the path of their propagation.

Q.X-rays are a form of electromagnetic radiation, similar to visible light. Unlike light, however, x - rays have higher energy and can pass through most objects, including the body. Medical x-rays are used to generate images of tissues and structures inside the body



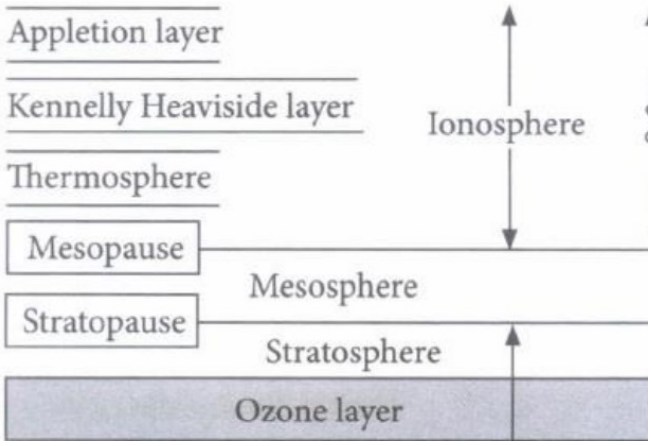
1. What is the most common method of preparation of X rays ?
a) magnetron valve b) vibration of atoms and molecules
c) bombardment of metal by high energy electrons d) radioactive decay of nucleus

2 Which of the following set of instrument /equipment can detect X- rays
a) Photocells, photographic film b) Thermopiles, bolometer
c) Photographic film, Geiger tube d) Geiger tube, human eye

3. Where do X rays fall on the electromagnetic spectrum?
a) Between UV region and infrared region b) Between gamma rays and UV region
c) Between infrared and microwaves d) Between microwaves and radio waves

4. What is the use of rays lying beyond X ray region in electromagnetic spectrum
a) used to kill microbes b) used to detect heat loss in insulated systems
c) used in standard broadcast radio and television d) used In oncology, to kill cancerous cells.
ANS - 1. c, 2a ,3 b,4a

Q. Radio waves are produced by the accelerated motion of charges in conducting wires. Microwaves are produced by special vacuum tubes. Infrared waves are produced by hot bodies and molecules also known as heat waves. UV rays are produced by special lamps and very hot bodies like Sun.



(1) Earth's atmosphere is richest in
(a) ultraviolet (b) infrared (c) X-rays (d) microwaves

(2) What is the cause of greenhouse effect?
(a) Infrared rays (b) Ultraviolet rays (c) X-rays (d) Radio waves

(3) Biological importance of ozone layer is
(a) it stops ultraviolet rays (b) It layer reduces greenhouse effect
(c) it reflects radio waves (d) none of these

(4) Ozone is found in
(a) stratosphere (b) ionosphere (c) mesosphere (d) troposphere

[ans- 1. b 2. a 3. a 4. a]

RAY OPTICS

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

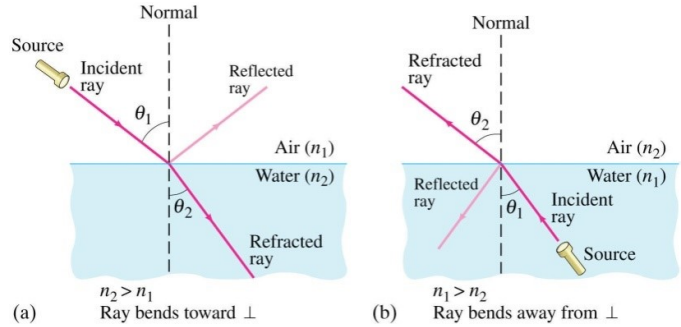
where, f=focal length, u=distance of the object from mirror, v=distance of image from mirror.
Focal length of mirror $f=\frac{R}{2}$ where, R= radius of curvature of mirror

Linear Magnification The ratio of the size of the image formed by a spherical mirror I to the size of the object O is called the linear magnification produced by the spherical mirror.

$$m=\frac{I}{O}=-\frac{v}{u}=\frac{f}{f-u}=\frac{f-v}{f}$$

Where, I=height of image and O= height of object, it is negative corresponding to real image and positive for virtual image.

Laws of Refraction



(i) incident ray, refracted ray and normal at the point of incidence all lie in the same plane.
(ii) The ratio of the sine of the angle of incidence to the sine of the angle of refraction is constant for the two given media. This constant is denoted by n and is called the relative refractive index.
n = sin i/sin r (Snell's law)
where, n is refractive index of the second medium when first medium is vacuum or air.
Refractive index of medium 2 w.r.t. medium 1 is denoted as n21 and defined as $n_{21} = \frac{n_2}{n_1} = \frac{v_1}{v_2} = \frac{\lambda_1}{\lambda_2}$ where, v1, λ1 are speed and wavelength of light in the first medium, similarly v2 and λ2 for second medium. n1 and n2 are absolute refractive indices of medium1 and medium 2 respectively.
Mathematically, absolute refractive index is given by $n = \frac{speed\ of\ light\ in\ vacuum}{speed\ of\ light\ in\ the\ material} = \frac{c}{v}$

Principle of reversibility of light states that when final path of a ray of light after any number of reflections and refractions is reversed, the ray retraces its entire path.

$$n_{21} \times n_{12} = 1\ or\ n_{21} = \frac{1}{n_{12}}$$

& Refractive index, $n = \frac{real\ depth}{apparent\ depth}$

Total Internal Reflection (TIR) When a ray of light travelling from denser medium to rarer medium is incident at the interface of two medium at an angle greater than the critical angle for the two media, the ray is totally reflected back to denser medium. This phenomenon is called Total Internal Reflection. It occurs only when angle of incidence in denser medium is greater (not equal) than critical angle, i.e. i> ic
Optical fibre, mirage, sparkling of diamond, totally reflecting prism, etc. work on the principle of total internal reflection.
Critical Angle (ic)- It is the angle of incidence in denser medium for which angle of refraction in rarer medium is 900. i.e. $n = \frac{1}{sini_c}$

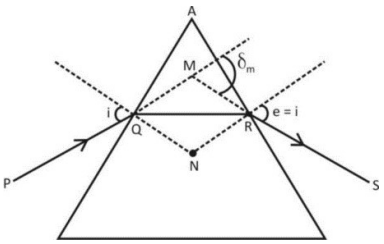
Refraction formula for refraction by convex or concave spherical refracting surface is given by $\frac{n_2}{v} - \frac{n_1}{u} = \frac{n_2 - n_1}{R}$ where n1, n2 are refractive indices of rarer and denser media respectively and u, v& R are to be taken with proper signs.
When refraction takes place denser to rarer medium, then $\frac{n_1}{v} - \frac{n_2}{u} = \frac{n_1 - n_2}{R}$
Lens maker's formula $\frac{1}{f} = (n_{21} - 1)(\frac{1}{R_1} - \frac{1}{R_2})$
Power of Lens The ability of a lens to converge or diverge the rays of light incident on it is called the power of the lens.
$P = \frac{1}{f(in\ m)}$ S.I. unit of power of lens is dioptre (D)=m^{-1}
Power of combination lenses in contact is given by

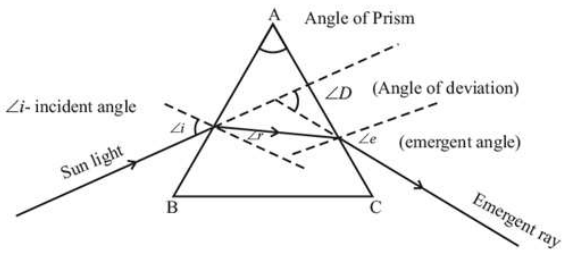
$$P = P_1 + P_2 + \cdots \ldots . + P_n$$

OR, $\frac{1}{f} = \frac{1}{f_1} + \frac{1}{f_2} + \cdots \ldots . + \frac{1}{f_n}$

Magnification by combination of lenses is given by m = m1 × m2 × m3 …….

(i) Prism have got the property of bending the incident light towards its base. A prism is a portion of a transparent medium bounded by two plane faces inclined to each other at a suitable angle.

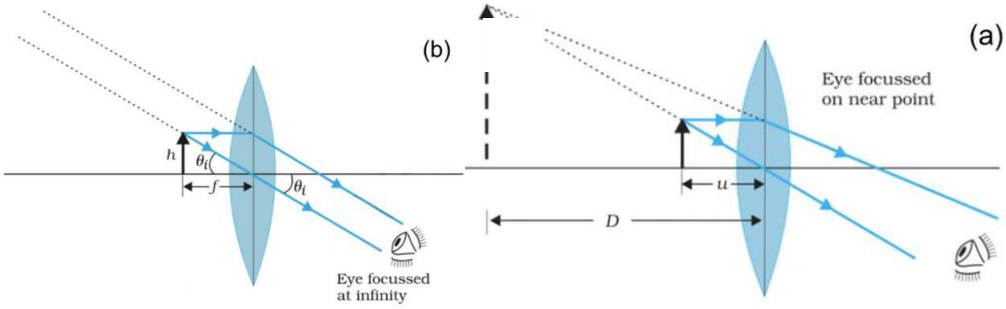




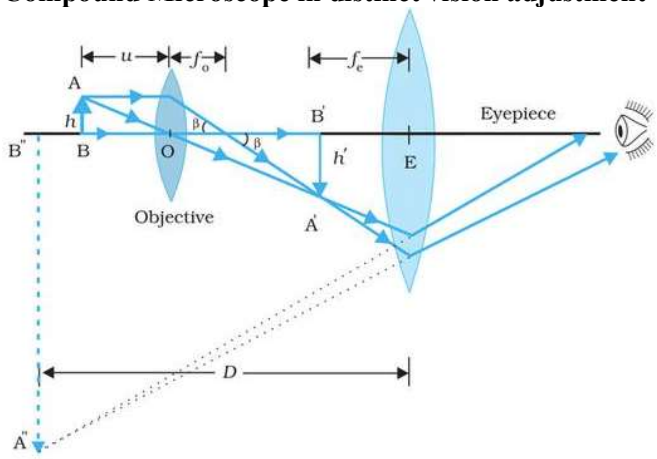
(ii) When the prism is adjusted at angle of minimum deviation, then
(a) angle of incidence is equal to the angle of emergence
(b) $i_1=i_2$, $r_1=r_2$, $\delta=\delta_m=2i$ and $2r=A$.
(c) $n = \frac{\sin\left(\frac{A+\delta_m}{2}\right)}{\sin\frac{A}{2}}$ and $\delta m=(n-1)A$ for small angle of prism

Dispersion by a Prism The phenomenon of splitting of light into its component colours is known as dispersion.
Angular Dispersion Angular dispersion produced by a prism for white light is the difference in the angles of deviation for two extreme colours i.e. violet and red.
Angular deviations for violet $\delta_v = (n_v - 1)A$
For Red, $\delta_R = (n_R - 1)A$ and for Yellow $\delta_Y = (n_Y - 1)A$
Dispersive power, $\omega = \frac{n_v - n_R}{n_y - 1} = \frac{\delta_v - \delta_R}{\delta_y} = \frac{Angular\ dispersion}{Mean\ deviation}$
Where, δ_y= mean deviation or deviation for yellow colour
Angular dispersion= $\delta_v - \delta_R$

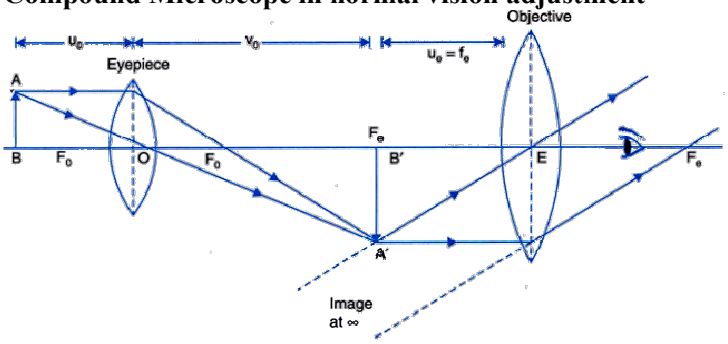
Magnifying power of simple microscope—
(i) when final image is formed at D m = 1 + D/f
(ii) when final image is formed at infinity m = D/f
17. Magnifying power of compound microscope---
(i) when final image at D $m = \frac{v_0}{-u_0}\left(1 + \frac{D}{f_e}\right)$
(ii) when final image at infinity $m = \frac{LD}{f_o f_e}$
18. Magnifying power of Telescope---
(i) when final image is formed at D $m = \frac{-f_0}{f_e}\left(1 + \frac{f_e}{D}\right)$
Length of tube $L = f_o + \frac{f_e D}{f_e + D}$
(ii) when final image at infinity $m = \frac{-f_0}{f_e}$
Length of tube $L = f_o + f_e$
Advantage of reflecting type telescope—
(i) Reflecting type telescopes using parabolic mirrors are free from chromatic and spherical aberrations. Hence sharp image of object is formed.
(ii) The parabolic mirrors of large aperture can be easily manufactured.
(iii) Reflecting type telescopes has good light gathering power and good resolving power.
Important ray diagrams-
(i) Simple Microscope in relax vision (ii) Simple Microscope in distinct vision



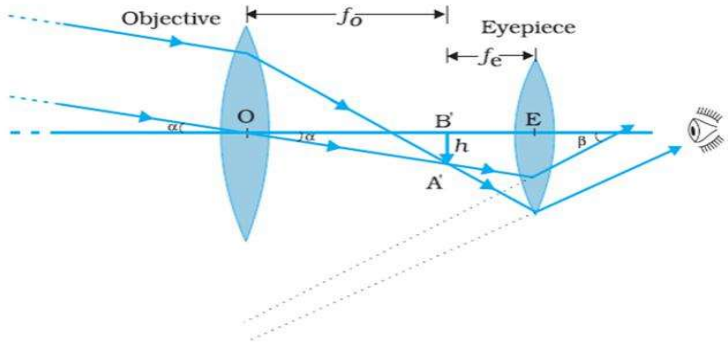
Compound Microscope in distinct vision adjustment



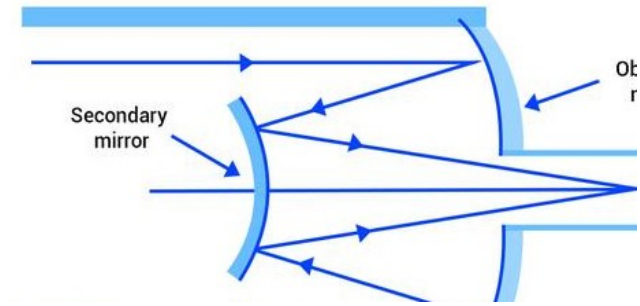
Compound Microscope in normal vision adjustment



Telescope in normal adjustment



(vii) Reflecting type Telescope



Practice questions

Q.Write two advantages of reflecting type telescope.

Q.What is the working principle of Optical fibers?
Ans Total Internal Reflection of light

Q.How does the angle of minimum deviation of a glass prism vary, if the incident violet light is replaced with red light?
Ans- We know that λ red > λ violet, therefore μ red < μ violet and hence δ red < δ violet. When incident violet light is replaced with red light, the angle of minimum deviation of a glass decreases.

Q.Two thin lenses of power -4D and 2D are placed in contact coaxially. Find the focal length of the combination.
Ans- Power of combination = – 4D + 2D = – 2D ∴ Focal length, f = – 50 cm

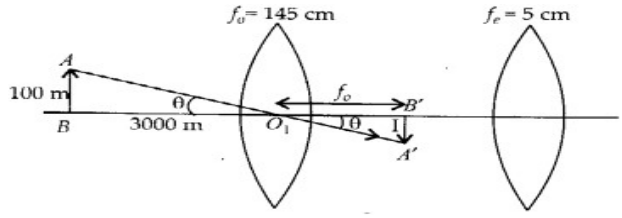
Q.A convex lens of focal length 30cm is in contact with a concave lens of focal length 20cm. Is the system a converging or a diverging lens?
Ans- Diverging

Q.Why must both the objective and the eyepiece of a compound microscope have short focal lengths?
Ans- Angular magnification of eye piece is (1+d/fe). This increases as fe decreases. Further, magnification of objective lens is υ/u. As object lies close to focus of objective lens u≈f0. To increase this magnification (υ/f0),f0 should be smaller.

Q.A small telescope has an objective lens of focal length 140cm and an eyepiece of focal length 5.0cm. What is the magnifying power of the telescope for viewing distant objects when

(1) the telescope is in normal adjustment (i.e., when the final image is at infinity)?
(2) the final image is formed at the least distance of distinct vision (25cm)?
(3) what is the separation between the objective lens and the eyepiece?
(4) If this telescope is used to view a 100 m tall tower 3 km away, what is the height of the image of the tower formed by the objective lens?

Ans- 1) m=f0/fe = 28
2) $\boldsymbol{m} = \frac{-f_0}{f_e}(\mathbf{1} + \frac{f_e}{D})$ = 33.6
3) $\boldsymbol{L} = \boldsymbol{f_o} + \boldsymbol{f_e}$=145cm4)



A'B'= 140X100/3000 =4.7cm

Q.Draw a schematic arrangement of a reflecting telescope (Cassegrain) showing how rays coming from a distant object are received at the eye-piece.

Q.The radii of curvature of the faces of a double convex lens are 10 cm and 15 cm. If focal length of the lens is 12 cm, find the refractive index of the material of the lens.
Ans n= 1.5
Q.A converging lens of refractive index 1.5 is kept in a liquid medium having same refractive index. What would be the focal length of the lens in this medium?
Ans Infinite/Not defined

Q.How does the angle of minimum deviation of a glass prism of refractive index 1.5 change, if it is immersed in a liquid of refractive index 1.3?
Ans:- decrease
Q.When light travels from a rarer to a denser medium, the speed decreases. Does this decrease in speed imply a decrease in the energy carried by the light wave? Justify your answer.
Ans:-1- No, the energy carried by the lightwave remains the same. Reason : As energy E = hv
Q.Which two of the following L1 , L2 and L3 will you select as objective and eyepiece for constructing best possible (i) telescope (ii) microscope? Give reason to support your answer.

Lens	Power (P)	Aperture (A)
L1	6D	1cm
L2	3D	8cm
L3	10D	1cm

Ans.(i) Telescope : L2 : objective, L3 = eyepiece
Reason : Light gathering power magnifying power will be larger.
(ii) Microscope : L3 : objective, L1 = eyepiece
Reason : Angular magnification is more for short focal length of objective and eyepiece.

Q.A convex lens, of focal length 25 cm, and a convex mirror, of radius of curvature 20 cm, are placed co-axially 40 cm apart from each other. An incident beam, parallel to the principal axis, is incident on the convex lens. Find the position and nature of the image formed by this combination.
Ans 6cm

Q.Plane and convex mirrors produce virtual images of objects. Can they produce real images under some circumstances? Explain
A virtual image, we always say, cannot be caught on a screen. Yet when we 'see' a virtual image, we are obviously bringing it on to the 'screen' (i.e. the retina) of our eye. Is there a contradiction?
Ans:-In this situation when rays are convergent behind the mirror, both plane mirror and convex mirror can form real images of virtual objects.
Here, the retina is working as a screen, where the rays are converging, but this screen is not at the position of formed virtual image, in fact the reflected divergent rays are converged by the eye lens at retina. Thus, there is no contradiction.

(Competency based question)

Q.A ray 'PQ' of light is incident on the face AB of a glass prism ABC and emerges out of the face AC. Trace the path of the ray. Show that ∠i + ∠e = ∠A + ∠δ where δ and e denote the angle of deviation and angle of emergence respectively. Plot a graph showing the variation of the angle of deviation as a function of angle of incidence. State the condition under which ∠δ is minimum.

Q.An equiconvex lens of refractive index μ_1, focal length 'f' and radius of curvature 'R' is

immersed in a liquid of refractive index μ_2. For
(i) μ_2 μ_1, and

(ii) $\mu_2 < \mu_1$,
draw the ray diagrams in the two cases when a beam of light coming parallel to the principal axis is incident on the lens. Also find the focal length of the lens in terms of the original focal length and the refractive index of the glass of the lens and that of the medium.
Ans:- 2 (i) The ray diagrams are as shown below:

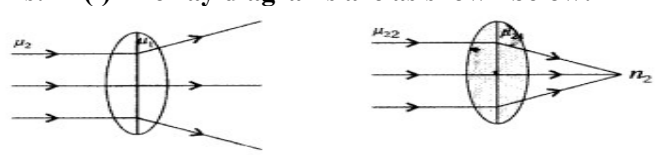


Figure (i) $\mu_1 < \mu_2$ *Figure (ii)* $\mu_1 > \mu_2$

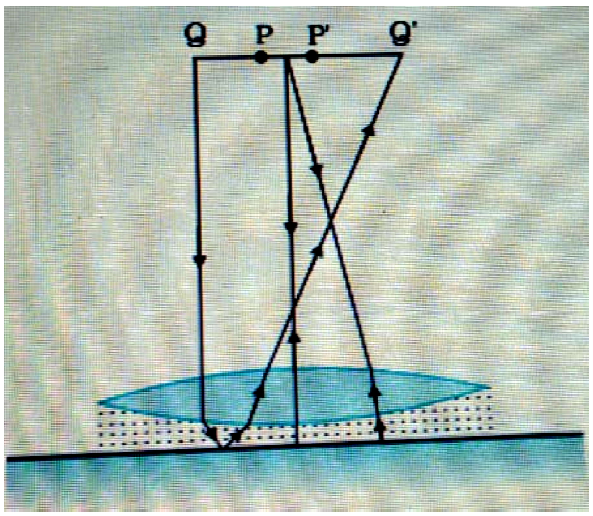
$$(ii)\quad \frac{1}{f_1} = (\mu_1 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right),\quad \frac{1}{f_2} = (\mu_2 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$

$$\frac{\frac{1}{f_1}}{\frac{1}{f_2}} = \frac{(\mu_1 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)}{(\mu_2 - 1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)} \Rightarrow \frac{f_2}{f_1} = \frac{(\mu_1 - 1)}{(\mu_2 - 1)}$$

$$\text{Hence}\quad f_2 = \frac{(\mu_1 - 1)}{(\mu_2 - 1)} \times f_1$$

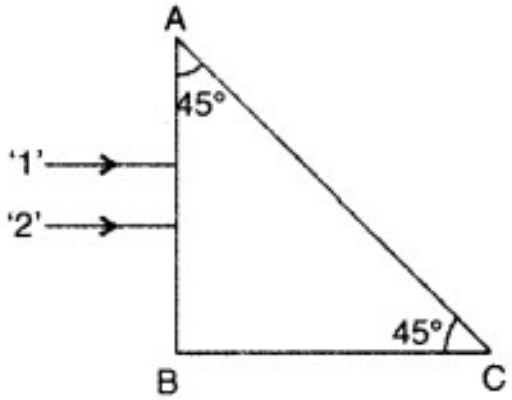
Q.An optical instrument uses eye-lens of power 16 D and objective lens of power 50 D and has a tube length of 16.25 cm. Name the optical instrument and calculate its magnifying power if it forms the final image at infinity.
Ans;- 3- The optical instrument is Compound Microscope

Q.Figure shows an equiconvex lens (of refractive index 1.50) in contact with a liquid layer on top of a plane mirror. A small needle with its tip on the principal axis is moved along the axis until its inverted image is found at the position of the needle. The distance of the needle from the lens is measured to be 45.0cm. The liquid is removed and the experiment is repeated. The new distance is measured to be 30.0cm. What is the refractive index of the liquid?



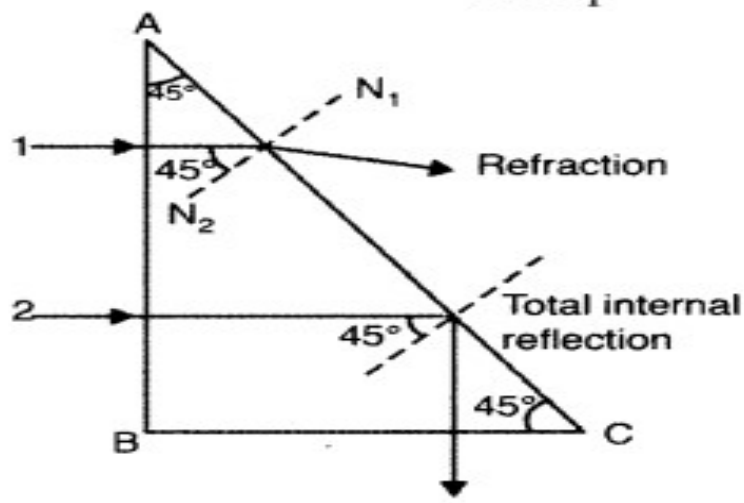
Ans –n=4/3

Q.Two monochromatic rays of light are incident normally on the face AB of an isosceles right angled prism ABC. The refractive indices of the glass prism for the two rays '1' and '2' are respectively 1.35 and 1.45. Trace the path of these rays entering through the prism.



Ans.

(i) *For the ray 1,* $\mu_1 = \frac{1}{\sin C_1}$



$$\sin C_1 = \frac{1}{\mu_1} = \frac{1}{1.35} = 0.74$$

$$\angle C_1 = 48° \text{ more than } 45°$$

Since the angle of incidence (45°) is less than the critical angle (48°), the ray will be refracted.

(ii) For the ray 2,

$$\sin C_2 = \frac{1}{\sin \mu_2} = \frac{1}{1.45} = 0.68$$

$$\angle C_2 = 43° \text{ less than } 45°$$

Since the angle of incidence (45°) is more than the critical angle (43°), the ray will be total internally reflected.

Q.The angle subtended at the eye by an object is equal to the angle subtended at the eye by the virtual image produced by a magnifying glass. In what sense then does a magnifying glass provide angular magnification?

In viewing through a magnifying glass, one usually positions one's eyes very close to the lens. Does angular magnification change if the eye is moved back?

Magnifying power of a simple microscope is inversely proportional to the focal length of the lens. What then stops us from using a convex lens of smaller and smaller focal length and achieving greater and greater magnifying power?

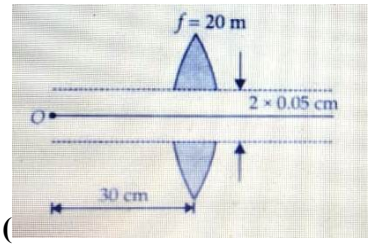
Ans:-

In magnifying glass the object is placed closer than 25 cm, which produces image at 25 cm. This closer object has larger angular size than the same object at 25 cm. In this way although the angle subtended by virtual image and object is same at eye but angular magnification is achieved.

On moving the eye backward away from lens the angular magnification decreases slightly, as both the angle subtended by the

image at eye 'a' and by the object at eye 'α' decreases. Although the decrease in angle subtended by object a is relatively smaller.
If we decrease focal length, the lens has to be thick with smaller radius of curvature. In a thick lens both the spherical aberrations and chromatic aberrations become pronounced. Further, grinding for small focal length is not easy. Practically we can not get magnifying power more than 3 with a simple convex lens.
Q.A convex or converging lens is thicker at the centre than at the edges. It converges a parallel beam of light on refraction through it. It has a real focus.
Convex lens is of three types: (A) Double convex lens (B) Plano-convex lens (C) Concavo-convex lens. Concave lens is thinner at the centre than at the edges. It diverges a parallel beam of light on refraction through it. It has a virtual focus.

(i)A point object 0 is placed at a distance of 0.3 m from a convex lens (focal length 0.2 m) cut into two halves each of which is displaced by 0.0005 m as shown in figure. What will be the location of the image?



(

a) 30cm right of lens (b) 60cm right of lens (c) 70cm left of lens (d) 40cm left of lens
(ii)Two thin lenses are in contact and the focal length of the combination is 80 cm. If the focal length of one lens is 20 cm, the focal length of the other would be
(a)-26.7cm (b) 60cm (c) 80cm (d) 20cm

(iii)A spherical air bubble is embedded in a piece of glass. For a ray of light passing through the bubble, it behaves like a
(a) converging lens (b) diverging lens (c) plano-converging lens (d) plano-diverging lens

(iv)Lens used in magnifying glass is
(a) concave lens (b) convex lens (c) both (d) none of these

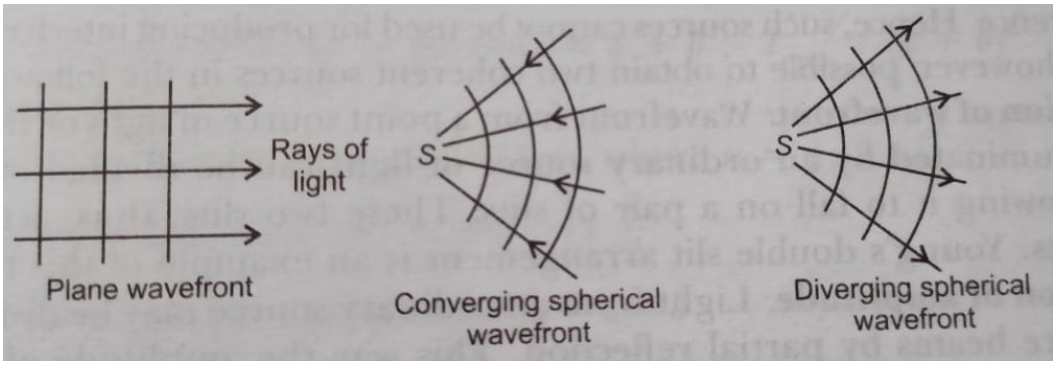
(v)The magnification of an image by a convex lens is positive only when the object is placed
(a) at its focus F (b)between F and 2F (c) at 2F (d)between F and optical centre

Ans- (i) b (ii) a (iii) b (iv) b (v) d

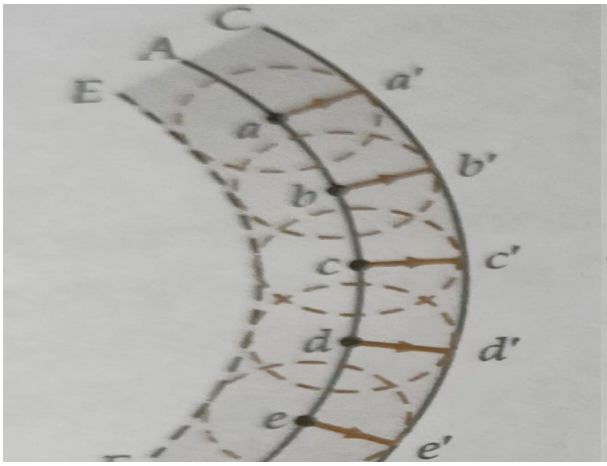
WAVE OPTICS

Wavefront: A locus of points oscillating in same phase in the path of light is called a wavefront.

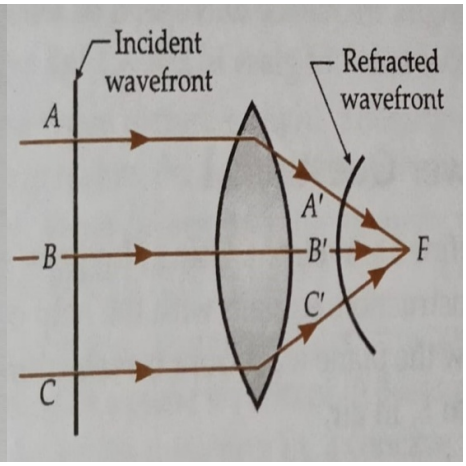
Types of wavefront: spherical wavefront , cylindrical wavefront and plane wavefront
Spherical wavefront is produced by a point source.
Cylindrical wavefront is produced by linear light source.
A small part of a spherical or a cylindrical wavefront originating from a distant source of light can be considered as a plane wavefront.



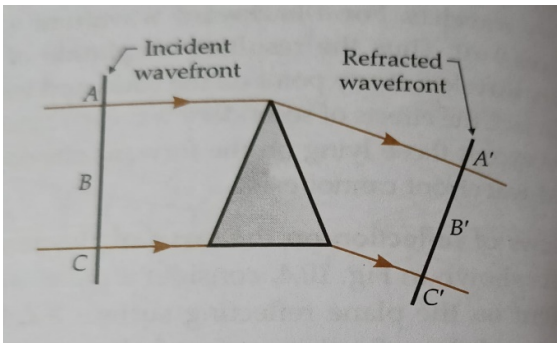
Huygen's principle: Each point of the wavefront is the source of a secondary disturbance. The secondary wavelets from each point of the wavefront spread out in all directions with the speed of light .A common tangent drawn to all secondary wavelets gives the new position of the wavefront at a later time.
To construct the new wavefront from a wavefront by using Huygen's principle , arcs of radius equal to the products of speed of light and time are drawn from each point of disturbance of initial wavefront . A common tangent drawn to all these arcs gives the position of new wavefront.

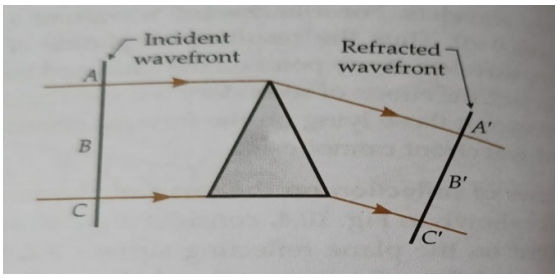


Backward wavefront does not exist .

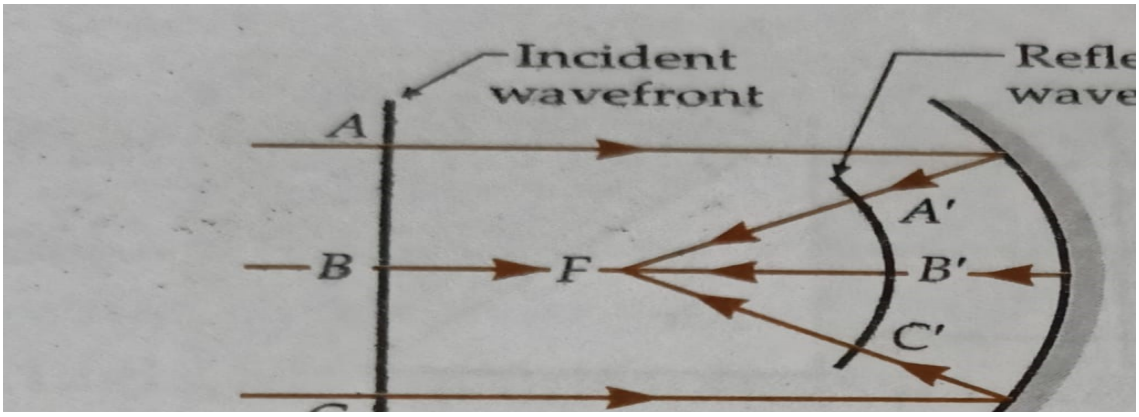


Refraction of plane wavefront



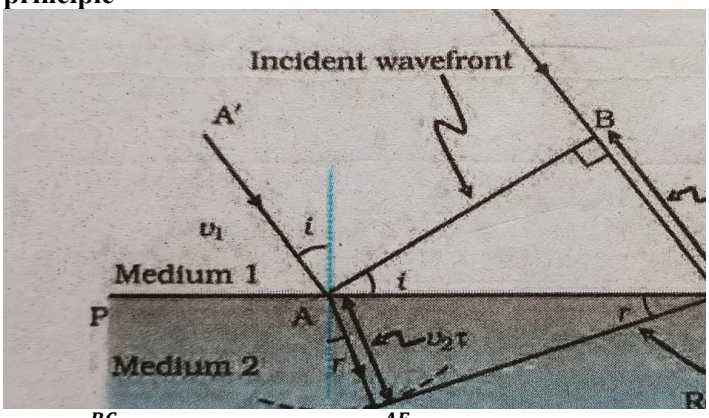


through a prism



RELECTED WAVEFRONT FORMED BY A CONCAVE MIRROR

Proof of laws of refraction of light from rarer medium to denser medium by Huygen's principle



Sin i = $\frac{BC}{AC}$ **sin r = $\frac{AE}{AC}$**

$\frac{\sin i}{\sin r} = \frac{BC}{AE}$

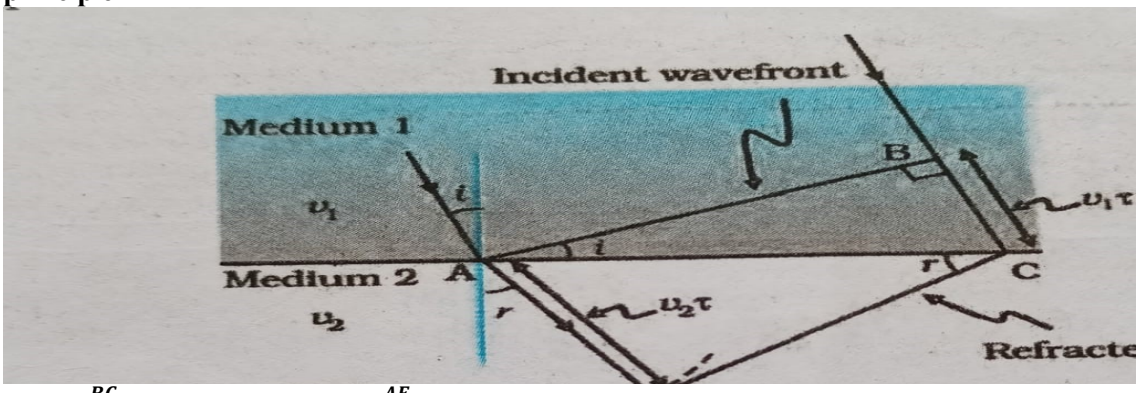
BC= v1 τ **AE = v2 τ**

So $\frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{v1\,\tau}{v2\,\tau} = \frac{v1}{v2}$= n21 = refractive index of 2nd medium with respect to 1st medium

This proves 2nd law of refraction of light.

From the figure, we see that the incident ray ,the refracted ray and the normal lie on the same plane. This proves 1st law of refraction of light.

Proof of laws of refraction of light from denser medium to rarer medium by using Huygen's principle



Sin i = $\frac{BC}{AC}$ **sin r = $\frac{AE}{AC}$**

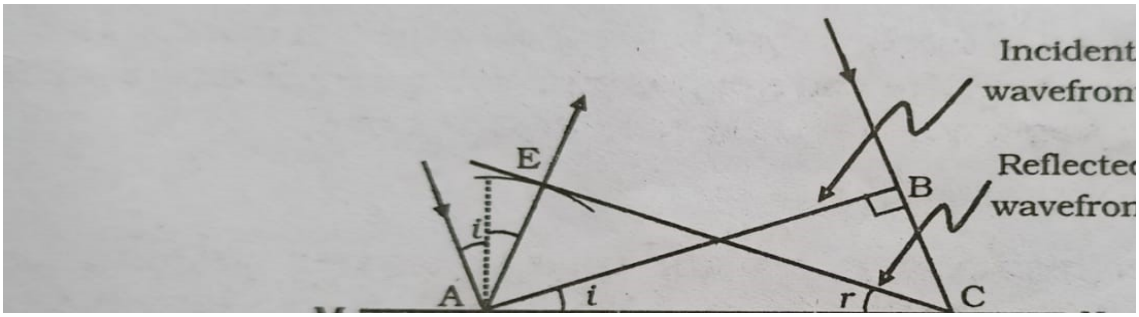
$\frac{\sin i}{\sin r} = \frac{BC}{AE}$

BC= v1 τ **AE = v2 τ**

So $\frac{\sin i}{\sin r} = \frac{BC}{AE} = \frac{v1\,\tau}{v2\,\tau} = \frac{v1}{v2}$= n21 = refractive index of 2nd medium with respect to 1st medium

From the figure, we see that the incident ray , the refracted ray and the normal lie on the same plane.
Thus, laws of refraction of light are proved.

PROOF LAWS OF REFLECTION OF LIGHT BY HUYGEN'S PRINCIPLE



Here BC = vτ where v = speed of wave and τ = time taken by the incident wavefront from B to C
From the diagram, we get AE = BC = vτ
Triangle EAC and triangle BAC are congruent.
So angles i and r are equal.
From the figure, we find that the incident ray, the reflected ray and the normal lie on the same plane.
Thus , laws of reflection of light are proved.

Coherent sources: Sources emitting light waves of same frequency or wavelength having either a zero or a constant phase difference are called coherent sources.
Interference of light: The phenomenon of redistribution of light energy in a medium due to superposition of light waves from two coherent sources is called interference.
Conditions for stable interference pattern
1.Two sources of light should produce waves of same wavelength.
2. Two sources should be coherent.
3. Amplitudes of two waves should be either equal or nearly equal for good contrast.

Young's double slit experiment

This is an experiment conducted to produce interference pattern on a screen.
Fringe width
Separation between the centres two consecutive maxima or minima is called fringe width.
Diffraction of light : The phenomenon of bending of light around the corners of an obstacle or aperture is called diffraction .
In diffraction of light at a single slit , we get a central maximum and secondary maxima around it of rapidly falling intensities. In between the maxima , we get the secondary minima.

Formulae for wave optics

Conditions for constructive interference
Path difference between two waves = nλ where n= 0,1,2,3,……..
Phase difference between two waves = 2nπ where n= 0,1,2,3,……..
Conditions for destructive interference
Path difference between two waves = (n+ $\frac{1}{2}$)λ where n= 0,1,2,3,……..
Phase difference between two waves = (n+ $\frac{1}{2}$)2π where n= 0,1,2,3,……..
Resultant displacement due to superposition of two waves = y = 2a cos ($\phi/2$) cos($\omega t + \phi/2$)
Amplitude of resultant displacement due to superposition of two waves = 2a cos ($\phi/2$)
Here a= amplitude of each wave and ϕ = phase difference between two waves
Intensity at the point of interference = I = 4 I0 cos^2 ($\emptyset/2$)
Here $I_0 = a^2$ and a = amplitude of each wave
Fringe width in interference = $\beta = \frac{D\lambda}{d}$
Where D = distance between screen and slits , λ = wavelength of monochromatic light and d = distance of separation between two slits

The angular width of an interference fringe = $\theta = \frac{\beta}{D} = \frac{\lambda}{d}$

When the entire apparatus of Young's double slit experiment is immersed in a transparent medium of refractive index , the new fringe width is given by $\beta' = \frac{\beta}{\mu} = \frac{D\lambda}{\mu d}$

Conditions for nth secondary maximum in diffraction of light at a single slit

Path difference between light waves coming from two different points of a wavefront = a sin θ = (n+1/2) λ where n= +1 or -1 , + 2 or – 2 , +3 or -3 and so on

Here a = width of single slit and θ = angle of diffraction of light

Conditions for nth secondary minimum in diffraction of light at a single slit

Path difference between light waves coming from two different points of a wavefront = a sin θ = nλ where n= +1 or -1 , + 2 or – 2 , +3 or -3 and so on

Here a = width of single slit and θ = angle of diffraction of light

Linear width of central maximum in diffraction of light at a single slit = $\frac{2D\lambda}{a}$

Angular fringe width of central maximum = $\frac{2\lambda}{a}$

Linear width of secondary maximum = $\frac{D\lambda}{a}$

Angular width of secondary maximum = $\frac{\lambda}{a}$

Practice questions

Q.When can we say that two sources of light are coherent sources ?

Hint: two sources emitting light waves of constant phase difference or having same phase and having same frequency and same wavelength

Q.Write the condition for constructive interference of light.

Hint: Path difference between two light waves = nλ/2 where n = 0,1,2,3,…….

Q.Name the wavefront that will emerge from a distance source of light like a star.

Hint: plane wavefront

Q.State the essential condition for diffraction of light.

Hint Size of slit/ aperture must be of the order of wavelength of light.

Q.What is the phase difference between two points on a cylindrical wavefront?

Ans. Zero.

Q.In a single slit diffraction pattern, how does the angular width of central maximum change when width of the slit is decreased ?

Hint: Angular width of central maximum = θ = $\frac{2\lambda}{d}$ If d → decreases Angular width increases.

Q.Why do secondary maxima get weaker in intensity with increasing the order? Explain.

Hint: Intensity of diffraction pattern drops rapidly with order because every higher order maxima gets intensity only from $\frac{1}{2n+1}$ part of the slit. The central maximum gets intensity from the whole slit. 1st secondary maximum gets its intensity only from 1/3 part of slit and 2nd secondary maximum gets its intensity only from 1/5 part of slit and so on.

Q.If the width of the slit is made double to original width in diffraction at a single slit, how does it affect the size and intensity of the central band ?

Hint: y0 = $\frac{2D\lambda}{a}$ and I is directly proportional to a^2

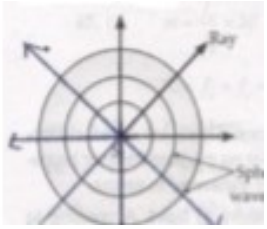
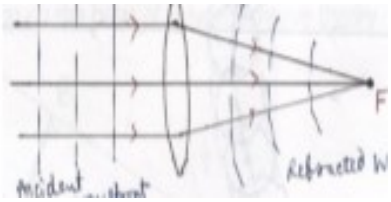
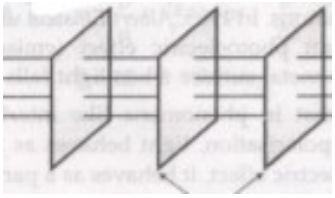
Hence the size of central band will become half of the initial size and the intensity becomes 4 times to the initial intensity.

Q.What will be the effect on interference fringes if red light is replaced by blue light?

Hint: $\beta = D\lambda / d$,the wavelength of blue light is less than that of red light; hence if red light is replaced by blue light, the fringe width decreases. So fringes come closer to each other.

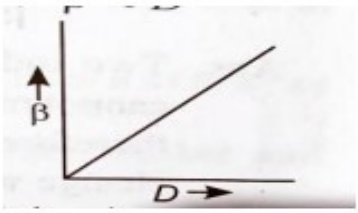
Q.How would the diffraction pattern due to a single slit be affected when the width of the slit is decreased?
Hint: On decreasing a, θn will increase hence, diffraction pattern is spread out.
Q.(i) Using Huygens's principle deduce the laws of reflection of light? (ii) What changes in diffraction pattern of a single slit will you observe. when the monochromatic source of light is replaced by a source of white light?

Hint: (i)To see NCERT textbook
(ii) The diffracted image of the slit gets dispersed into constituent colours of white light. Central max. will become white. Either sides of central max. will be coloured fringes.
Q.What is the shape of the wavefront in each of the following cases: (a) light diverging from a point source. (b) light emerging out of a convex lens when a point source is placed at its focus. (c) the portion of a wavefront of light from a distant star intercepted by the earth.

(a)  **(b)**  
(c)
Hint: (a) The wavefront will be spherical of increasing radius
(b) The rays coming out of the convex lens, when point source is at focus, are parallel, so wavefront is plane.
c) The wavefront starting from star is spherical. As star is very far from the earth, so the wavefront intercepted by earth is a very small portion of a sphere of large radius which is plane (i.e., wavefront intercepted by earth is plane)

Q.In Young's double slit experiment, plot a graph showing the variation of fringe width versus the distance of the screen from the plane of the slits keeping other parameters same. What information can one obtain from the slope of the curve ?

Hint:
β=λD/ d,β is proportional to D.



β/D=λ/d

Q.Two slits are made 1mm apart and the screen is placed 1m away. What should be the width of each slit to obtain 10 maxima of the double slit pattern within the central maximum of the single slit pattern ?
Hint:

$$\beta = \frac{D\lambda}{d} \quad \& \quad y_0 = \frac{2D\lambda}{a}$$

Given, $y_0 = 10\beta \Rightarrow \frac{2D\lambda}{\quad} = 10\frac{D\lambda}{\quad} \Rightarrow a = \frac{d}{\quad} = \frac{1}{\quad}m$

Q.In a Young's double-slit experiment, the slits are separated by 0.28 mm and the screen is placed 1.4 m away. The distance between the central bright fringe and the fourth bright fringe

is measured to be 1.2 cm. Determine the wavelength of light used in the experiment.

HINT: To see question 10.4 of NCERT textbook

Q.a) In a single slit diffraction experiment, the width of the slit is made double the original width. How does this affect the size and intensity of the central diffraction band? (b) In what way is diffraction from each slit related to the interference pattern in a double slit experiment?
Hint: In a single slit diffraction experiment, if the width of the slit is made double the original width, then the size of the central diffraction band reduces to half and the intensity of the central diffraction band increases up to four times. (b) The interference pattern in a double-slit experiment is modulated by diffraction from each slit. The pattern is the result of the interference of the diffracted wave from each slit.

Q.(a)When a low flying aircraft passes overhead, we sometimes notice a slight shaking of the picture on our TV screen. Suggest a possible explanation. (b) As you have learnt in the text, the principle of linear superposition of wave displacement is basic to understanding intensity distributions in diffraction and interference patterns. What is the justification of this principle?

Hint: (a) Weak radar signals sent by a low flying aircraft can interfere with the TV signals received by the antenna. As a result, the TV signals may get distorted. Hence, when a low flying aircraft passes overhead, we sometimes notice a slight shaking of the picture on our TV screen.
(b) The principle of linear superposition of wave displacement is essential to our understanding of intensity distributions and interference patterns. This is because superposition follows from the linear character of a differential equation that governs wave motion. If y1 and y2 are the solutions of the second order wave equation, then any linear combination of y1 and y2 will also be the solution of the wave equation.

Q.What is the effect on the interference fringes in a Young's double-slit experiment due to each of the following operations: (a) the screen is moved away from the plane of the slits; (b) the (monochromatic) source is replaced by another (monochromatic) source of shorter wavelength ?
Hint: (a) Angular separation of the fringes remains constant (= λ/d). The actual separation of the fringes increases in proportion to the distance of the screen from the plane of the two slits.
(b) The separation of the fringes (and also angular separation) decreases.

Q,When monochromatic light is incident on a surface separating two media, the reflected and refracted light both have the same frequency as the incident frequency. Explain why? (b) When light travels from a rarer to a denser medium, the speed decreases. Does the reduction in speed imply a reduction in the energy carried by the light wave? (c) In the wave picture of light, intensity of light is determined by the square of the amplitude of the wave. What determines the intensity of light in the photon picture of light.
Hint: (a) Reflection and refraction arise through interaction of incident light with the atomic constituents of matter. Atoms may be viewed as oscillators, which take up the frequency of the external agency (light) causing forced oscillations. The frequency of light emitted by a charged oscillator equals its frequency of oscillation. Thus, the frequency of scattered light equals the frequency of incident light.
(b) No. Energy carried by a wave depends on the amplitude of the wave, not on the speed of wave propagation.
(c) For a given frequency, intensity of light in the photon picture is determined by the number of photons crossing an unit area per unit time.

Q.In a double-slit experiment the angular width of a fringe is found to be 0.2° on a screen placed 1 m away. The wavelength of light used is 600 nm. What will be the angular width of the fringe if the entire experimental apparatus is immersed in water? Take refractive index of water to be 4/3.

Hint:

Distance of the screen from the slits, D = 1 m

Wavelength of light used, $\lambda_1 = 600 \text{ nm}$

Angular width of the fringe in air, $\theta_1 = 0.2°$

Angular width of the fringe in water = θ_2

Refractive index of water, $\mu = \frac{4}{3}$

Refractive index is related to angular width as:

$$\mu = \frac{\theta_1}{\theta_2}$$

$$\theta_2 = \frac{3}{4}\theta_1$$

Work function-The minimum amount of energy required by an electron to just escape from the metal surface is known as work function of the metal.

One Electron Volt (1eV)-It is the kinetic energy gained by an electron when it is accelerated through a potential difference of 1 volt.

$$1\,eV = 1.6 \times 10^{-19}\ J$$

The main features of photons are as follows:-

(i) A photon travels with the speed of light.
(ii) The rest mass of a photon is zero i.e., a photon cannot exist at rest.
(iii) Energy of a photon, E = hv
(iv) Momentum of a photon, p =mc

Photoelectric Effect: -The phenomenon of emission of electrons from a metallic surface when light of appropriate frequency (above threshold frequency) is incident on it, known as photoelectric effect.

Hertz's observations

The phenomenon of photoelectric emission was discovered in 1887 by Heinrich Hertz (1857-1894), during his electromagnetic wave experiments.

Hertz observed that high voltage sparks across the detector loop were enhanced when the emitter plate was illuminated by ultraviolet light from an arc lamp. Light shining on the metal surface some how facilitated the escape of free, charged particles which we now know as electrons. When light falls on a metal surface, some electrons near the surface absorb enough energy from the incident radiation to overcome the attraction of the positive ions in the material of the surface. After gaining sufficient energy from the incident light, the electrons escape from the surface of the metal into the surrounding space.

Hallwachs' and Lenard's observations

Lenard (1862-1947) observed that when ultraviolet radiations were allowed to fall on the emitter plate of an evacuated glass tube enclosing two electrodes (metal plates), current flows in the circuit As soon as the ultraviolet radiations were stopped, the current flow also stopped. These observations indicate that when ultraviolet radiations fall on the emitter plate C, electrons are ejected from it which are attracted towards the positive, collector plate A by the electric field. The electrons flow through the evacuated glass tube, resulting in the current flow. Thus, light falling on the surface of the emitter causes current in the external circuit. Hallwachs and Lenard studied how this photo current varied with collector plate potential, and with frequency and intensity of incident light.

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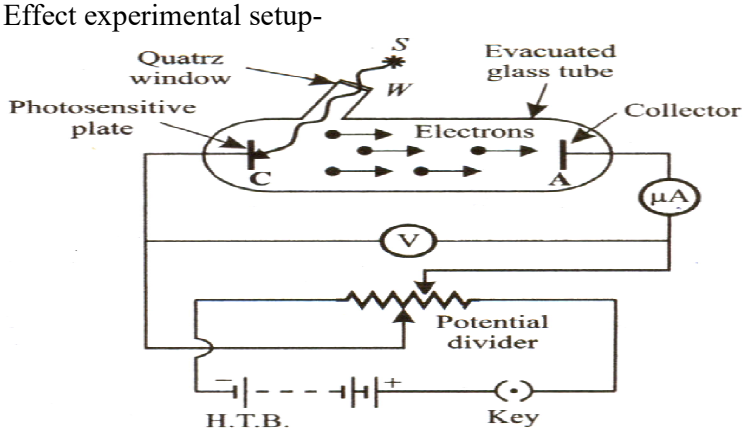
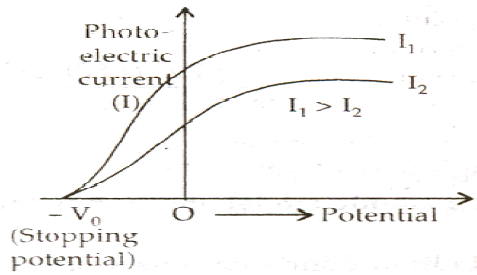
Photoelectric Effect experimental setup-

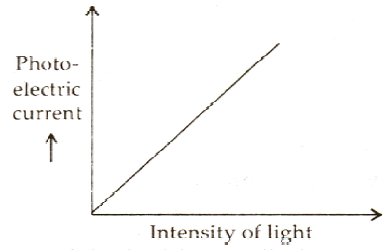


Factors which Effect Photoelectric Effect:-

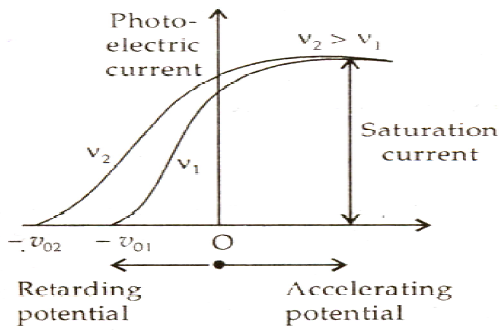
(i) Effect of potential on photoelectric current: It is can be shown in fig. potential v/s photoelectric current.



(ii) Effect of intensity of incident radiations on photoelectric current: For frequency of radiations as constant.



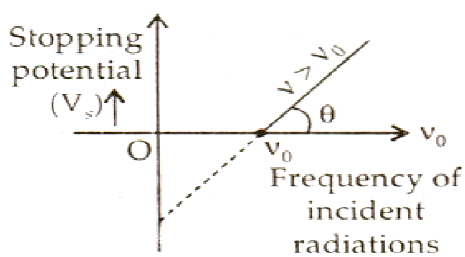
(iii) Effect of frequency of the incident radiations on stopping potential: For constant intensity.



- The stopping potential V_o depends on(i) The frequency of incident light and (ii) the nature of

emitter material. For a given frequency of incident light, the stopping potential is independent of its intensity.

$$eV_o = (1/2)m v_{max}^2 = K_{max}$$



- From this graph between frequency ν, stopping potential Plank's constant (h) can be determined.

De-Broglie Hypothesis-According to de Broglie, *every moving particle is associated with a wave which controls the particle in every respect.* The wave associated with a particle is called matter wave or de Broglie wave. $\lambda = \frac{h}{p} = \frac{h}{mv}$ This is known as de-Broglie equation.

de-Broglie wavelength of an electron of kinetic energy K-

$$\lambda = \frac{h}{\sqrt{2mK}} \qquad \lambda = \frac{h}{\sqrt{(2meV)}} = \frac{1.23}{\sqrt{V}}\text{ nm} = \frac{12.27}{\sqrt{V}}\text{ A}^0$$

Practice questions

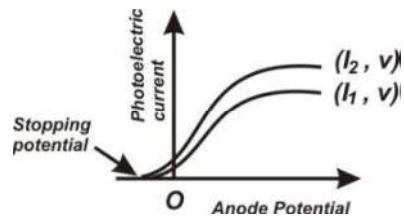
Q. The minimum energy required by a free electron to just escape from the metal surface is called as ---------.

Ans: Work function

Q. The maximum kinetic energy of emitted photoelectrons depends on the -------- of incident radiation and the nature of material.

Ans. Frequency

Q. Following graph shows the variation of photoelectric current with anode potential for two light beam of same wavelength but different intensity. Find the correct relation:



(a) $I_1 > I_2$ (b) $I_1 = I_2$

(c) $I_1 < I_2$ (d) $I_1 \leq I_2$

Ans. (c) $I_1 < I_2$

Q. The threshold wavelength for a metal having work function φ_0 is λ_0, what is the threshold wavelength for a metal whose work function is $\varphi_0/2$.

Ans. $2\lambda_0$

Hint ; $W_0 = \frac{hc}{\lambda 0}$

Q. An electron entering uniform magnetic fields describes a circle of a radius twice the radius of an alpha particle in the same magnetic field. How are their de-Broglie wavelength related to each other?

Ans∴ Momentum = p=mV=RqB

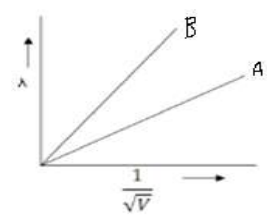
de Broglie wavelength = h/p

Since momentum is same, ratio of wavelengths is 1 .

Q.The two lines marked A and B in the given figure show a plot of de-Broglie wavelength λ versus $\frac{1}{\sqrt{V}}$, where V is the accelerating potential for two nuclei ${}^2_1H$ *and* ${}^3_1H$.

(i)What does the slope of the lines represent?

(ii) Identify which of the lines corresponded to these nuclei



Ans: (i) The slope of the line represent $\frac{h}{\sqrt{2mq}}$

(ii) ${}^2_1H$ and ${}^3_1H$ carry same charge as they have same atomic number $\lambda\sqrt{V}$ α $\frac{1}{\sqrt{m}}$

The lighter mass ${}^2_1H$ represented by line greater slope i. e., A and similarly ${}^3_1H$ by line B.

Q. A proton, a neutron, an electron and alpha particle have same kinetic energy, then arrange their

De- Broglie wavelengths in ascending orders.

Ans: λe> λp> λn> λa

Hint : $\lambda = \frac{h}{\sqrt{(2mK)}}$ and λ α $\frac{h}{\sqrt{m}}$

Q. The work function of Cesium is 2.14 eV.

Find (a) the threshold frequency for Cesium, and

(b) the wavelength of the incident light if the photocurrent is brought to zero by a stopping potential

of 0.60eV?

Ans (a) $\upsilon_0 = W/h = 5.16 \times 10^{14}$ Hz

(b) $\lambda = \frac{hc}{eV0 + W}$ **= 453.7 nm**

Q. An α-particle and a proton are accelerated from rest by the same potential. Find the ratio of their

de-Broglie wavelengths.

Ans: $\lambda = \frac{h}{p} = \frac{h}{\sqrt{2qVm}}$

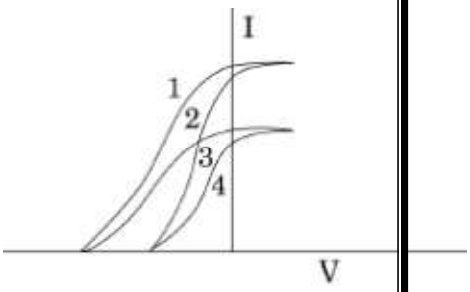
$$\frac{\lambda_\alpha}{\lambda_p} = \sqrt{\frac{m_p q_p}{m_\alpha q_\alpha}} = \frac{1}{2\sqrt{2}}$$

Q. The given graph shows the variation of photoelectric current (I) with applied voltage (V) for two different materials and for two different intensities of the incident radiations. Identify the pair of curves that corresponds to

(i) different materials but same intensity of incident radiation

(ii) different intensities but same material.

Ans. (i) (1,2) and (3,4) (ii) (1,3) and (2,4)]



Q. In an experiment on photo electric emission , following observations were made;

(i) wave length of incident light = 1.98 x 10^{-7}m (ii) stopping potential = 2.5 V.

Find (a) kinetic energy of photo electrons with maximum speed

(b) work function &

(c) threshold frequency

Ans: (a) K_{max} = 2.5eV (b) work function = 3.76eV (c) threshold frequency = 9.1x10^{14}Hz

Q. The work function of cesium metal is 2.14 eV. When light of frequency 6 x 10^{14} Hz is incident on

the metal surface, photoemission of electron occurs. What is the

a. Maximum KE of emitted electron

b. Stopping potential

c. Maximum speed of emitted photoelectrons

Ans: (a) Maximum KE = 0.34 eV

(b) Stopping potential = 0.34 V

(c) Maximum speed of emitted = 345.8 X 10^3 m/s

Q. A beam of light consists of four wavelengths 4000Å, 4800Å, 6000Å & 7000Å, each of intensity

1.5mW/m^2. The beam falls normally on an area $10^{-4}m^2$ of a clean metallic surface of work function

1.9eV.Assuming no loss of kinetic energy, calculate the number of photoelectrons emitted per second.

Ans :E_1 = 3.1eV, E_2 = 2.58eV, E_3 = 2.06eV, E_4 = 1.77eV

Only the first three wave lengths can emit photo electrons.

Number of photo electrons emitted per second = IA ($1/E_1+1/E_2+1/E_3$)

= 1.12 x 10^{12}.(Hint – convert eV into joule before substitution)

Atoms & Nuclei

Thomson's Model of an Atom: An atom consists of positively charged matter in which the negatively charged electrons are uniformly embedded like plums in a pudding. This model could not explain scattering of alpha-particles through thin foils and hence discarded.

Rutherford's Model of an Atom: Geiger and Marsden in their experiment on scattering of alpha-particles found that most of the alpha-particles passed un deviated through thin foils but some of them were scattered through very large angles.

From the results of these experiments, Rutherford proposed the following model of an atom:-

a) An atom consists of a small and massive central core in which the entire positive charge and almost the whole mass of the atom are concentrated. This core is called the nucleus.

b) The nucleus occupies a very small space as compared to the size of the atom.

c) The atom is surrounded by a suitable number of electros so that their total negative charge is equal to the total positive charge on the nucleus and the atom as a whole is electrically neutral.

d) The electrons revolve around the nucleus in various orbits just as planets revolve around the sun.

e) The centripetal force required for their revolution is provided by the electrostatic attraction between the electrons and the nucleus.

Draw-back of Rutherford Model: This model could not explain instability of the atom because according to classical electromagnetic theory the electron revolving around the nucleus must continuously radiate energy in the form of electromagnetic radiation and hence it should fall into the nucleus.

Distance of Closest Approach: When an alpha-particle of mass m and velocity v moves directly towards a nucleus of atomic number Z, its initial energy E, which is just the kinetic energy K gets completely converted into potential energy U at stopping point. This stopping point happens to be at a distance of closest approach d from the nucleus.

Hence,

$$d = \frac{2Ze^2}{4\pi\varepsilon_0 K}$$

Impact Parameter:

a) It is defined as the perpendicular distance of the velocity of the alpha-particle from the centre of the nucleus, when it is far away from the atom.

b) The shape of the trajectory of the scattered alpha-particle depends on the impact parameter b and the nature of the potential field.

c) Rutherford deduced the following relationship between the impact parameter b and the scattering angle θ:-

Quantisation or Discretisation: The quantization or discretisation of a physical quantity means that it cannot have any arbitrary value but can change only to take certain specific value.

Bohr's Model for the Hydrogen Atom: Basic postulates:-

a) Nuclear concept: An atom consists of a small massive centre called nucleus around which planetary electrons revolve. The centripetal force required for their rotation is provided by the electrostatic attraction between the electrons and the nucleus.

b) Quantum condition: Of all the possible circular orbits allowed by the classical theory, the electrons are permitted to circulate only in such orbits in which the angular momentum of an electron is an integral multiple of $\frac{h}{2\pi}$, h being Planck's constant.where n is called principal quantum number.

c) Stationary orbits: While revolving in the permissible orbits, an electron does not radiate energy. These non-radiating orbits are called stationary orbits.

d) Frequency condition: An atom can emit or absorb radiation in the form of discrete energy photons only when an electron jumps from a higher to a lower orbit or from a lower to a

higher orbit. If E1 and E2 are the energies associated with these permitted orbits then the frequency of the emitted/absorbed radiation is,

$$h\nu = E_2 - E_1$$

e) Radius of the orbit of an electron in hydrogen atom is, $r = \frac{e^2}{4\pi\varepsilon_0 m v^2}$

f) Kinetic energy K & electrostatic potential energy U of the electron in hydrogen atom:-

$$K = \frac{1}{2}mv^2 = \frac{e^2}{8\pi\varepsilon_0 r}$$

$$U = \frac{e^2}{4\pi\varepsilon_0 r}$$

g) Total energy E of the electron in hydrogen atom:-

$$E = K + U = -\frac{e^2}{8\pi\varepsilon_0 r}$$

h) Speed of an electron in the nth orbit is,

Where $\alpha = \frac{2\pi k e^2}{ch}$ is fine structure constant.

Failure of Bohr's Model:

a) This model is applicable only to hydrogen-like atoms and fails in case of higher atoms.

b) It could not explain the fine structure of the spectral lines in the spectrum of hydrogen atom.

Spectral Series of Hydrogen Atom: Whenever an electron in hydrogen atom makes a transition from a higher energy level n2 to a lower energy level n1, the difference of energy appears in the form of a photon of frequency ν is given by-

Different Spectral Series of Hydrogen Atom:

These are as follows:

a) Lyman Series. Here n2 = 2, 3, 4,…..and n1 = 1. This series lies in the ultraviolet region.

b) Balmer Series. Here n2= 3, 4, 5,…. and n1 = 2. This series lies in the visible region.

c) Paschen Series. Here n2= 4, 5, 6,…..and n1 = 3. This series lies in the infrared region.

d) Brackett Series. Here n2= 5, 6, 7,…..and n1 = 4. This series lies in the infrared region.

e) Pfund Series. Here n2= 6, 7, 8,…. and n1= 5. This series lies in the infrared region.

Excitation Energy: It is defined as the energy required by an electron of an atom to jump from its ground state to any one of its existed state.

Ionisation Energy: It is defined as the energy required to remove an electron from an atom, i.e., the energy required to take an electron from its ground state to the outermost orbit (n = ∞)

Excitation Potential: It is the accelerating potential which gives sufficient energy to a bombarding electron, so to excite the target atom by raising one of its electrons from an inner to and outer orbit.

Ionisation Potential: It is the accelerating potential which gives to bombarding electron, sufficient energy to ionise the target atom by knocking one of its electrons completely out of the atom.

Nuclei

Atomic Number: The number of protons in the nucleus is called the atomic number. It is denoted by Z.

Mass number: The total number of protons and neutrons present in a nucleus is called the mass number of the element. It is denoted by A.

No. of Protons, Electrons, Nucleons, and Neutrons in an Atom:

Number of protons in an atom = Z

Number of electrons in an atom = Z

Number of nucleons in an atom = A

Number of neutrons in an atom = N = A – Z.

Nuclear Mass: The total mass of the protons and neutrons present in a nucleus is called the nuclear mass.

Nuclide: A nuclide is a specific nucleus of an atom characterized by its atomic number Z and mass number A. It is represented as, $_{Z}X^{A}$

Where X = chemical symbol of the element, Z = atomic number and A = mass number

Isotopes:

1.The atoms of an element which have the same atomic number but different mass number are called isotopes.

2.Isotopes have similar chemical properties but different physical properties.

Isobars: The atoms having the same mass number but different atomic number are called isobars.

Isotones: The nuclides having the same number of neutrons are called isotones.

Isomers: These are nuclei with same atomic number and same mass number but in different energy states.

Electron Volt: It is defined as the energy acquired by an electron when it is accelerated through a potential difference of 1 volt and is denoted by eV.

Atomic Mass Unit:

It is $\frac{1}{12}^{th}$ of the actual mass of a carbon atom of isotope $_{6}C^{12}$. It is denoted by amu or just by u.

amu =1.660565×10^{-27} kg

The energy equivalence of 1 amu is 1 amu = 931 MeV

Discovery of Neutrons:

1.Neutrons were discovered by Chadwick in 1932.

2.When beryllium nuclei are bombarded by alpha-particles, highly penetrating radiations are emitted, which consists of neutral particles, each having mass nearly that of a proton. These particles were called neutrons.$^{4}_{2}He + ^{9}_{4}Be \rightarrow ^{1}_{0}n + ^{12}_{1}C$

3.A free neutron decays spontaneously, with a half- life of about 900 s, into a proton, electron and an antineutrino.$^{1}_{0}n \rightarrow ^{1}_{1}H + ^{0}_{-1}e + \bar{v}$

Size of the Nucleus:

1.It is found that a nucleus of mass number A has a radius

$R = R_o A^{1/3}$Where, $R_0 - 1.2 \text{ x } 10^{-15} m$

2.his implies that the volume of the nucleus, which is proportional to R3 is proportional to A.

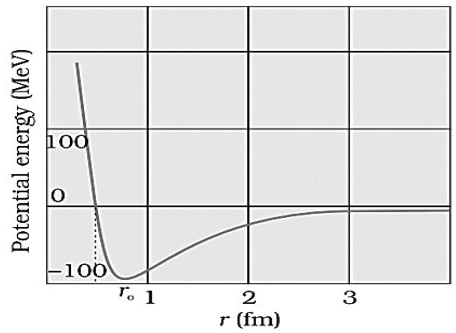
Density of the Nucleus: Density of nucleus is constant; independent of A, for all nuclei and density of nuclear matter is approximately $2.3 \times 10^{17} kgm^{-3}$

which is very large as compared to ordinary matter, say water which is 103 kg m-3.

Mass-Energy equivalence: Einstein proved that it is necessary to treat mass as another form of energy. He gave the mass-energy equivalence relation as, E = mc2 Where m is the mass and c is the velocity of light in vacuum.

Nuclear density $\rho_v = \frac{\text{Nuclear mass}}{\text{Nuclear volume}}$

Nuclear Forces:



1.Nuclear force is a strong fundamental force in nature.
2.Nuclear force is mainly an attractive force: Nuclear force is charge independent.
3.Nuclear force is short-range force.
4.Nuclear force is a saturated force.
5.Nuclear force is an exchange force.
6.Nuclear force is non-central force.
7.Nuclear force is spin-dependent.

Mass Defect: The difference between the rest mass of a nucleus and the sum of the rest masses of its constituent nucleons is called its mass defect. It is given by-

$$\Delta m = [Zm_p + (A - Z)m_n] - m$$

Binding Energy:

1.It may be defined as the energy required to break a nucleus into its constituent protons and neutrons and to separate them to such a large distance that they may not interact with each other.

2.It may also be defined as the surplus energy which the nucleus gives up by virtue of their attractions which they become bound together to form a nucleus.

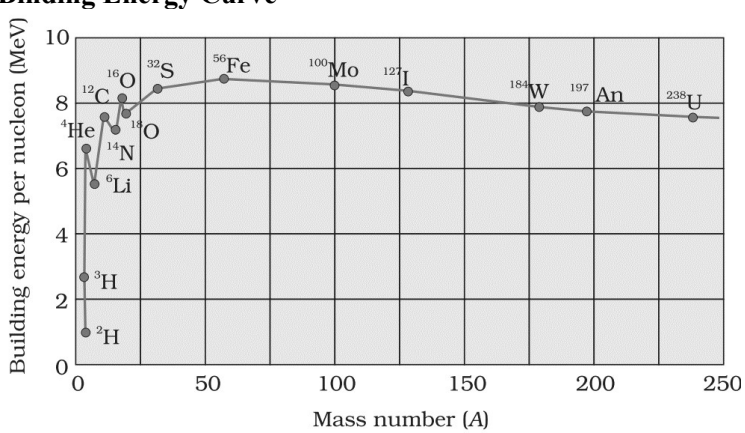
3.The binding energy of a nucleus $_ZX^A$ is-

$$B.E. = [Zm_p + (A - Z)m_n - m]c^2$$

Binding Energy per Nucleon: It is average energy required to extract one nucleon from the nucleus. It is obtained by dividing the binding energy of a nucleus by its mass number.

$$\bar{B} = \frac{B.E}{A} = \frac{[Zm_p + (A - Z)m_n - m]c^2}{A}$$

Binding Energy Curve



Main features of the curve are given below:

(i) The binding energy per nucleon (Ebn) is practically constant, i.e. practically independent of the atomic number for nuclei of middle mass number (30 < A < 170). The curve has a maximum of about 8.75 MeV for A = 56 and has a value of 7.6 MeV for A = 238.

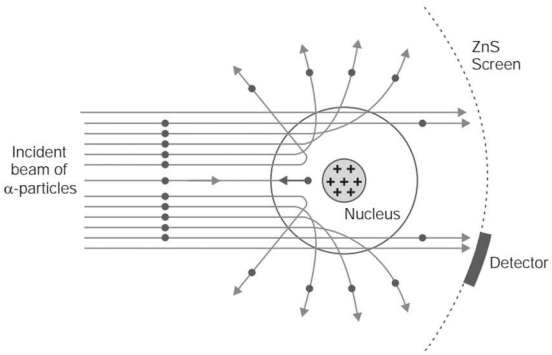
(ii) Binding energy per nucleon is lower for both light nuclei (A<30) and heavy nuclei (A>170).

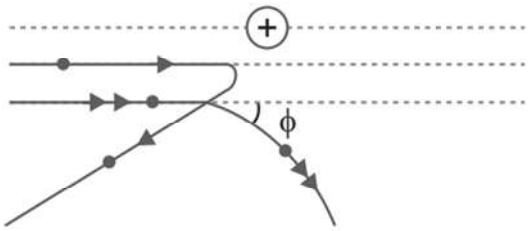
From above two observations we can draw the conclusions given below:
(a) The force is attractive and sufficiently strong to produce a binding energy of a few MeV per nucleon.
(b) The constancy of the binding energy in the range 30 < A < 170 is a consequence of the fact that the nuclear force is short-ranged.
(c)A very heavy nucleus, say A = 240, has lower binding energy per nucleon compared to that of a nucleus with A = 120. Thus if a nucleus A = 240 breaks into two A = 120 nuclei, nucleons get more tightly bound. This implies energy would be released in the process.
(d) Consider two very light nuclei (A ≤ 10) joining to form a heavier nucleus. The binding energy per nucleon of the fused heavier nuclei is more than the binding energy per nucleon of the lighter nuclei. This means that the final system is more tightly bound than the initial system. Again energy would be released in such a process of fusion. This is the energy source of the sun.

Nuclear Reaction: It is a reaction which involves the change of stable nuclei of one element into the nucleus of another element.
Nuclear Fission: It is the process in which a heavy nucleus when excited gets split into two smaller nuclei of nearly comparable masses. For example-
$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{141}_{56}Ba + ^{92}_{36}Kr + 3^{1}_{0}n + Q$
Nuclear Reactor: It is a device in which a nuclear chain reaction is initiated, maintained and controlled.
Nuclear Fusion: It is the process of fusion of two smaller nuclei into a heavier nucleus with the liberation of large amount of energy.
Critical size and Critical Mass:
1.The size of the fissionable material for which reproduction factor is unity is called critical size and its mass is called critical mass of the material.
2.The chain reaction in this case remains steady or sustained.
Moderator:
1.Any substance which is used to slow down fast moving neutrons to thermal energies is called a moderator.
2.The commonly used moderators are water, heavy water (D2O) and graphite.

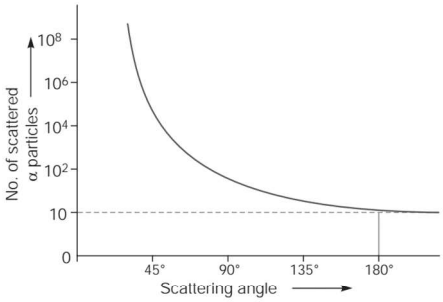
Important diagram and graph

1.α- Partical scattering

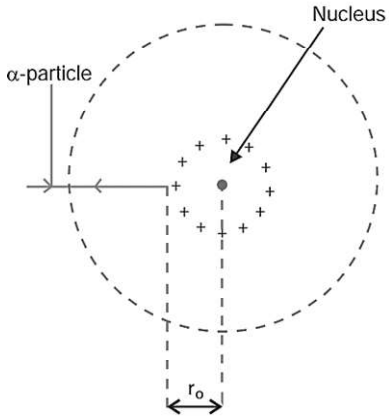




2 Graph between scattered particle and scattering angle



3.Closest Approch

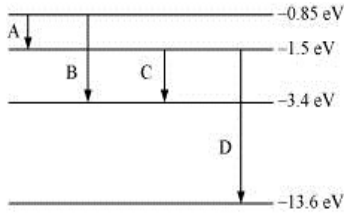


Practice questions

Q. What is the ratio of nuclear densities of two nuclei having mass number 1:4?
Answer: 1:1

Q. When is Hα line of the Balmer series in the emission spectrum of hydrogen atom obtained? 1
Answer:It is obtained when an electron jumps from n =3 to n = 2 level.
Q.What is impact parameter of α-particle scattered through 180 degrees?
Answer: ∞
Q. (a) The mass of a nucleus in its ground state is always less than the total mass of its constituents- neutrons and protons. Explain.
(b) Plot a graph showing the variation of potential energy a pair of nucleons as a function of their separation.
Q. Draw a plot of the potential energy of a pair of nucleons as a function of their separations. Mark the regions where the nuclear force is (i) attractive and (ii) repulsive. Write any two characteristic features of nuclear forces.
Hint: Draw correct graph and mention attractive and repulsive portion
Q. The total energy of an electron in the first excited state of the hydrogen atom is about –3.4 eV. 2
(a) What is the kinetic energy of the electron in this state?
(b) What is the potential energy of the electron in this state?
(c) Which of the answers above would change if the choice of the zero of potential energy is changed?
Hint: U=P.E. +K.E. ,K.E. is never negative and independent of choice of zero of potential energy.
Q. Show that the density of nucleus over a wide range of nuclei is constant- independent of mass number A.
Hint: Density= Mass/Volume; Nuclear radius $\alpha A^{1/3}$

Q Calculate the radius of $_{197}Au^{79}$ nucleus.
Answer: R = 1.2 × 10-15 × (197)1/3 = 6.97 × 10-15m
Q. The energy level diagram of an element is given below. Identify, by doing necessary calculations for each.which transition corresponds to the emission of a spectral line of wavelength 102.7 nm. 3



Solution:
For A: $E = E_2 - E_1 = -0.85 - (-1.5) = -0.85 + 1.5 = 0.65$
For B: $E = E_2 - E_1 = -0.85 - (-3.4) = -0.85 + 3.4 = 2.55$ eV
For C: $E = E_2 - E_1 = -1.5 - (-3.4) = -1.5 + 3.4 = 1.9$ eV
For D: $E = E_2 - E_1 = -1.5 - (-13.6) = 12.1$ eV
Hence, transition D corresponds to a spectral line of wavelength 10.27 nm.
Q. What is the ratio of radii of the orbits corresponding to first excited state and ground state in a hydrogen atom?
Answer: 4:1
Q. (b) A nucleus of mass number 240 and having binding energy/nucleon 7.6 MeV splits into two fragments Y, 1 of mass numbers 110 and 130 respectively. If the binding energy/ nucleon of Y, 1 is equal to 8.5 MeV each, calculate the energy released in the nuclear reaction.
Answer: Energy released per fission

= (110 + 130) × 8.5 – 240 × 7.6
= 240 × (8.5 – 7.6) MeV
= 240 × 0.9 = 216.0 MeV

Q. Everything around us which has mass and occupies space is matter. An atom is the basic unit of matter. It cannot be broken down further using any chemical means because it is the basic building block of an element. Every state of matter solid, liquid, gas, and plasma is composed of either atom either it is neutral (unionized), or ionized atoms. An atom is made up of three particles known as protons, neutrons, and electrons. And these particles are also made up from sub-particles. Among these three particles, protons have a positive charge while electrons carry a negative charge and the third particle neutrons have no electrical charge. And the charge of atoms depends on the number of protons and electrons, i.e an atom is electrically neutral if the number of protons and electrons are equal. If an atom has more or fewer electrons than protons, then it has an overall negative or positive charge, respectively.

Q1.What is the basic unit of matter?
a) Atom b) Electron c) Proton d) Neutron
Q2.Which particle is responsible for the ionization of the atom?
a) Positron b) Electron c) Proton d) Neutron
Q3. If number of protons in an atom is equal to (number of electrons + 2). Then the atom is said to be
a) Single ionized positive ion b) Single ionized positive atom
c) Double ionized positive ion d) Double ionized positive atom

Answer : Q1 – a; Q2 – b; Q3 – c;

Q. In Rutherford's nuclear model of the atom, the entire positive charge and most of the mass of the atom are concentrated in the nucleus with the electrons some distance away. The electrons would be moving in orbits about the nucleus just as the planets do around the sun. Rutherford's experiments suggested the size of the nucleus to be about10–15 m to 10–14 m. From kinetic theory, the size of an atom was known to be 10–10 m,about 10,000 to 100,000 times larger than the size of the nucleus. Thus, the electrons would seem to be at a distance from the nucleus of about 10,000 to 100,000 times the size of the nucleus itself. Thus, most of an atom is empty space. With the atom being largely empty space, it is easy to see why most α -particles go right through a thin metal foil. However, when α-particle happens to come near a nucleus, the intense electric field there scatters it through a large angle. The atomic electrons, being so light, do not appreciably affect the α-particles. The scattering data shown in Fig. can be analysed by employing Rutherford's nuclear model of the atom. As the gold foil is very thin, it can be assumed that α-particles will suffer not more than one scattering during their passage through it. Therefore, computation of the trajectory of an alpha-particle scattered by a single nucleus is enough. Alpha particles are nuclei of helium atoms and, therefore, carry two units,2e, of positive charge and have the mass of the helium atom. The charge of the gold nucleus is Ze, where Z is the atomic number of the atom; for gold Z = 79. Since the nucleus of gold is about 50 times heavier than α-particle, it is reasonable to assume that it remains stationary throughout the scattering process. Under these assumptions, the trajectory of an alpha particle can be computed employing Newton's second law of motion and the Coulomb's law for electrostatic force of repulsion between the alpha-particle and the positively charged nucleus.

Q1. What percentage of α particle scattered at an angle more than 90º?
a) 0.0125% b) 0.125% c) 1.25% d) 12.5%
Q2. Why the nucleus of gold remains stationary throughout the scattering process?
a) Because its mass is 100 times the mass of proton. b) Because its mass is 50 times the mass of proton. c) Because its mass is 150 times the mass of proton. d) Because its mass is 200 times the mass of proton.
Answer : Q1 – a; Q2 – d

Q. Rutherford was the pioneer who postulated and established the existence of the atomic nucleus. At Rutherford's suggestion, Geiger and Marsden performed their classic experiment:

on the scattering of α-particles from thin gold foils. Their experiments revealed that the distance of closest approach to a gold nucleus of an α-particle of kinetic energy 5.5 MeV is about 4.0 × 10–14 m. The scattering of α-particle by the gold sheet could be understood by Rutherford by assuming that the coulomb repulsive force was solely responsible for scattering. Since the positive charge is confined to the nucleus, the actual size of the nucleus has to be less than 4.0 × 10–14 m. If we use α-particles of higher energies than 5.5 MeV, the distance of closest approach to the gold nucleus will be smaller and at some point the scattering will begin to be affected by the short range nuclear forces, and differ from Rutherford's calculations. Rutherford's calculations are based on pure coulomb repulsion between the positive charges of the α particle and the gold nucleus. From the distance at which deviations set in, nuclear sizes can be inferred. By performing scattering experiments in which fast electrons, instead of α-particles, are projectiles that bombard targets made up of various elements, the sizes of nuclei of various elements have been accurately measured. It has been found that a nucleus of mass number A has a radius R = R0 A1/3, where R0 = 1.2 × 10–15 m. This means the volume of the nucleus, which is proportional to R3 is proportional to A. Thus the density of nucleus is a constant, independent of A, for all nuclei. Different nuclei are likes drop of liquid of constant density. The density of nuclear matter is approximately 2.3 × 1017 kgm–3.This density is very large compared to ordinary matter, say water, which is 103 kg m–3. This is understandable, as we have already seen that most of the atom is empty. Ordinary matter consisting of atoms has a large amount of empty space.

Q1. Relative density of nucleus with respect to water is

a) 2.3 × 1017 kgm–3 b) 2.3 × 1014 kgm–3 c) 23 × 1017 kgm–3 d) .23 × 1017 kgm–3

Q2. From $R = R_0 A^{1/3}$ how can we conclude that density of almost all the nucleus is same

a) Volume being proportional to square of R density becomes independent of mass number A

b) Volume being proportional to cube of R density becomes independent of mass number A

c) Volume being proportional to R density becomes independent of mass number A

d) Density has no relation with R

Q3. What is the range of volume of hydrogen nucleus?

a) 10^{-45}m. b) 10^{-30}m. c) 10^{-15}m. d) 10^{-60}m.

Answer : Q1 – b; Q2 – b; Q3 – a

Q. Write the unit of R/λ, where R is Rydberg's constant and λ wavelength of spectral line.

Ans : Unit m^{-2}

Q. Out of three radiations of the wavelengths 5000A0 , 8000A0 and 1000A0 , which one corresponds to Lyman series of hydrogen atom.

Ans 1000A^0 because it belongs to ultraviolet

Q. The first excitation potential of a given atom is 10.2V. What will be the value of ionisation potential for this atom?

Ans E = -13.6 e V / n^2

Q.The ground state energy of hydrogen atom is 13.6 eV. What are the kinetic and potential energies of electron in this state ?

The value of ground state energy of hydrogen atom is 13.6 eV

(i)what does the negative sign signify ?

(ii)How much energy is required to take an electron in this atom from the ground state to the first excited state ?

Ans (i) Negative sign shows that electron is bound with the nucleus by electrostatic force

(ii) $E = {-13.6}/{n^2}$For ground state n =1 and for first excited state n =2

$\Delta E = E1 - E2$=- 3.4+ 13.6 = 10.2 Ev

Q.Calculate the shortest wavelength of the spectral lines emitted in Balmer series

Ans 12As per Balmer series, wavelength is given by :

$$\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$$

For shortest wavelength, n = ∞
λ=4×10−7 m

Q. Calculate the energy released in MeV in the following nuclear reaction:
calculate the energy released in MeV in the following nuclear reaction:

$$^{238}_{92}U \longrightarrow ^{234}_{90}Th + ^{4}_{2}He + Q$$

[Mass of $^{238}_{92}U$ = 238.05079 u,

Mass of $^{234}_{90}Th$ = 234.043630 u,

Mass of $^{4}_{2}He$ = 4.002600 u, 1u = 931.5 MeV/c²]

Nuclear reaction

$$^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He + Q$$

Energy released, $Q = \Delta mC^2$

$= (M_U - M_{Th} - M_{He})C^2$

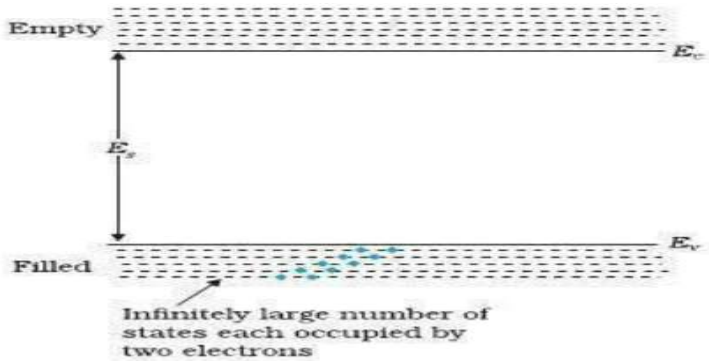
$= 0.00456 \times 931.5$ MeV

$=$ **4.25 MeV**

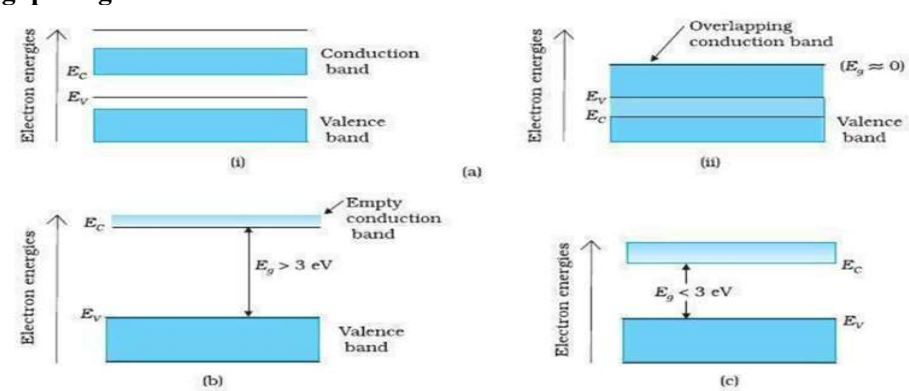
Ans

SEMICONDUCTOR

The substances whose conductivity is in between conductors and insulators are called Semiconductors.
Solids are also classified on the basis of their Energy bands.
According to Bohr model, every electron of an isolated atom has well defined energy level.
Inside a crystal each electron will have a different energy level. These different energy levels with continuous variation forms energy bands.
The energy band which contains the energy levels of valence electrons is known as valence band. This is the lower energy band. This band is never empty.
The upper unfilled energy band is called conduction band. This band is completely empty at 0 K. At room temperature, this band is empty or partially filled with electrons.
The separation between the highest energy level of valence band and the lowest energy level of conduction band is known as Energy band gap/Forbiddon energy gap. (Eg)



In case of metals, Energy gap is very less or zero or valence band and conduction bands are overlapping. Fig. (a) i and ii .
In case of insulators Energy gap is very large. Eg>3 eV Fig. (b)
In case of semiconductors Energy gap is small. Eg<3 eVFig. (c). therefore at 0 K semiconductor behaves as an insulator and at room temperature some electrons in the valence band get thermal energy and jump over to conduction band, hence acquire small conductivity. Energy gap for germanium is 0.72 eV and for Silicon it is 1.1 eV.



INTRINSIC SEMICONDUCTORS

Intrinsic Semiconductors are pure semiconductors, in which number of free electrons in conduction band is equal to the number of holes in the valence band. $n_e = n_h = n_i$
Conductivity of Intrinsic Semiconductors is small at room temperature.
Electrical conductivity of semiconductor is due to the motion of electrons in the conduction band and motion of holes in the valence band. I = Ie + Ih
Hole is considered as a seat of positive charge, having equal charge to that of an electron. Breakage of one covalent bond produces one free electron and one hole.

EXTRINSIC SEMICONDUCTORS

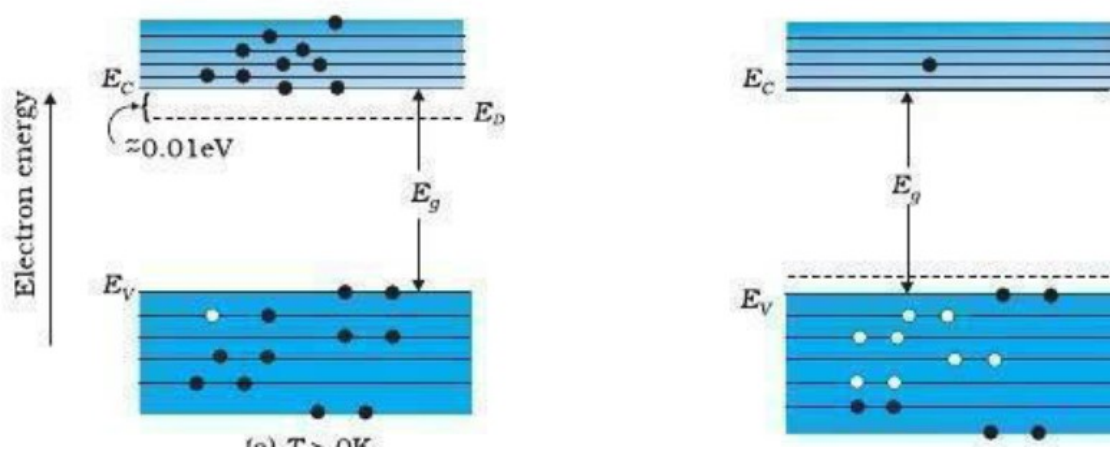
A doped semiconductor or a semiconductor with suitable impurity atoms is called Extrinsic semiconductor.
Doping: Doping is a process of deliberate addition of desirable impurity atoms to a PURE semiconductor. The impurity atoms added are called dopants.
Extrinsic Semiconductors are of two types,
i) N- type semiconductor ii) P-type semiconductor

N- TYPE SEMICONDUCTOR

When pure Ge or Si semiconductor is doped with pentavalent atoms (Bi, P, As and Sb) an N-type semiconductor is formed.
The 4 of the 5 valence electrons of the impurity atoms will form covalent bonds by sharing the electrons, while 5th electron is loosely bound to the parent atom and is free to move. Therefore the number of electrons becomes more than the number of holes.ne>nh and $n_e n_h = n_i^2$
In an n- type semiconductor electrons are majority carriers and holes are minority carriers.

P- TYPE SEMICONDUCTOR

When pure Ge or Si semiconductor is doped with trivalent atoms (Al, In and B) a P-type semiconductor is formed.
The three valence electrons of the impurity atoms will form covalent bonds by sharing electrons but one hole is present as the fourth covalent bond is not formed or left empty.
Therefore the number of holes become more than the number of electrons.
nh>ne and $n_e n_h = n_i^2$
In a P- type semiconductor holes are majority carriers and electrons are minority carriers.
Energy band diagram of N- type(a) and P-type(b) semiconductors



ELECTRICAL CONDUCTIVITYOF EXTRINSIC SEMICONDUCTORS

Let us consider a semiconductor block of length 'l' and area of cross section 'A'
Let V be the potential difference applied across the ends of the semiconductor.
The total current $I = I_e + I_h$
We know that I = neAv so $Ie = n_e eAv_e$ and $I_h = nh_e Av_h$
$\therefore I = eA(n_e v_e + n_h v_h)$
$I/A = e(n_e v_e + n_h v_h)$
$\rho = RA/l$

$E = V/l$
$E/\rho = V/RA = I/A = e (n_e v_e + n_h v_h)$
$E/\rho = e (n_e v_e + n_h v_h)$
$1/\rho = e (n_e v_e + n_h v_h) /E = = e [n_e(v_e/E) + n_h(v_h/E)]$
$\sigma = e (n_e \mu_e + n_h \mu_h)$ Where μ_e is mobility of electron and μ_h is mobility of hole.
Mobility is defined as the drift velocity per unit electric field.

P-N JUNCTION DIODE

When a P-type semiconductor is brought into close contact with N-type semiconductor, the resulting arrangement is called PN junction diode.

FORMATION OF PN JUNCTION

Thin slices of N-type and P-type semiconductors, called wafers are kept one on the other and heated to a high temperature.

Two important processes occur during the formation of PN junction, diffusion and drift.

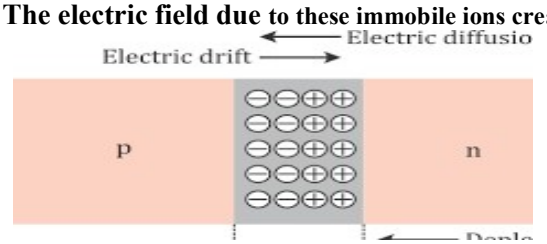
Due to difference in concentration of charge carriers in the two regions in PN junction, the electrons from N side diffuse through the junction into P side.

On the other hand holes from P side diffuse through the junction into N side.

This is known as diffusion and the current due to this is diffusion current.

This creates + ions on N side and – ions on P side, this region where the ions are present and no free charge carriers are present is called Depletion region.

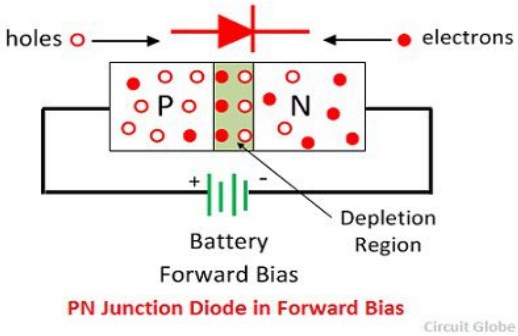
The electric field due to these immobile ions creates a potential which is called potential Barrier.



A PN junction can be biased in two ways i) forward biasing ii) reverse biasing

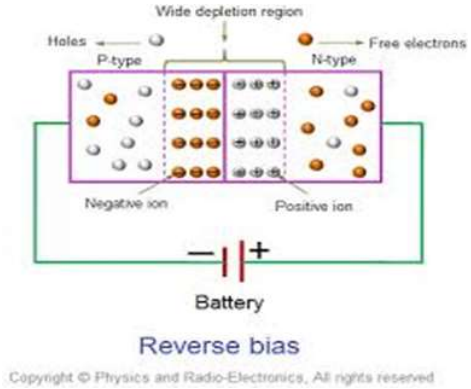
In Forward biasing the positive terminal of the battery is connected to P side and negative terminal of the battery is connected to N side.

During this process the width of the depletion region decreases and the potential barrier also decreases. A current flows through the junction, which is known as forward current. The diode conducts.



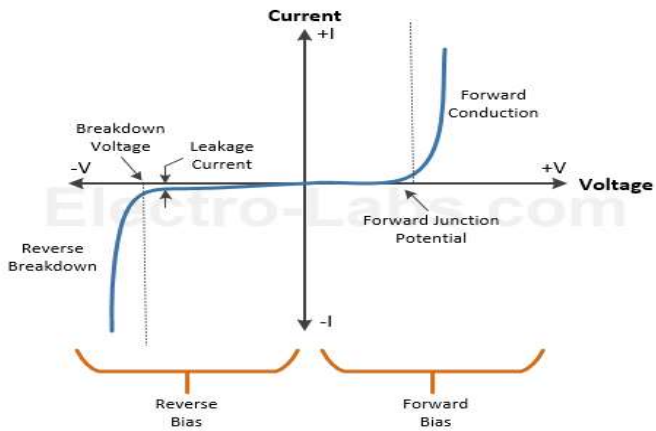
In Reverse biasing the positive terminal of the battery is connected to N side and negative terminal of the battery is connected to P side.

During this process the width of the depletion region increases and the potential barrier also increases. The resistance to the flow of current is high at the junction. The diode does not conduct.



PN JUNCTION DIODE CHARACTERISTICS

It is the graphical representation between voltage and current through the junction.



When the diode is forward biased the current slowly increases up to a certain voltage then it increases exponentially, this voltage is known as threshold voltage or cut-in voltage (0.2 V for Ge and 0.7 V for Si)

The dynamic resistance of the diode when it is conducting is given by, r = $\frac{dV}{dI}$.

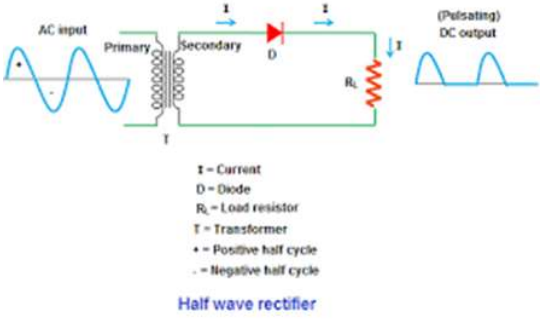
When the diode is reverse biased, a very small current almost remains the same known as reverse saturation current. After certain voltage, called break down voltage current suddenly increases as shown in graph.

RECTIFIER

It is a device used to convert AC into DC. There are two types of rectifier circuits, i) Half wave rectifier ii) Full wave rectifier

HALF WAVE RECTIFIER

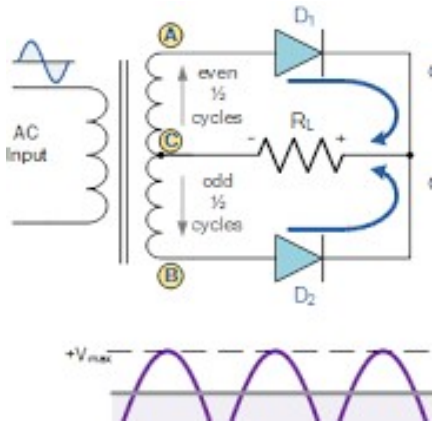
Principle: The diode conducts only when it is forward biased.



During the positive half cycle the diode is forward biased hence it conducts and the output is present across the load resistance. During the negative half cycle the diode is reverse biased so no output. Since the rectified output of this circuit is only for half of the input ac wave it is called as half- wave rectifier.

FULL WAVE RECTIFIER

The circuit uses two diodes and a centre- tap transformer. It gives rectified output for both positive and negative half cycles of AC. Hence it is known as full wave rectifier.
During the positive half cycle A is positive, diode D1 is forward biased and conducts but terminal B is negative,D2is reverse biased, and does not conducts, the output is present across the load resistance due to the diodeD1.
During the negative half cycle A is negative, diode D1 is reverse biased and not conducting but terminal B is positive, D2is forward biased, and conducts, the output is present across the load resistance due to the diodeD2. So we get output for both half cycles.



Practice questions

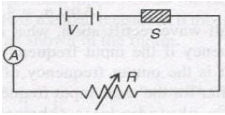
Q.Give the ratio n_h/ n_e of the number of holes and number of conduction electrons in an intrinsic semiconductor.
(a) 2 (b) 1.5 (c) 1 (d) none
Ans. $nh/ ne = 1$
Q.How does the energy gap of an intrinsic semiconductor vary, when doped with a trivalent impurity/pentavalent impurity?
(a) Increases (b) Decreases (c)constant (d) none

Ans. Decreases
Q.How does the forbidden energy gap of an intrinsic semiconductor vary with increase in temperature?
(a) Increases (b) Decreases (c)constant (d) no effect

[Ans. no effect
Q.Name the two factors on which electrical conductivity of a pure semiconductor at a given temperature depends.
(a) The width of the forbidden band (b) Intrinsic charge carrier concentration
(c)both (d) None
[Ans. Both (i) The width of the forbidden band
(ii) Intrinsic charge carrier concentration

Q.The diagram shows a piece of pure semiconductor 'S' in series with variable resistor R and a source of constant voltage V. Would you increase or decrease the value of R to keep the reading of ammeter (A) constant when semiconductor 'S' is heated ? Give

one reason.



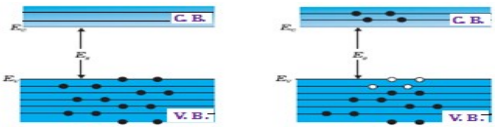
[Ans. Increase the value of R
Reason : on heating, conductivity of the semiconductor increases

Q. (a)Give reason, why, a p-type semiconductor crystal is electrically neutral, although $n_h >> n_e$
[Ans. because impurity atoms added to the semiconductor are electrically neutral
(b).An n-type semiconductor has a large number of electrons but still it is electrically neutral. Explain the reason.
[Ans. because impurity atoms added to the semiconductor are electrically neutral]

Q.Why does the conductivity of a semiconductor increase with the rise in its temperature?
[Ans. σ= e [$+ n_h \mu_h$]
On increasing the temperature μ_e & μ_h decreases (due to increase in the collision frequency). But ne& nh increases $-Eg$
Since ne & nh is so large that decrease of μe & μh does not affect too much. So overall conductivity of the semiconductor increases

Q. Draw the energy band diagram of an intrinsic semiconductor at 0K and room temperature.

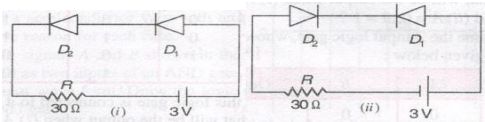
Ans.



Q. Draw the energy band diagram of $n - type$ & $p - type$ semiconductor.

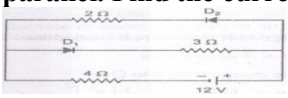
Ans.

Q. Determine the currents through the resistance R of the circuits (i) and (ii), when similar diodes D1 and D2 are connected as shown.



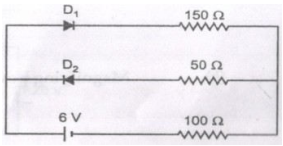
[Ans. (i) 0. 1 A (ii) zero

Q.The circuit shown in the figure has two oppositely connected ideal diodes connected in parallel. Find the current flowing through each diode in the circuit .



[Ans. through D_1, I=0, through D_2, I = 2A]

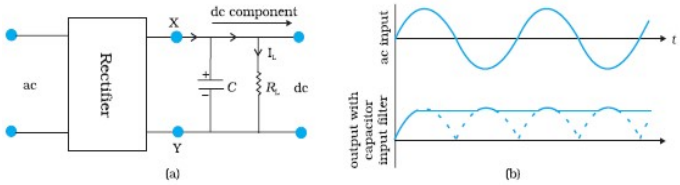
Q .The circuit shown in the figure consists of two diodes each with a forward resistance of 50 Ω and infinite backward resistance. Find the current through 100 Ω resistance.



[Ans. 6/300 A, 6/350 A]

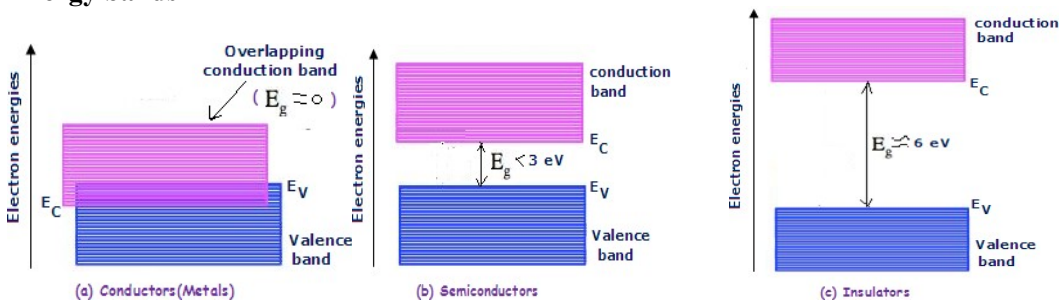
Q. Describe briefly the role of a capacitor in filtering.

[Ans. A capacitor connected across the output terminals of a rectifier offers a low resistance path for a.c. and blocks dc. So all dc will pass through load resistance RL and we get steady current.

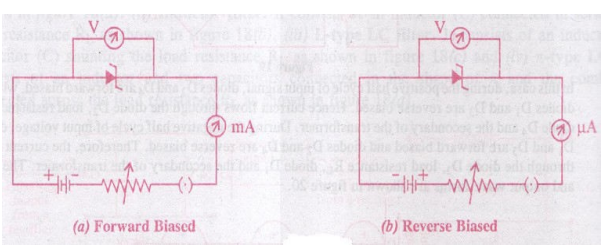


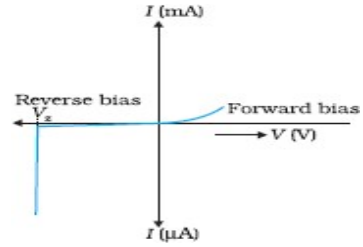
Q. Distinguish between a conductor, an insulator and a semiconductor on the basis of energy band diagrams.

[Ans. Distinction between Conductors (metals), insulators and semiconductors on the basis of Energy bands



16. Draw the circuit diagram to study the characteristic curves of a Zener diode and draw its typical I-V characteristics.



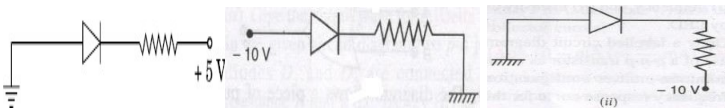


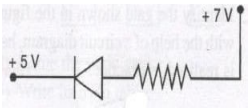
[Ans. Circuit diagram to draw characteristic curves : I-V characteristic curves

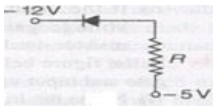
Q.The band gap of the semiconductor used for fabrication of visible LED's must at least be 1.8 eV. Why ?

[Ans. The photon energy of visible light photons varies about 1.8 eV to 3 eV. Hence for visible LED's the semiconductor used must have a band gap of at least 1.8 eV

Q. In the following circuit diagram, is the junction diode forward biased or reverse biased?







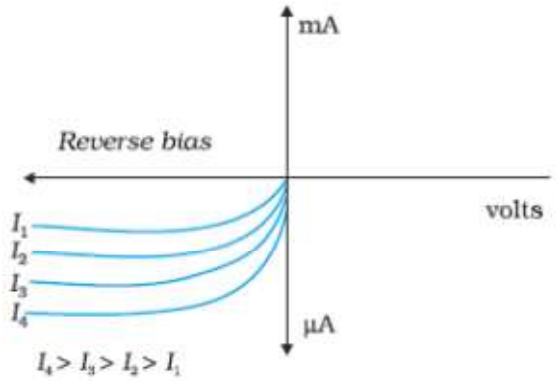
[Ans. (i) reverse bias (ii) reverse bias (iii) Forward bias (iv) forward bias (v) forward bias

Q. Define the terms 'depletion region' and 'potential barrier' in a p-n junction.
Explain how the width of depletion region in a p-n junction diode change,
when the junction is- (i) forward biased (ii) reverse biased.
[Ans. Depletion region : The small space charge region on either side of the p-n junction which becomes depleted from mobile charge carriers. is known as depletion region
Potential barrier : The potential difference developed across the p-n junction due to diffusion of majority charge carriers, which prevents the further movement of these charge carriers through it, is called potential barrier
Width of depletion region decreases in forward bias
Reason : In the forward bias, external battery pushes the majority charge carriers towards the junction.
Width of depletion region increases in reverse bias
Reason : In the reverse bias, external battery attracts the majority charge carriers away from the junction.

Q. Frequency of an a.c. input signal is 50 Hz. What is the output frequency of a
(i)Half wave rectifier (ii) Full wave rectifier
[Ans. (i) 50 Hz (ii) 100 Hz

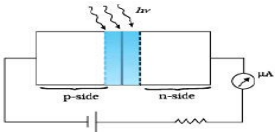
Q. Which semiconductors are preferred to make LEDs and why ?
[Ans. GaAs and GaAsP
Reason: these materials have energy gap $Eg \geq 1.8$ eV which is suitable to produce visible light of desired wavelengths

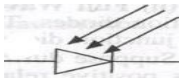
Q Study the I-V characteristics given below and answer the following:
(i) Identify the device and state one use of it
(ii) Draw the circuit diagram used to obtain the typical I – V characteristics of the device

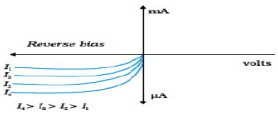


Ans :Photo diode
Any one use
Circuit diagram of photo diode (reference NCERT book)
Q.What is the conductivity of a semiconductor sample having electron concentration of 5×10^{18} m^{-3}, hole concentration of 5×10^{19} m^{-3}, electron mobility of 2.0 $m^2 V^{-1} s^{-1}$ and hole mobility of 0.01 $m^2 V^{-1} s^{-1}$?
(Take charge of electron as 1.6 × 10–19 C)
Ans = 1.68
Q. How does a light emitting diode (LED) work? Give two advantages of LED's over the conventional incandescent lamps.

Ans. A light emitting diode is simply a forward biased p-n junction which emits spontaneous light radiation. At the junction, energy is released in the form of photons due to the recombination of the excessminority charge carrier with the majority charge carrier.
Advantages :(i) Low operational voltage and less power.
(ii) Fast action and no warm up time required.
Q. State the factor which controls (i) wavelength/frequency of light (ii) intensity of light emitted by LED.
[Ans. (i) nature of material of diode/band gap (ii) forward biasing of LED
Q. How is photodiode fabricated ? Describe the working of photodiode by drawing the circuit diagram. Also draw the characteristics of a photodiode for different illumination intensities.
Ans. Fabrication of Photodiode : It is a special reverse biased p-n junction diode fabricated with a transparent window to allow the light of suitable frequency (hν>Eg) to fall on the junction of diode







Biasing of a photodiode Symbol of a photodiode Characteristics of a photodiode
Working : (i) when light of energy (hν>Eg) falls on photodiode, electron-holes pairs are generated in the depletion region due to absorption of photons
due to electric field at the junction, electrons and holes are separated before they recombine electrons are collected on n-side and holes are collected at p-side, giving rise to an emf and current
Q. A semiconductor has equal electron and hole concentrations of 2 × 108/m3. On doping with a certain impurity, the hole concentration increases to 4 × 1010/m3.
i. What type of semiconductor is obtained on doping?
ii. Calculate the new electron hole concentration of the semiconductor.
Ans (i) p Type semiconductor
(ii) ne = 106 m3

Q. A heavily doped p-n junction diode under forward bias can emit spontaneous radiation. The diode is encapsulated with a transparent cover so that emitted light can come out. When the diode is forward biased, electrons are sent from n → p (where they are minority carriers) and holes are sent from p → n (where they are minority carriers). At the junction boundary, the concentration of minority carriers increases as compared to the equilibrium concentration (i.e., when there is no bias).
Thus at the junction boundary on either side of the junction, excess minority carriers are there which recombine with majority carriers near the junction. On recombination, the energy is released in the form of photons. Photons with energy equal to or slightly less than the band gap are emitted. When the forward current of the diode is small, the intensity of light emitted is small. As the forward current increases, intensity of light increases and reaches a maximum. Further increase in the forward current results in decrease of light intensity
The V-I characteristics is similar to that of a Si junction diode. But the threshold voltages are much higher and slightly different for each colour. The reverse breakdown voltages are very low, typically around 5 V. So, care should be taken that high reverse voltages do not appear across them. It can emit red, yellow, orange, green and blue light are commercially available.
(i) Which special purpose diode is mentioned above?
a) Solar cell
b) LED
c) Photodiode
d) Zener Diode

(ii) During recombination at the junction, emitted photons have:
(a) energy equal to or slightly less than the band gap.
(b) Energy greater than the band gap.
(c) Energy which has no relation with the band gap.

(d) Very low energy compared to band gap.
(iii) Which of the following is true about n type semiconductor?

a) Concentration of electrons is less than that of holes
b) Concentration of electrons is more than that of holes.
c) Concentration of electrons equal to that of holes.
d) None of these
(iv) Which of the following device is forward biased?

a) Solar cell b)LED
c) Photodiode d) Zener Diode
(v) Threshold voltage of LED is:
(a) lower compared to other p-n junction diodes and slightly different for each colour.
(b) lower compared to other p-n junction diodes and same for all colours.
(c) higher compared to other p-n junction diodes and same for all colours.
(d) higher compared to other p-n junction diodes and slightly different for Each colour.
ANS. (i) b (ii). a (iii). b (iv). b (v). d
……..##.....

SAMPLE QUESTION PAPER 1 (THEORY)

Class: XII (2022-2023)

SUBJECT: PHYSICS

Maximum Marks: 70 Marks Time Allowed: 3 hours.

General Instructions:

(1) There are 35 questions in all. All questions are compulsory

(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.

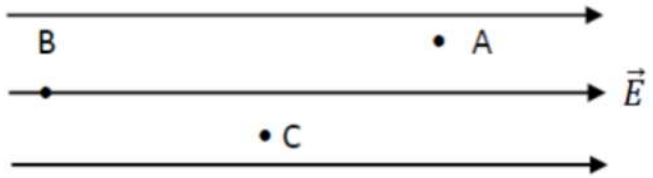
(3) Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.

(4) There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.

5. Use of calculators is not allowed.

SECTION- A

1. A, B & C are three points in a uniform electric field.



The electric potential is

A) Maximum at C B) Same at all the three points A, B & C

C) Maximum at A D) Maximum at B

2. Equal charges are given to two spheres of different radii. The potential will:

A) Be more on bigger sphere

B) Be more on smaller sphere

C) Be equal on both the spheres

D) Depend on the nature of the materials of the spheres

3. If the potential difference V applied across a conductor is increased to 2V with its temperature kept constant, free electrons in a conductor

A) remain the same B) become half of its previous value

C) be double of its initial value D) become zero.

4. Two wires of the same length are shaped into a square of side 'a' and a circle with radius 'r'. If they carry same current, the ratio of their magnetic moment is

A) 2 : π B) π : 2 C) π : 4 D) 4 : π

5. In order to float a wire carrying current I with linear mass density μ in the air , the direction and magnitude of magnetic field to be is (Current is passing left to right)

A) μg/I into the plane B) μg/I vertically upward

C) μg/IL into the plane D) μg/I L vertically upward

6. The relative permeability of a substance X is slightly less than unity and that of substance Y is slightly more than unity then

A) X is paramagnetic and Y is ferromagnetic B) X is diamagnetic and Y is ferromagnetic

C) X and Y both are paramagnetic D) X is diamagnetic and Y is paramagnetic

7. An AC voltage source of variable angular frequency ω and fixed amplitude V connected in series with a capacitance C and an electric bulb of resistance R (inductance zero). When ω is increased

A)The bulb glows dimmer B) Bulb glows brighter

C) Net impedance of circuit is unchanged D) Total impedance of the circuit increases

8. We consider the radiation emitted by the human body. Which one of the following statement is true?

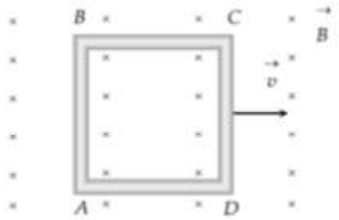
A)The radiation emitted is in the infrared region.

B) The radiation is emitted only during day time.

C) The radiation is emitted during summers and absorbed during winters

D) The radiation emitted lies in the ultraviolet region and hence it is not visible.

9. A conducting square loop of side 'L' and resistance 'R' moves in its plane with the uniform velocity 'v' perpendicular to one of its sides. A magnetic induction 'B' constant in time and space pointing perpendicular and into the plane of the loop exists everywhere as shown in the figure. The current induced in the loop is



A) BLv/R Clockwise B) BLv/R Anticlockwise

C) 2BLv/R Anticlockwise D) Zero

10. In a Young's double-slit experiment the center of a bright fringe occurs wherever waves fromthe slits differ in phase by a multiple of:

A) π/4 B) π/2 C) 2π D) 3π/4

11. Sodium and copper have work functions 2.3 eV and 4.5 eV respectively. Then the ratio of the Threshold wavelengths is nearest to

A) 1:2 B) 2:1 C) 3:2 D) 2:3

12. The ground state of energy of hydrogen atom is -13.6 eV. What is the kinetic energy of electron in the second excited state?

A) 3.02 eV B)3.34 eV C)1.15 eV D) 0.25 eV

13. What is true about Bohr's atomic model

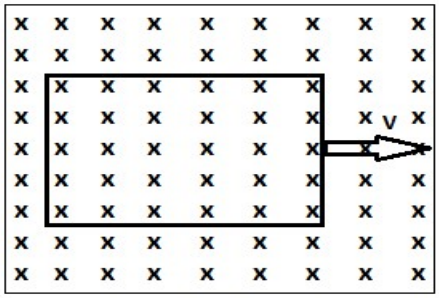
A) This model was unique totally different from other.

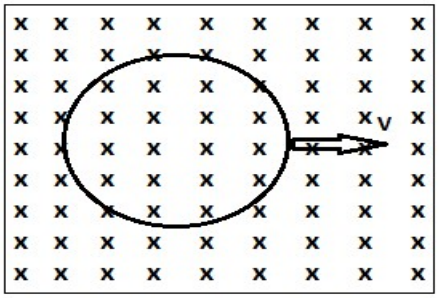
B) This model is modification of Rutherford's atomic model.

C) This model is modification of Thomson's atomic model.

D) None of the above.

14. A rectangular loop and a circular loop are moving out of a uniform magnetic field region in the given figure to a field free region with a constant velocity v. In which loop you expect the induced emf to be constant during the passage out of the field region:

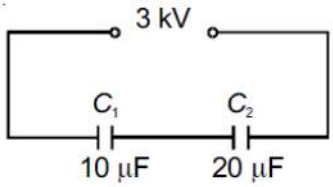




A) Rectangular loop B) Circular loop

C) Both (a) and (b) D) Neither (a) nor (b)

15. Capacitors C 1 is 10 μF and C2 is 20 μF are connected in series across a 3 kV supply, as shown. What is the charge on the capacitor C1?



A) 45000 μC B) 20000 μC C) 15000 μC D) 10000 μC

16. Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is NOT the correct explanation of A

c) A is true but R is false

d) A is false and R is also false

Assertion: If the temperature of a semiconductor is increased then it's resistance decreases.

Reason: The energy gap between conduction band and valence band is very small.

17. Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is NOT the correct explanation of A

c) A is true but R is false

d) A is false and R is also false

Assertion: No interference pattern is detected when two coherent sources are infinitely close toeach other.

Reason: The fringe width is inversely proportional to the distance between the two sources.

18. Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.

a) Both A and R are true and R is the correct explanation of A

b) Both A and R are true and R is NOT the correct explanation of A

c) A is true but R is false

d) A is false and R is also false

Assertion: In photoelectron emission, the velocity of electron ejected from near the surface is larger than that coming from interior of metal.

Reason: The velocity of ejected electron will be zero.

SECTION- B

19. The following table gives the wavelength range of some constituents of the electromagnetic spectrum

o.	velength
	m to 700 nm
	) nm to 1 nm
	m to 10^{-3} nm
	0^{-3} nm

Select the wavelength range and name of the electromagnetic waves that are (i) widely used in the remote switches and household electronic devices. (ii) produced in nuclear reactions.

20. The following figure shows the variation of intensity of magnetization versus the applied magnetic field intensity H for two magnetic materials A and B.(i) Identify the material A and B. (ii) Why does the material B have a larger susceptibility than A for a given field at constant temperature?

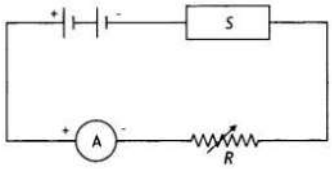
21. Given the value of ground state energy of hydrogen atom as - 13.6 eV. Find out its kineticenergy and potential energy in the ground and second excited state.

OR

A beam of alpha particles of velocity 2.1×10^{7} m/s is scattered by a gold foil (Z = 79). Find the distance of closest approach of the Alpha particle to the gold nucleus. The value of the charge /mass of Alpha particle is 4.8×10^{7} C kg^{-1}.

22. A concave lens of refractive index 1.5 is immersed in a medium of refractive index 1.65. What is the nature of the lens?

23. The diagram below shows a piece of pure semiconductor S in series with a variable resistor R and a source of constant voltage V. Would you increase or decrease the value of R to keep the reading of ammeter (A) constant when semiconductor S is heated? Give reason.

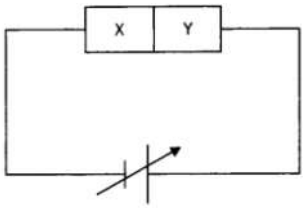


OR

Two semiconductor materials X and Y showed in the figure are made by doping germanium crystal with indium and arsenic respectively. The two are joined end to end and connected to a battery as shown,

(i) Will the junction be forward or reverse biased?

(ii) Sketch a V-l graph for this arrangement.



24. A parallel beam of light of wavelength 600 nm is incident normally on a slit of width 'a'. If the distance between the slits and the screen is 0.8 m and the distance of 2nd order maximum from the centre of the screen is. 15 mm, calculate the width of the slit.

25. A spherical Gaussian surface encloses a charge of 8.85×10^{-10} C (a) Calculate the electric flux through the surface. (b) How would the flux change if the radius of the Gaussian surface is doubled and why?

SECTION- C

26. (i) Write an expression for the force experienced by a charge q moving with a velocity v in a magnetic field B. Use this expression to define the unit of magnetic field. (ii) Obtain an expression for the force experienced by a current carrying wire in a magnetic field.

27. A conducting rod PQ of length l connected to a resistor R is moved at a uniform speed v normal to a uniform magnetic field B as shown in the figure. (i) Deduce the expression for the emf induced in the conductor. (ii) Find the force required to move the rod in the magnetic field. (iii) Mark the direction of induced current in the conductor.

28. A series LCR circuit is connected to an AC source. Using the phasor diagram derive the expression for the impedance of the circuit. Plot a graph to show the variation of current with frequency of the source explaining the nature of its variation.

OR

In a series LCR circuit connected to an AC source of variable frequency and voltage $V = V_o \sin \omega t$ draw a plot showing the variation of current I with angular frequency ω for two different values of resistance R_1 and R_2 ($R_1 > R_2$). Write the condition under which the phenomenon of resonance occurs. For which value of the resistance out of the two curves a sharper resonance is produced?

29. Define the terms cut-off voltage and threshold frequency in relation to the phenomenon of photoelectric effect. Using Einstein's photoelectric equation show how the cut-off voltage and threshold frequency for a given photosensitive material can be determine with the help of a suitable graph.

OR

Draw a plot showing the variation of photoelectric current with collector plate potential for two different frequencies $\nu_2 > \nu_1$ of incident radiation having the same intensity. In which case will the stopping potential be higher? Justify your answer.

30. (i) Define neutron multiplication factor and critical size for a fissionable material.

(ii) If 200 MeV energy is released in the fission of a single nucleus of $^{238}U_{92}$, how many fission must occur to produce a power of 1KW?

SECTION- D

31. Derive an expression for the energy stored in parallel plate capacitor. On charging a parallel plate capacitor to a potential V the space between the plates is halved and a dielectric medium of $\varepsilon_r = 10$ is introduced between the plates without disconnecting the DC source. Explain using suitable expression how the (i) capacitance (ii) electric field and (iii) energy density of the capacitor charge?

OR

Using Gauss' law deduce the expression with diagram for the electric field due to a uniformly charged spherical conducting shell of radius R at a point (i) outside and (ii) Inside the shell. Plot a graph showing variation of electric field as a function of $r > R$ and $r < R$. (r being the distance from the centre of the shell)

32. (a) A cell of emf E and internal resistance r is connected across a variable resistor R. Plot a graph showing the variation of terminal potential V with resistance R.

(b) Two cells of emf 2E and E and internal resistances 2r and r respectively are connected in parallel. Obtain the expression for the equivalent emf and the internal resistance of the combination.

OR

State Kirchhoff's rules. Apply these rules to the loop PRSP and PRQP to write the expression for the currents I_1, I_2 and I_3 in the given circuit.

33. (a) How will interference pattern in Youngs double slit experiment get affected when (i) distance between the slit S_1 and S_2 reduced and (ii) the entire setup is immerged in water? Justify your answer in each case.

(b) Three light rays red (R)green (G) and blue (B) are incident on a right angled prism ABC at face AB. The refractive indices of the material of the prism for red green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. Out of the three which colour of ray will emerge out of face ac? Justify your answer. Trace the path of these rays after passing through face ab.

OR

(a) Write Huygens' principle use this law verify the laws of refraction.
(b) A ray of light falls on a transparent right angled isosceles prism made from a glass of refractive index $\sqrt{2}$. Draw the ray diagram for this prism when the incident ray falls normally on one of the equal sides of this prism.

SECTION- E

34. **CASE STUDY QUESTIONS:**
Read the following paragraph and answer the questions.
Telescope: Rafisa wanted to see the stars of the night sky. She knows that she needs a telescope to see those distant stars. She finds out that the telescopes, which are made of lenses, are called refracting telescopes and the ones which are made of mirrors are called reflecting telescopes. So, she decided to make a refracting telescope. She bought two lenses, L1 and L2. out of which L1 was bigger and L2 was smaller. The larger lens gathers and bends the light, while the smaller lens magnifies the image. Big, thick lenses are more powerful. So, to see far away, she needed a big powerful lens. Unfortunately, she realized

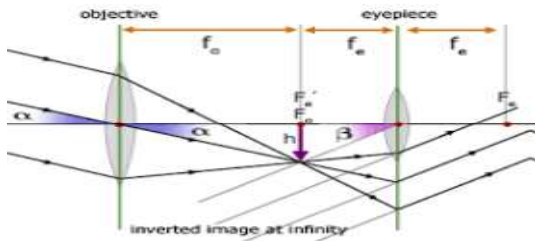
that a big lens is very heavy. Heavy lenses are hard to make and difficult to hold in the right place. Also, since the light is passing through the lens, the surface of the lens has to be extremely smooth. Any flaws in the lens will change the image. It would be like looking through a dirty window.

In the normal adjustment final image is formed at infinity and for normal adjustment magnification

$$m = fo / |fe|$$

In the normal adjustment of telescope, distance between objective lens and eye lens is

$$L = fo + fe$$



i. A telescope has been adjusted for relaxed eye. How will he change the distance between objective and eye piece lens if final image is to be seen at the least distance of distinct vision?

ii. The diameter of objective of a telescope is doubled. What is its effect on intensity of image seen?

iii. Write two points of difference between a compound microscope and an astronomical telescope

OR

State two advantages of this telescope over a reflecting telescope.

35. **CASE STUDY QUESTIONS:**

Read the following paragraph and answer the questions.

p-n Junction: Consider a thin p-type silicon (p-Si) semiconductor wafer. By adding precisely, a small quantity of pentavalent impurity, part of the p-Si wafer can be converted into n-Si. There are several processes by which a semiconductor can be formed. The wafer now contains p-region and n-region and a metallurgical junction between p-, and n- region. Two important processes occur during the formation of a p-n junction: diffusion and drift. We know that in an n-type semiconductor, the concentration of electrons (number of electrons per unit volume) is more compared to the concentration of holes. Similarly, in a p-type semiconductor, the concentration of holes is more than the concentration of electrons. During the formation of p-n junction, and due to the concentration gradient across p-, and n- sides, holes diffuse from p-side to n-side (p → n) and electrons diffuse from n-side to p-side (n → p). This motion of charge carries gives rise to diffusion current across the junction.

(i) How can a p-type semiconductor be converted into n- type semiconductor?

(ii) What are the majority charge carrier in p-type semiconductor.

(iii) What are the processes that occur during formation of a p-n junction?

OR

Draw input and output wave form for full wave rectifier.

=====

Marking Scheme of sample paper 1

Q No.	Answer/Steps	Marks
1	Maximum at B	1
2	Be more on smaller sphere	1
3	become half of its previous value	1
4	π : 4	1
5	μg/I vertically upward	1
6	X is diamagnetic and Y is paramagnetic	1
7	The bulb glows brighter	1
8	Every body at a temperature T > 0 K emits radiation in the infrared region.	1
9	Zero	1
10	2π	1
11	2:1	1
12	1.15 Ev	1
13	This model is modification of Rutherford's atomic model.	1
14	Rectangular loop	1
15	20000 μC	1
16	A	1
17	A	1
18	C	1
19	(i) Infrared waves are used in remotes switches and house hold circuits (1 nm to 700 nm) (ii) Gamma rays are produced in nuclear reactions (< 10^{-3} m).	1 1
20	(i) Material A Paramagnetic substance (χ_m is small positive) (ii) Material B Ferromagnetic substance (χ_m is large positive)	1 1
21	E_n=-13.6 eV (i) Kinetic energy at the ground state = 13.6 eV Potential energy at the ground state = -2(13.6) eV = -27.2 eV (ii) Kinetic energy at second excited state = = -3.4 eV Potential energy = -2 (3.4) eV = -6.8 Ev OR At the distance of closest approach Electrostatic potential energy = initial kinetic energy of Alpha particle.K Ze.2e/r_o= 1/2 (mv^2) r_o= 2KZe.2e/v^2m= 2.5x10^{-14}m	 1 1 1 1
22	**Since μ for lens. < *μ* for surrounding.** **It behaves like converging lens.**	1 1
23	When a semiconductor is heated, its resistance decreases. As a result, the total resistance of the circuit will decrease. In order to maintain constant current flow, the total resistance of the circuit must remain constant. Hence, the external resistance has to be increased to compensate for the decrease of resistance of the semiconductor.	1 1

	OR Material X is p-type and material Y is n-type. (i) The junction is reverse biased. (ii) For the V-l graph	 1 1
24	$Y_2 = \frac{5\lambda D}{2d}$ d = 80 μm	½ $1^1/_2$
25	$\Phi = q/\varepsilon_o = 100 Nm^2/C$ Unchanged because it is depends only the charge enclosed	1 1
26	Derivation of F= qvB sin θ Definition of one tesla Derivation of F = ilB sin θ	1 1 1
27	$dA = l(x_2-x_1) = l dx$ $d\varphi/dt = e = Blv$ $I = e/R = vBl/R$ $F = vB^2l^2/R$	 1 1 1
28	Phasor diagram for LCR circuit, derivation $Z = \sqrt{\{R^2 + (X_L - X_C)^2\}}$, The graph between I_m and ω. OR Graph between I_m and ω. Condition for resonance $X_L = X_C$, $\omega_o = 1/\sqrt{(LC)}$ Current amplitude is sharper for R_2 (when $R_1 > R_2$)	1 1 1 1 1 1
29	Definition of Cut off voltage and Threshold frequency Einstein's equation Graph OR Graph correct answer, It is clear that for higher frequency cut off potential is higher.	1 1 1 1 1 1
30	**(a)** The neutron **multiplication factor** of fissionable mass is defined as the ratio of the number of neutrons present in the beginning of a particular generation to the number of neutrons present in the beginning of the previous generation .Multiplication factor k gives ameasure of the growth rate of the neutron in a fissionable mass. **Critical size** : The size of the fissionable material for which the multiplication factor k=1 , iscalled the critical size and the corresponding mass is called the Critical Mass **(b)** Let the number of fissions per second be n. Energy released per second = nx200MeV = nx200X $1.6X10^{-19}$ J Energy required per second = 1000J nx200X $1.6X10^{-19}$ J = 1000 **$n = 3.125x10^{13}$**	1 1 1
31	Derivation of $U = CV^2/2$ When spacing between plates halved and introducing the dielectric slab (a) $C_2 = 20 C_1$ (b) $E_2 = 3 E_1$ (c) $U_2 = 4 U_1$ OR Diagram (i) Outside of shell Derivation of $E = \frac{1}{4\pi\varepsilon_o}\frac{q}{r^2}$ (ii) Inside of shell E = 0 Graph	2 1 1 1 1 2 1 1

32	(a) $V = (\frac{E}{R+r})R$ Graph (b)Circuit $V = \frac{4E}{3} - I\frac{2r}{3}$ $E_{eq} = 4E/3$ $r_{eq} = 2r/3$ OR Kirchhoff's 1st and 2nd rule $I_1 = 11/172$ A $I_2 = 4/215$ A $I_3 = 39/860$ A	1 1 1 1 ½ ½ 2 1 1 1
33	(a) (i) fringe width increases correct explanation (ii) fringe width decreases correct explanation (b) $\sqrt{2} < \mu$ TIR takes place on AC for ray $\mu > \sqrt{2} = 1.414$ i.e. green and blue colour suffers TIR where as red undergoes refraction with diagram. OR (a) Huygens' principle Verification the laws of refraction with diagram (b) $\mu = 1/\sin i_c$ $i_c = 45^0$ Ray diagram	1 1 1 2 1 2 1 1
34	(i) reduced (ii) becomes 4 times (iii)Two differences OR Two advantages	1, 1 2
35	(i) Adding pentavalent impurity (ii) Holes (iii)Drift and Diffusion OR Input and Output wave form	1,1 2

KENDRIYA VIDYALAYA SANGATHAN,RAIPUR REGION
SAMPLE PAPER (2) 2022-23
PHYSICS

Time : 3 hrs. **Class XII** **M.M. : 70**

General Instructions :

(a) All questions are compulsory.

(b) There are 35 questions in total. Q. Nos. 1 to 18 carry 1 mark each, Q. nos. 19 to 25 carry 2 marks each, Q. Nos. 26 to 30 carry 3 marks each, Q. No. 31 to Q.33 carry 5 mark each, Q No 34 to Q No 35 are case based question carrying 4 marks Each.

(c) There is no overall choice. However, an internal choice has been provided in 1 question of 2 marks, 1 question of 3 marks and all 3 questions of 5 marks each. You have to attempt only one of the given choices in such questions.

SECTION A

Q1- Electric dipole placed in a non - uniform electric field can experience
(a) a force but not a torque (b) a torque but not a force
(c) always a force and a torque (d) neither a force not a torque

Q2- If the net electric flux through a closed surface is zero then we can infer
(a) no net charge is enclosed by the surface
(b) uniform electric field exist within the surface
(c) electric potential varies from point to point inside the surface
(d)charge is present inside the surface.

Q3- The magnitude of electric field due to a point charge 2 q , at a distance r is E. Then the magnitude of the electric field due to a uniformly charged thin spherical shell of radius R with total charge q at a distance of r/2 (r>>R) will be
(a) E/4 (b) 0 (c) 2E (d) 4E

Q4- The potential difference of 200 volt is maintained across a conductor of resistance 100 ohm . The number of electron passing through it in 1 s is
(a)1.25×10^{19} (b) 2.5×10^{18} (c) 1.25×10^{18} (d) 2.5×10^{16}

Q5- Which one of the following is not affected by the presence of magnetic field?
(a) current carrying conductor (b) moving charge (c) stationary charge
(d) a rectangular current loop with its plane parallel to the field.

Q6- In a certain region of ,electric field E and magnetic field B are perpendicular to each other. An electron enter to the region perpendicular to both E and B and moves undeflected. The speed of the electron is
(a) $\vec{E}.\vec{B}$ (b)$|\vec{E}x\vec{B}|$(c) $\vec{E}/\vec{B}$ (d) $\vec{B}/\vec{E}$

Q7- If the speed v of a charged particle, moving in a magnetic field B(v is perpendicular to B) is halved then the radius of its path will be-
(a) will not change (b) becomes 2 times (c) becomes one fourth (d) becomes half.

Q8- A circular current carrying coil produces a magnetic field B at its center. The coil is rewound so as to have three turns and the same current is passed through it. The new magnetic field at the center is –
(a) 3B (b) B/3 (c) B/9 (d)9 B

Q9 - An electron is released from rest in a region of uniform electric and magnetic fields acting parallel to each other. The electron will
(a)move in straight line(b) move in a circle
(c) remain stationary (d) move in helical path.

Q10- The phase difference between the electric and the magnetic field vectors in lectromagnetic waves is

(a) π4 (b) π2 (c) π (d) zero

Q11- The refractive indices (R.I.) of glass and water with respect to air are 3/2 and 4/3 respectively. The R.I. of glass w.r. to water is:
(a) 8/9 (b) 9/8 (c) 7/6 (d) 2

Q12-Protons and alpha particles have the same de-Broglie wavelength. What is same for both of them ?
(a) Energy (b) Time period (c) Frequency (d) Momentum

Q13-The work function of photoelectric material is 3.3 eV. The threshold frequency will be equal to:
(a) 8×10^{14} Hz (b) 8×10^{10} Hz (c) 5×10^{10} Hz (d) 4×10^{14} Hz

Q14- Ratio of the radii of the nuclei with mass numbers 8 and 27 would be
(a) $\frac{27}{8}$ (b) $\frac{8}{27}$
(c) $\frac{2}{3}$ (d) $\frac{3}{2}$

Q15- The angle of minimum deviation for an equilateral glass prism is 30°. Refractive index of the prism is:
(a) 1√3 (b) √2 (c) 1 (d) can't be determined

Q16- Two lens of power -15 D and +5 D are placed in contact co-axially. The focal length of equivalent lens is:
(a) -10 cm (b) -20 cm (c) +10 cm (d) None

Q17- With fall of temperature, the forbidden energy gap of a semiconductor
(a) increases (b) decreases (c) sometimes increases or decreases(d) remains unchanged

Q18- In reverse biasing:
(a) large amount of current flows (b) no current flows
(c) potential barrier across junction increases (d) depletion layer resistance increases

SECTION B

Q19-(i)Define the term electric flux. Write its SI unit .
(ii)What is the flux due to electric field $E = 3 \times 10^{3}$ i N / C through a square of side 10 cm when it is held normal to E ?

Q20-. A parallel plate capacitor of capacitance C is charged to V volt by a battery . After sometime the battery is disconnected and the distance between the plate is doubled. Now a slab of dielectric constant 1< K < 2 is introduced to fill the space between the plates . How will the following affected ?
(I) the electric field between the plates of the capacitor
(ii) the energy stored in the capacitor justify your answer in each case.

Q21- Two identical bars ,one of paramagnetic material and other of diamagnetic material are kept in a uniform magnetic field parallel to it. Draw diagrammatically the modifications in the magnetic field pattern in each case.

Q22- A long straight wire AB carries a current of 4A .A proton P travels at 4×10^{6} m/s parallel to the wirev0.2m from it and in a direction opposite to the current as shown in the figure. Calculate

the force which the magnetic field due to the current carrying wire exert on the proton. Also specify the direction.

Q23- You are given following three lenses. Which two lenses will you use as an eyepiece and as an objective to construct an astronomical telescope?

LENS	Lens Power (P)	Aperture (A)
L1	3 D	8 CM
L2	6 D	1 CM
L3	10 D	1 CM

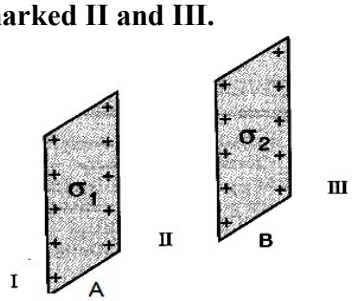
Q24- The ground state energy of hydrogen atom is 13.6 eV. What are the kinetic and potential energies of electron in this state ?

Q25- Write the two processes that take place in the formation of a p–n junction. Explain with the help of a diagram, the formation of depletion region and barrier potential in a p–n junction.

SECTION C

Q26- Explain the working of p-n junction diode as a full wave rectifier? Draw the input output waveforms.

Q27- Two infinitely large plane thin parallel sheets having the surface charge densities σ 1 and σ 2 (σ 1 >>> σ 2)as shown in the figure. Write the magnitudes and direction of the net electric field in the region marked II and III.



Q28- A coil of number of turns N area A is rotated at a constant speed ω in a uniform magnetic field B and connected to aresistor R. Deduce expressions for (i) maximum emf induced in the coil (ii) power dissipation in the coil.

Q29-.Draw a graph showing variation of the resultant intensity in the interference pattern against position 'x' on the screen. (b) Compare and contrast the pattern which is seen with two coherently illuminated narrow slits in Young's experiment with that seen for a coherently illuminated single slit producing diffraction.

Q30- Calculate the energy released in MeV in the following nuclear reaction:

calculate the energy released in MeV in the following nuclear reaction:

$$^{238}_{92}U \longrightarrow {}^{234}_{90}Th + {}^{4}_{2}He + Q$$

[Mass of $^{238}_{92}U = 238.05079$ u,

Mass of $^{234}_{90}Th = 234.043630$ u,

Mass of $^{4}_{2}He = 4.002600$ u, $1u = 931.5\ MeV/c^2$]

SECTION D

Q31-A) In a series LCR circuit connected to an AC source of variable frequency and voltage $V = V_o \sin \omega t$ draw a plot showing the variation of current I with angular frequency ω for two different values of resistance R_1 and R_2 ($R_1 > R_2$). Write the condition under which the phenomenon of resonance occurs. For which value of the resistance out of the two curves a sharper resonance is produced?

B) A light bulb is rated 150 W for 220 V AC supply of 60 Hz. Calculate (i) the resistance of the bulb (ii) the rms current through the bulb.

OR

A) Draw a labeled diagram of an AC generator. Explain briefly its principle and working.
B) An AC voltage $V = V_o \sin \omega t$ is applied across a pure capacitor C. Obtain an expression for the current I in the circuit and hence obtain the (i) capacitive reactance of the circuit and (ii) the phase of the current flowing with respect to the applied voltage.

Q32- A) Define the term 'wave front'. Draw the wave front and corresponding rays in the case of a (i) diverging spherical wave (ii) plane wave. Using Huygens's construction of a wave front, explain the refraction of a plane wave front at a plane surface and hence deduce Snell's law.

B) Draw a graph to show variation of angle of deviation 'D' with that of angle of incidence 'i' for a monochromatic ray of light passing through a glass prism of reflecting angle 'A'.

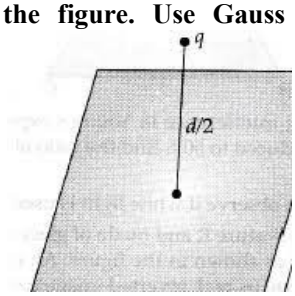
OR

i) Stating the assumptions and sign conventions, derive expression for lens maker's formula.
ii) A concave lens made of material of refractive index n1 is kept in a medium of refractive index n2. A parallel beam of light is incident on the lens. Complete the path of rays of light emerging from the concave lens if: (i) n1> n2, (ii) n1 = n2, & (iii) n1< n2.

Q33-A) State Gauss law on electrostatic and derive an expression for the electric field due due to a infinitely charged large plane sheet with surface charge density σ.
B) Draw the pattern of electric field lines when a point charge + Q is kept near a uncharged conducting plate.

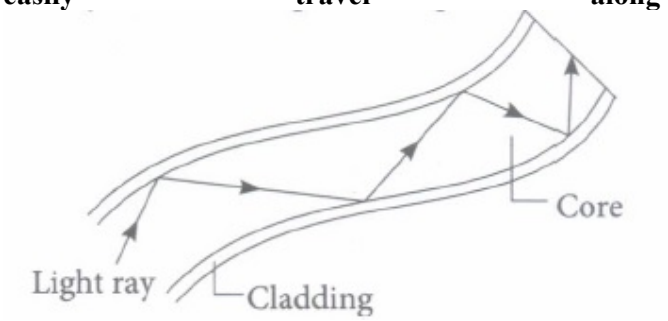
OR

A) Derive an expression for the electric field E due to a dipole of length 2a at a point of distant r from the centre of the dipole on the axial line . Draw a graph of E versus r for r >> a.
B)A point charge q is at a distance of d / 2 directly from the centre of the square of side d as shown in the figure. Use Gauss law to obtain the expression for the electric flux through the square.



SECTION E

Q34-An optical fibre is a thin tube of transparent material that allows light to pass through, without being refracted into the air or another external medium. It make use of total internal reflection. These fibres are fabricated in such a way that light reflected at one side of the inner surface strikes the other at an angle larger than critical angle. Even, if fibre is bent, light can easily travel along the length.



(i) Which of the following is based on the phenomenon of total internal reflection of light?
(a) Sparkling of diamond (b) Optical fibre communication

a) Sparkling of diamond

(b) Optical fibre communication

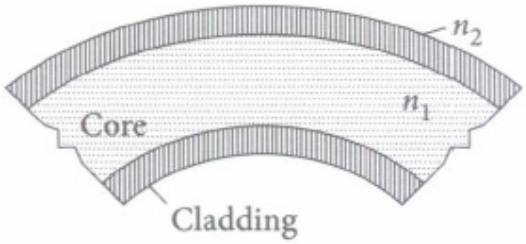
(c) Instrument used by Doctors for endoscopy

(d) All the above

(ii) A ray of light will undergo rotal internal reflection inside the optical fibre, if it

(a) goes from rarer medium to denser medium
(b) is incident at an angle less than the critical angle
(c) strikes the interface normally
(d) is incident at an angle greater than the critical angle
(iii) If in core, angle of incidence is equal to critical angle, then angle of refraction will be
(a) 0° (b) 45° (c) 90 (d) 180°

(iv) In an optical fibre (shown), correct relation for refractive indices of core and cladding is



(a) $n_1 = n_2$ (b) $n_1 > n_2$ (c) $n_1 < n_2$ (d) $n_1 + n_2 = 2$

Q35-Photoelectric effect is the phenomenon of emission of electrons from a metal surface, when radiations of suitable frequency fallon them. The emitted electrons are called photoelectrons and the current so produced is called photoelectric current.
(i) With the increase of intensity of incident radiations on photoelectrons emitted by a photo tube, the number of photoelectrons emitted per unit time is

(a) increases **(b) decreases**

(c) remains same **(d) none of these**

(ii) It is observed that photoelectron emission stops at a certain time t after the light source is switched on. The stopping potential (V) can be represented as

(a) $2(KE_{max}/e)$ **(b) (KE_{max}/e)**

(c) $(KE_{max}/3e)$ **(d) $(KE_{max}/2e)$**

(iii) A point source of light of power 3.2×10^{-3} W emits monoenergetic photons of energy 5.0 eV and work function 3.0 eV. The efficiency of photoelectron emission is 1 for every 10^6 incident photons. Assume that photoelectrons are instantaneously swept away after emission. The maximum kinetic energy of photon is

(a) 4 eV **(b) 5 eV**

(c) 2 eV **(d) Zero**

(iv) Which of the following device is the application of Photoelectric effect?

(a) Light emitting diode **(b) Diode**

(c) Photocell **(d) Transistor**

CBSE SAMPLE QUESTION PAPER 3 (THEORY)

Class: XII

SESSION : 2022-2023

SUBJECT: PHYSICS

Maximum Marks: 70 Marks **Time Allowed: 3 hours.**

General Instructions:

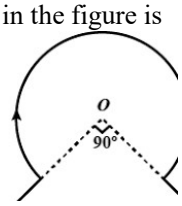
(1) There are 35 questions in all. All questions are compulsory

(2) This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.

(3) Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of three marks each, section D contains three long questions of five marks each and Section E contains two case study based questions of 4 marks each.

(4) There is no overall choice. However, an internal choice has been provided in section B, C, D and E. You have to attempt only one of the choices in such questions.

5. Use of calculators is not allowed.

	SECTION A	
1.	A conducting sphere of radius 5 cm is charged 15 C . Another uncharged sphere of radius 10 cm is allowed to touch it for enough time . After that two are separated , the surface charge density of charge on two sphere will be a. 2:1 b. 1:2 c. 1:1 d. 3:1	1
2.	At the surface of a charge conductor, electrostatic field must be a . normal to the surface at every point b. never normal to the surface at every point c. tangential to the surface at every point d. parallel to the surface at every point	1
3.	Two wire A and B of the same material , having radii in the ratio 1 : 2 and carrying current in the ratio 4: 1 , the ratio of the drift speed of electrons in A and B is a. 16:1 b. 1:16 c. 4: 1 d. 1:4	1
4.	A narrow beam of protons and deuterons having the same momentum values , enter a region of uniform magnetic field directed perpendicular to their common direction of motion . What would be the ratio of the radii of the circular path describe by protons and deuterons a. 2 : 1 b. 1 : 2 c. 1 : 1 d. 3 : 1	1
5.	The maagnetic field at the centre of the circular coil of radius 1 cm and carrying current of 4 ampere as shown in the figure is  a. $(8\pi/3)\times10^{-4}$ T b. $(8\pi/3)\times10^{-5}$ T c. $2\pi\times10^{-5}$ T d. $2\pi\times10^{-4}$T	1
6.	A straight current carrying conductor is placed inside a uniform magnetic field .The force per unit length acting on the conductor is a. Maximum when the conductor is perpendicular to the direction of magnetic field. b. Maximum when the conductor is along the direction of magnetic field. c . Minimum when the conductor is perpendicular to the direction of magnetic field. d .Minimum when conductor makes an angle of 45° with the direction of magnetic field.	1

7.	A emf of 100 mV is induced in a coil when current in the another nearby coil becomes 10 A from 0s to 0.1 s . The coefficient of mutual induction between the two coils will be a. 100mH b. 1mH c. 1000 mH d. 10 mH	1
8.	Choose the correct statement a. A capacitor can conduct a dc circuit but not an inductor. b. In a dc circuit the inductor can conduct but not a capacitor . c. In dc circuit both the inductor and capacitor cannot conduct . d. The inductor has infinite resistance in a dc circuit.	1
9.	The magnetic flux linked with a closed circuit of resistance 8Ω varies with time according to the expression $\varphi = (5t^2 - 4t + 2)$ where φ is in millI weber and t in second. What will be the value of induce current at t = 0.2 s? a. 1V b. 1.5V c. 2V d. 3V	1
10.	A beam of light consisting of two wavelengths, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment. Find the ratio of fringe widths in the two cases provided the geometry of set up in two cases is same. a. 1.47 b. 1.25 c. 1.37 d. 1.27	1
11.	If the threshold wavelength of radiations required to eject a photoelectron from a metal surface is 6×10^{-7}m , then work function of the metal is a.3.4×10^{-19} J b. 3.5×10^{-19} J c. 3.3×10^{-19} J d. 3.4×10^{-19} J	1
12.	A beam of alpha particleis incident on a target of lead . A particular alpha particle comes in head - on to a particular lead nucleus and stops 6.5 x 10 - 14 m away from the centre of the nucleus .(This point is well outside the nucleus) Assume that the lead nucleus, which has 82 protons , remains at rest. The mass of the Alpha particle is 6.64 x 10 - 27 kg. What is the initial kinetic energy (in Mev) did the alpha particle have ? a. 3.93 MeV b. 3.63 MeV c. 3.73 MeV d. 3.83 MeV	1
13.	Infrared waves are produced by a. permanent magnets b. dipole oscillations c. all hot bodies and molecules d. static charges	1
14.	Choose the WRONG statement. a.The nuclear force becomes very strong if the nucleus contains a large number of nucleons. b. The nuclear force becomes weak if the nucleus contains too many neutrons compared to the number of protons c. Nuclei with atomic number greater than 82 show a tendency to disintegrate. d.The nuclear force becomes weak if the nucleus contains too many protons compared to the number of neutrons	1
15.	The electric potential V at any point (x , y ,z) is given by $v = 3x^2$ where x is in metre and V in volts. The electric field at the point (1 , 0 , 2)m is a. 6V /m along - x axis 6 V/m along +x axis b. 1.5 V/m along - x-axis 1.5 V/m along + x-axis	1
16.	**Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.** **a) Both A and R are true and R is the correct explanation of A** **b) Both A and R are true and R is NOT the correct explanation of** **c) A is true but R is false** **d) A is false and R is also false** **ASSERTION(A)**: When the apparatus of Young's double slit experimenr is brought in aliquid from air, the fringe width decreases. **Reason (R)**: The wavelength of light decreases in the liquid.	1
17	**Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.**	1

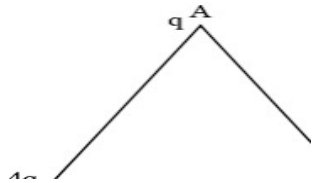
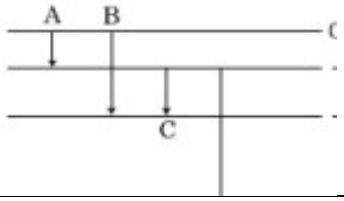
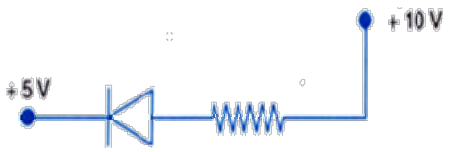
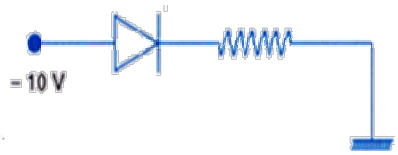
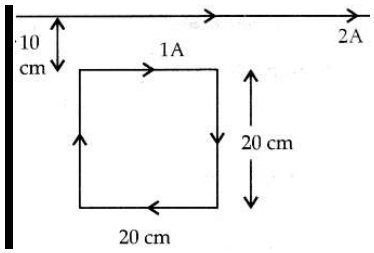
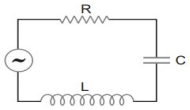
.	**a) Both A and R are true and R is the correct explanation of A** **b) Both A and R are true and R is NOT the correct explanation of** **c) A is true but R is false** **d) A is false and R is also false** **ASSERTION(A) :** Work function of aluminum is 4.2 eV. Emission of electrons will be possible by two photons, each of 2.5eV energy, striking the electron of aluminum. **Reason (R):** Energy of a photon can be less than the work function of the metal, for photoelectron emission.	
18.	**Two statements are given-one labelled Assertion (A) and the other labelled Reason (R). Select the correct answer to these questions from the codes (a), (b), (c) and (d) as given below.** **a) Both A and R are true and R is the correct explanation of A** **b) Both A and R are true and R is NOT the correct explanation of** **c) A is true but R is false** **d) A is false and R is also false** **ASSERTION(A) :** The conductivity of a pure semiconductorincreases on doping. **Reason (R)** : Doping causes the reduction in bond strength	1
	SECTION B	
19.	A magnetic dipole is under the influence of two magnetic fields. The angle between the field directions is 60°, and one of the fields has a magnitude of 1.2×10–2 T. If the dipole comes to stable equilibrium at an angle of 15° with this field, what is the magnitude of the other field?	2
20.	How does a charge q oscillating at certain frequency produce electromagnetic waves? Sketch schematic diagram depicting electric and magnetic fields for an electromagnetic wave propagating along the Z-direction	2
21.	Three point charges q , - 4q and 2q are placed at the vertices of an equilateral triangle ABC of side l as shown in the figure. (a) Obtain the expression for the magnitude of the resultant electric force acting on the charge Q .  (b) Find the amount of work done to separate the charges at infinite distance.	2
22.	Calculate the shortest wavelength of the spectral lines emitted in Balmer series **OR** The energy levels of a hypothetical atom are shown below. Which of the shown transitions will result in the emission of photon of wavelength 275nm?  	
23.	A small telescope has an objective lens of focal length 140cm and an eyepiece of focal length 5.0cm. What is the magnifying power of the telescope for viewing distant objects when the telescope is in normal adjustment (i.e., when the final image is at infinity)? the final image is formed at the least distance of distinct vision (25cm)? (3) what is the separation between the objective lens and the eyepiece? (4) If this telescope is used to view a 100 m tall tower 3 km away, what the height of the	

	image of th tower formed by the objective lens?	
24.	Explain, with the help of a circuit diagram, how the thickness of depletion layer in a pn junction diode changes when it is forward biased. In the following circuits which one of the two diodes is forward biased and which is reverse biased? (I)  (ii)  	
25	A double slit is illuminated by light of wavelength 6000 . The slits are 0.1 cm apart and the screen is placed 1 m away. Calculate: i. angular position of 10th maximum in radian ii. separation of two adjacent minima.	
	SECTION C	
26.	A square loop of side 20 cm carrying current of 1A is kept near an infinite long straight wire carrying a current of 2A in the same plane as shown in the figure.  Calculate the magnitude and direction of the net force exerted on the loop due to the current carrying conductor.	
27.	A wheel with 10 metallic spokes each 0.5 m long is rotated with a speed of 60 rev/min in a plane normal to the horizontal component of earth's magnetic field HE at a place. If the horizontal component of magnetic field = 0.4 G at the place, what is the induced emf between the axle and the rim of the wheel? Note that 1 G = 10^{-4} T	
28.	 	

The figure shows a series L-C-R circuit with L = 10 H, C= 40μF, R=600Ω connected to a variable frequency 240 V source. Calculate

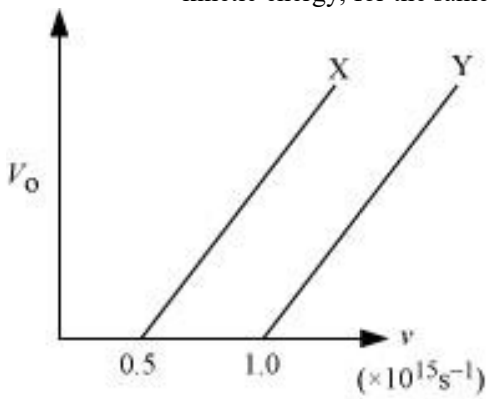
i. the angular frequency of the source which derives the circuit at resonance.
ii. the current at the resonating frequency.
iii. iii. the rms potential drop across the inductor at resonance.

OR

An AC source of voltage $V = V_0 \sin w t$ is connected to a series combination of L, C and R. Use the phasor diagram to obtain expressions for impedance of the circuit and phase angle between voltage and current. Find the condition when current will be in phase with the voltage. What is the circuit in the condition called?

29. The following graph shows the variant of stopping potential V_s with the frequency (v) of the incident radiation for two photosensitive metals X and Y.

(i) Which of the metals has larger threshold wavelength? Give reason.
(ii) Explain Giving reason which metal gives out electrons having larger kinetic energy, for the same wavelength of the incident radiation.



1. If the distance between the light source and metal X is halved, what will be the kinetic energy of electrons emitted due to this change? Give reason.

a. OR

2. Plot a graph showing the variation of photoelectric current with intensity of light.
3. Plot a graph showing the variation of photocurrent with collector plate potential for different intensity but same frequency of incident radiation
4. Plot a graph showing the variation of photocurrent with collector plate potential for different frequency but same intensity of incident radiation

30. a) The mass of a nucleus in its ground state is always less than the total mass of its constituents – neutrons and protons. Explain.
(b) Plot a graph showing the variation of potential energy of a pair of nucleons as a function of their separation.

OR

Calculate the energy released in MeV in the following nuclear reaction:

calculate the energy released in MeV in the following nuclear reaction:

$$^{238}_{92}U \longrightarrow ^{234}_{90}Th + ^{4}_{2}He + Q$$

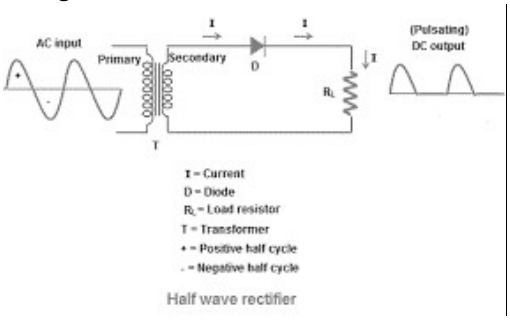
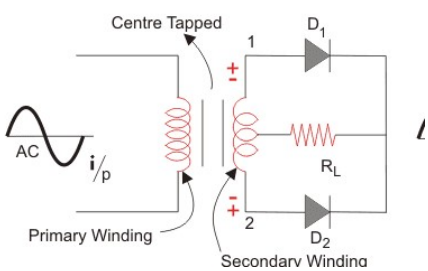
[Mass of $^{238}_{92}U$ = 238.05079 u,

Mass of $^{234}_{90}Th$ = 234.043630 u,

Mass of $^{4}_{2}He$ = 4.002600 u, 1u = 931.5 MeV/c²]

SECTION D

31 (i) Use Gauss law to derive the expression for the electric field E due to straight uniformly 5

.	charged infinite line of charge density λCm^{-1}. (ii) Draw graph to show the variation of E with perpendicular distance r from the line of charge . (iii) Find the work done in bringing a charge Q from perpendicular distance r_1 to r_2 ($r_2 >> r_1$). OR Define the term electric dipole moment of a dipole . State its SI unit. Derive an expression for the electric field due to dipole of dipole moment p at a point on its perpendicular bisector.	
32.	Explain the term 'drift velocity' of electrons in a conductor. Hence obtain the expression for the current through a conductor in terms of 'drift velocity' **OR** Use Kirchhoff's rules to obtain conditions for the balance condition in a Wheatstone bridge.	5
33.	(i) Plot a graph to show variation of the angle of deviation as a function of angle of incidence for light passing through a prism. (ii) Derive an expression for refractive index of the prism in terms of angle of minimum deviation and angle of prism. (iii)A prism of refractive index of has a refracting angle of 60°. At what angle must a ray be incident on it so that it suffers a minimum deviation? OR i. Write the conditions under which light sources can be said to be coherent. ii. Why is it necessary to have coherent sources in order to produce an interference pattern? iii. In Young's double slit experiment, monochromatic light of wavelength 630 nm illuminates the pair of slits and produces an interference pattern in which two consecutive bright fringes are separated by 8.1 mm. Another source of monochromatic light produces the interference pattern in which the two consecutive bright fringes are separated by 7.2 mm. Find the wavelength of light from the second source. What is the effect on the interference fringes, when the monochromatic source is replaced by a source of white light?	5
	SECTION E	
34.	**CASE STUDY : RECTIFIER** **Read the following paragraph and answer the questions :** Rectifier is a device is used for converting alternating current or voltage into direct current or voltage . It's working is based on the fact that the resistance of p-n junction diode becomes low when forward bias and becomes high when reverse biased . Half wave rectifier uses only single diode while full wave rectifier uses two diode at shown in the figure   	4

(i) What is the working principle of rectifier?

(ii) In half-wave rectification, what is the output frequency if the input frequency is 50 Hz. What is the output frequency of a full-wave rectifier for the same input frequency.

(iii) What happens to the width of depletion layer of a p-n junction when it is
(a) forward biased and (b) reverse biased?

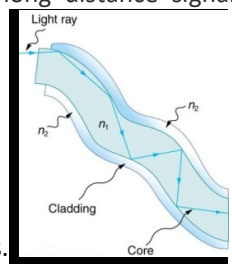
OR

Name the two processes involved in the formation of p-n junction diode

CASE STUDY : Optical fibres

Read the following paragraph and answer the questions

Optical fibres are used mainly for long distance transmission of signals. They are made up of high quality composite glass or quartz fibres which consists of core and cladding. The refractive index of core is higher than the cladding. So core acts as a rarer medium and cladding acts as the denser medium. The signal in the form of light is send from one end of the fibre at a particular angle of incidence so that the light must get totally internally reflected. In such way, light get totally internally reflected many times along the length of the fibre and finally will be received at the other end without loss in intensity. In this way, by total internal reflection of light the long distance signal transmission is possible through optical fibres. through optical fibres.



1. In total internal reflection when the angle of incidence is equal to the critical angle for the pair of media in contact what will be the angle of refraction?
2. The refractive index for a material is 1.62 .The sine of the critical angle for the total internal reflection at material-air interface is how much?
3. How total internal reflection of light to be possible in case of optical fibre.

OR

What are the two condition that are essential for a total internal reflection to occur.

KENDRIYA VIDYALAYA SANGATHAN (RAIPUR REGION)

CLASS XII PHYSICS THEORY ,Sample paper 4

SESSION 2022 - 23

MM : 70 **TIME : 3 Hours**

General Instructions:

- There are 35 questions in all. All questions are compulsory.
- This question paper has five sections: Section A, Section B and Section C, Section D and Section E. All the sections are compulsory.

- Section A contains eighteen MCQ of 1 mark each, Section B contains seven questions of two marks each, Section C contains five questions of 3 marks each , Section D contains three long questions of 5 marks and section-E contains two case study-based question of 4 marks each.
- There is no overall choice. However, an internal choice has been provided in section B,C,D and E. You have to attempt only one of the choices in such questions.
- You may use log tables if necessary but use of calculator is not allowed.

SECTION-A

Q1. Electric dipole placed in a non - uniform electric field can experience

(a) a force but not a torque (b) a torque but not a force

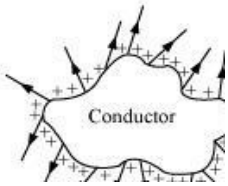
(c) always a force and a torque (d) neither a force not a torque

Q2.The unit of permittivity of free space (ε_0) is

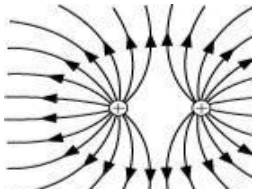
(a)$CN^{-1}m^{-1}$ (b)Nm^2C^{-2} (c) $C^2N^{-1}m^{-2}$ (d)$C^2N^{-2}m^{-2}$

Q3. Which among the curves shown in Fig. cannot possibly represent electrostatic field lines?

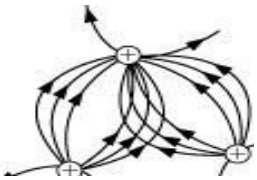
(a)



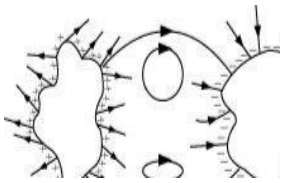
(b)



(c)



(d)



Q4. If positive charge is displaced against the electric field in which it was situated, then

(a)work will be done by the electric field on the charge. (b)The intensity of electric field decreases.

(c) energy of the system decrease.(d)energy will be provided by external source displacing the charge.

Q5.An electric dipole consisting of charges +q and –q separated by a distance of L is in stable equilibrium in a uniform electric field E. The electrostatic potential energy of the dipole is

(a)q LE (b) Zero (c) –q LE (d) -2qEL

Q6.Three charges +4q , Q and q are placed in a straight line of length l at points at distance 0,l/2 and l respectively. What should be Q in order to make the net force on q to be zero?

(a) –q (b) -2q (c) –q/2 (d) 4q

Q7. A bar magnet has magnetic moment M. Its initial position is parallel to the direction of uniform magnetic field B. In this position , the magnitudes of torque and force acting on it respectively are

(a) 0 and MB (b)MB and MB (c) 0 and 0 (d) |M x B| and 0.

Q8.A biconvex lens of glass having refractive index 1.47 is immersed in a liquid. It becomes invisible and behaves as a plane glass plate. The refractive index of the liquid is

(a) 1.47 (b) 1.62 (c) 1.33 (d) 1.51.

Q9.For a glass prism, the angle of minimum deviation will be smallest for the light of

(a) red colour (b) blue colour (c) yellow colour (d) green colour.

Q10.A welder wears special glasses to protect his eyes mostly from the harmful effect of

(a)X-rays (b) UV rays (c) Infrared rays (d) microwaves.

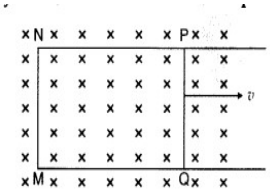
Q11.A ray of light moves from denser to rarer medium.Which of the following is correct?

(a)Energy increases (b) Frequency increases (c) Phase change by 90^0 (d) velocity increases.

Q12.Two waves having the intensities in the ratio of 9:1 produce interference.The ratio of maximum to minimum intensity is

(a)10:8 (b) 9:1 (c) 4:1 (d) 2:1

Q13. A rectangular loop PQMN with movable arm PQ of length 10 cm and resistance 2 Ω is placed in a uniform magnetic field of 0.1 T acting perpendicular to the plane of the loop as is shown in the figure. The resistances of the arms MN, NP and MQ are negligible. Then the emf induced in the arm PQ and the current induced in the loop when arm PQ is moved with velocity 20 m/s respectively are-



(a)0.2V,0.1A (b) 0.1V ,0.2A (c) 0.2V,0.2A (d) 0.1V, 0.1 A .

Q14.The kinetic energy of a proton and that of an alpha particle are 4 eV and 1eV respectively. The ratio of de-Broglie wavelengths associated with them will be

(a)2:1 (b) 1:1 (c) 1:2 (d) 4:1

Q15.Paschen series of atomic spectrum of hydrogen gas lies in

(a)Infrared region (b)UV region

(c)Visible region (d)partly in UV and partly in visible region.

Q16.In Bohr's model of hydrogen atom, the total energy of the electron in nth discrete orbit is

proportional to

(a) n (b) 1/n (c) n^2 (d) $1/n^2$

Mark the correct choice as :

(a)If both assertion and reason are true and reason is correct explanation of assertion.

(b)If both assertion and reason are true but reason is not the correct explanation of assertion.

(c)If assertion is true but reason is false.

(d) If both assertion and reason are false.

Q17.**Assertion**:The total energy of an electron revolving in any stationary orbit is negative.

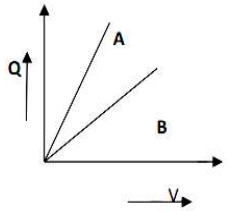
Reason: Energy can have positive or negative value.

Q18. **Assertion**: Nuclear force between neutron-neutron, proton-neutron and proton-proton is approximately the same.

Reason: The nuclear force does not depend on the electric charge.

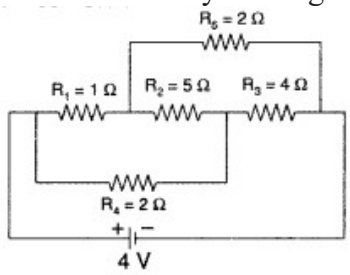
SECTION-B

Q 19. The given graph shows variation of charge Q versus potential difference V for two capacitor C_1 and C_2 . Both the capacitor of same plate separation but plate area of C_2 is greater than C_1. Which line (A or B) corresponds to C_1 and why?

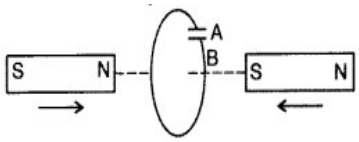


(OR)

Calculate the current drawn from the battery in the given network.

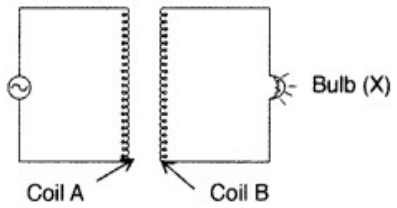


Q20. State Lenzs law .Predict the polarity of the capacitor when the two magnets are quickly moved in the directions marked by arrows.



Q21. The figure given shows an arrangement by which current flows through the bulb (X) connected with coil B, when a.c. is passed through coil A. (i) Name the Phenomenon involved.

(ii) If a copper sheet is inserted in the gap between the coils, explain, how the brightness of the bulb would change.



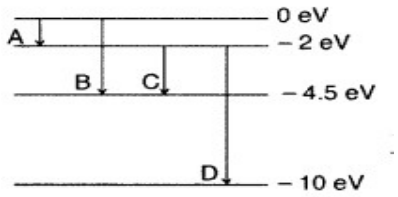
Q22. Using Huygens's wave theory, verify the laws of reflection(Draw required diagram).

(OR)

Arrange the following electromagnetic radiation in ascending order in respect of their frequencies. (i) Microwaves (ii) Radio waves (iii)X-rays (iv)Gamma rays. Write two uses of any one of these.

Q23. The energy levels of a hypothetical atom are shown below. Which of the shown transitions will result in the emission of a photon of wavelength 275 nm? Which of these transitions correspond to emission of radiation of

(i) maximum and
(ii) minimum wavelength ?



Q24. An electron and alpha particle have the same de-Broglie wavelength associated with them.

How are their kinetic energies related to each other?

Q25. Draw a circuit diagram of a full wave rectifier and draw input and output waveforms.

SECTION-C

Q26. Write two properties of equipotential surfaces. Depict equipotential surfaces due to an isolated point charge. Why do the equipotential surfaces get closer as the distance between the equipotential surface and the source charge decreases?

(OR)

Define the term 'drift velocity' of electrons in a current carrying conductor. Obtain the relationship between the current density and the drift velocity of electrons.

Q27 (a)The susceptibility of a magnetic material is 0.09853.Identify the type of magnetic material. Draw the modification of field pattern on keeping a piece of this material in a uniform magnetic field.

(b)Write two properties of that magnetic material .

(OR)

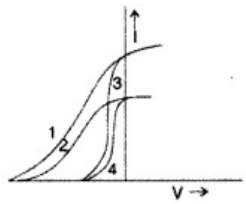
(a) Define mutual inductance and write its S.I. units.

(b) Derive an expression for the mutual inductance of two long co-axial solenoids of same length wound one over the other.

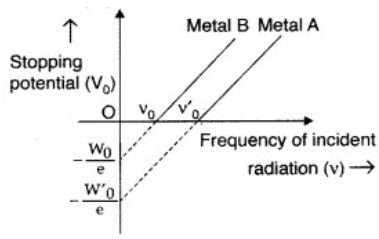
Q28 Draw a labelled diagram of a step-up transformer. On which principle it works. Obtain the ratio of secondary to primary voltage in terms of number of turns and currents in the two coils.

Q29.In the diffraction due to a single slit experiment, the aperture of the slit is 3mm.If monochromatic light of wavelength 620nm is incident normally on the slit, calculate the separation between the first order minima and the 3rd order maxima on one side of the screen. The distance between the slit and the screen is 1.5m.

Q30 (a)The given graph shows the variation of photo-electric current (I) versus applied voltage (V) for two different photosensitive materials and for two different intensities of the incident radiation. Identify the pairs of curves that correspond to different materials but same intensity of incident radiation. Justifi your answer.

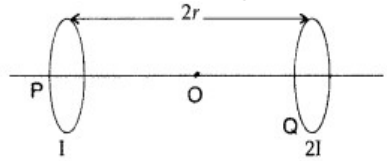


(b) The graph shows the variation of stopping potential with frequency of incident radiation for two photosensitive metals A and B. Which one of the two has higher value of work- function? Justify your answer.



SECTION-D

Q31.(a) Using Ampere's circuital law, obtain an expression for the magnetic field along the axis of a current carrying solenoid of length l and having N number of turns.
(b) Two identical circular loops, P and Q, each of radius r and carrying current I and 2I respectively are lying in parallel planes such that they have a common axis. The direction of current in both the loops is clockwise as seen from O which is equidistant from both the loops. Find the magnitude of the net magnetic field at point O.



(OR)

(a) A steady current (I_1) flows through a long straight wire. Another wire carrying steady current (I_2) in the same direction is kept close and parallel to the first wire. Show with the help of a diagram how the magnetic field due to the current I_1 exerts a magnetic force on the second wire. Write the expression for this force.

(b) State two characteristic properties distinguishing the behaviour of paramagnetic and diamagnetic materials.

Q32.(a) Draw a sketch showing the basic elements of an a.c. generator. State its principle and explain briefly its working. Write the expression for the emf induced in the rotating coil of N turns each of cross-sectional area A, in the presence of a magnetic field B.

(b) A rod of length l is moved horizontally with a uniform velocity 'v' in a direction perpendicular to its length through a region in which a uniform magnetic field is acting vertically downward. Derive the expression for the emf induced across the ends of the rod.

(OR)

(a) A lamp is connected in series with a capacitor. Predict your observations when the system is connected first across a d.c. and then an a.c. source. What happens in each case if the capacitance of the capacitor is increased?

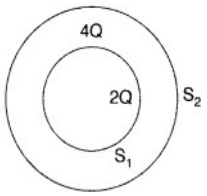
(b) A metallic rod of 'L' length is rotated with angular frequency of 'ω' with one end hinged at the centre and the other end at the circumference of a circular metallic ring of radius L, about an axis passing through the centre and perpendicular to the plane of the ring. A constant and uniform magnetic field B parallel to the axis is present everywhere. Deduce the expression for the emf between the centre and the metallic ring.

Q33. (a) Deduce the expression for the torque acting on a dipole of dipole moment p in the presence of a uniform electric field E.

(b) Consider two hollow concentric spheres, S_1 and S_2, enclosing charges 2Q and 4Q respectively as shown in the figure.

(i)Find out the ratio of the electric flux through them.

(ii) How will the electric flux through the sphere S_1 change if a medium of dielectric constant 'ε_r' is introduced in the space inside S_1, in place of air? Deduce the necessary expression .



(OR)

(a) Write statement of Gauss' law.Write expression for the electric field due to a uniformly charged spherical conducting shell of radius R at a point

(i) outside and

(ii) inside the shell.

Plot a graph showing variation of electric field as a function of r > R and r < R (r being the distance from the centre of the shell)

SECTION-E

Q34. As we know that, when light ray travels from one medium to another changes its direction of path due to the change in optical density of the medium. When light ray travels from optically denser medium to the optically rarer medium then some of the light get reflected back in the same medium and remaining light get refracted in the second

medium and such a phenomenon of light is called as internal reflector light. We know that, when a ray of light travels from denser medium to rarer medium then it get bended away from the normal. If we increase the angle of incidence slowly then angle of refraction also get increased and at one stage the angle of refraction is 90° for some angle of incidence. And further if we increase the angle of incidence then there will be no refraction of light and the ray will be totally internally get reflected. Such phenomenon of reflection of light is called as total internal reflection of light. And the angle of incidence in denser medium for which the angle of refraction in rarer medium is 90°, that angle of incidence is called as critical angle. So we define total internal reflection as, if the angle of incidence exceeds the critical angle then the total light get internally reflected. Mirage is the best real life example of total internal reflection of light. The highly brilliance of diamonds is only due to the total internal reflection of light through them which is get total internally reflected many times and causes brilliance of diamonds. Prisms are also made by using total internal reflection of light. We all know that, optics is the vast branch of physics which has vast application in our daily life such as optical fibre. Optical fibre are used for long distance transmission of audio and video signal also. And they are mainly constructed on the basis of total internal reflection of light to reduce the decrease in amplitude of the sending signal.

Answer the following questions:

Q (i) For critical angle, the value of corresponding angle of refraction is____

(a) 180° (b) less than 90°

(c) greater than 90° (d) 90°

Q (ii) As the refractive index of the medium increases the corresponding value of critical angle for that medium ____

(a) decreases (b) increases

(c) remains same (d) independent of refractive index of the medium

(iii) In case of total internal reflection, for angle of incidence greater than critical angle the refraction of light is not possible because____

(a) Snell's law of refraction get satisfied (b) Snell's law of refraction cannot be satisfied

(c) laws of refraction cannot be satisfied (d) can't say

(iv) How total internal reflection of light would be possible in case of optical fibres?

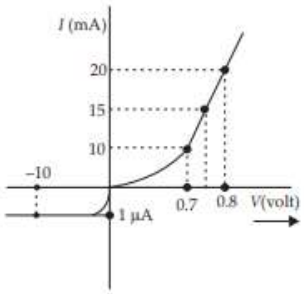
(OR)

Define absolute refractive index of a medium.What is its unit.

Q35. When the diode is forward biased, it is found that beyond forward voltage $V = V_k$, called knee voltage, the conductivity is very high. At this value of battery biasing for p-n junction, the potential barrier is overcome and the current increases rapidly with an increase in forwarding voltage. When the diode is reverse biased, the reverse bias voltage produces a very small current about a few microamperes which almost remains constant with bias. This small current is reverse saturation current.

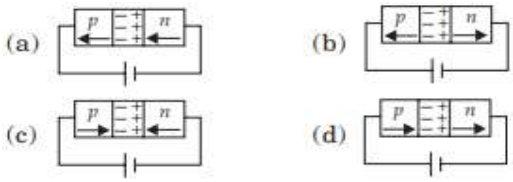
Answer the following questions:

(i)The V-I characteristic of a diode is shown in the figure. The ratio of forward to reverse bias resistance is

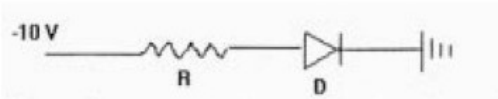


(a) 100 (b) 10^6 (c) 10 (d) 10^{-6}

(ii)In the case of forwarding biasing of a p-n junction diode, which one of the following figures correctly depicts the direction of conventional current (indicated by an arrow mark)?



(iii) In a given diagram, is the diode reverse (or) forward biased?



(iv) How the width of depletion region very when a p-n junction diode is reverse biased?

(OR)

What is the direction of diffusion current in a pn junction diode.

SAMPLE QUESTON PAPER 5 (2022 -23)

CLASS 12

SUBJECT - PHYSICS

TIME : 3HOURS MAX. MARKS - 70

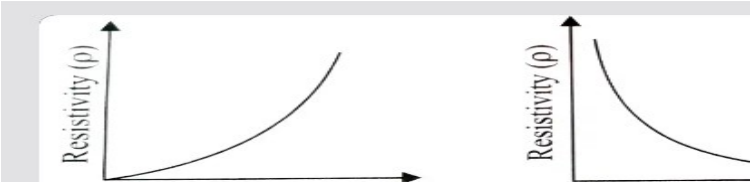
General Instructions:

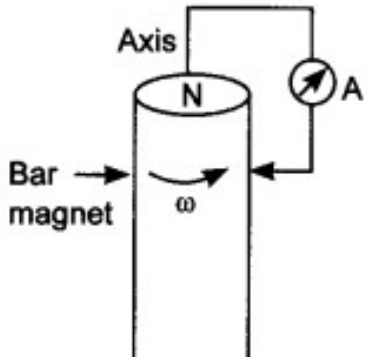
a. There are 35 questions in all. All questions are compulsory
b. This question paper has five sections: Section A, Section B, Section C, Section D and Section E. All the sections are compulsory.
c. Section A contains eighteen MCQ of 1 mark each, Section B contains
d. seven questions of two marks each, Section C contains five questions
e. of three marks each, section D contains three long questions of five
f. marks each and Section E contains two case study based questions of 4 marks each.
g. There is no overall choice. However, an internal choice has been provid in section B, C, D and E. You have to attempt only one of

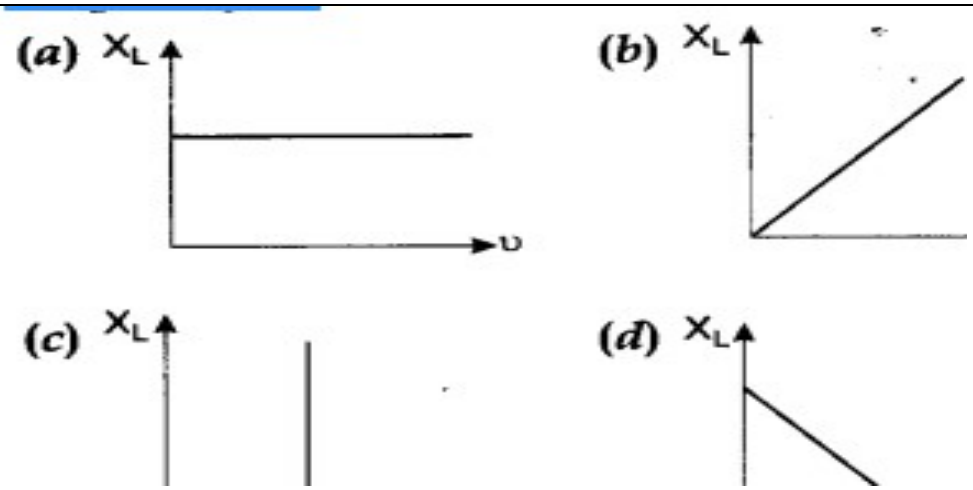
the choices in such questions.

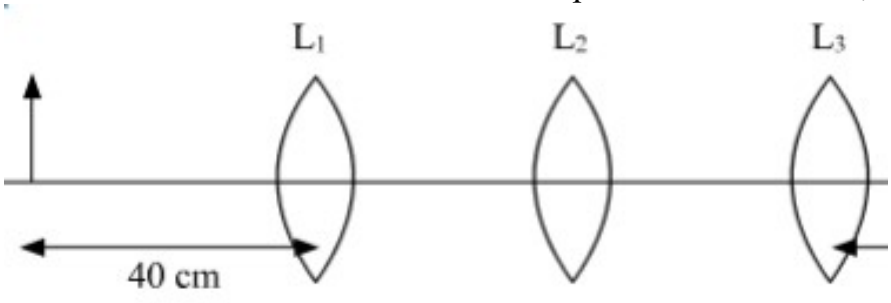
h. Use of calculators is not allowed**.**

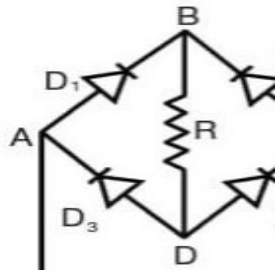
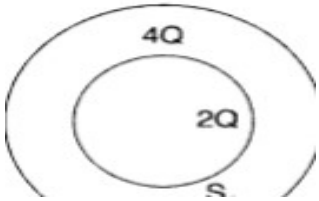
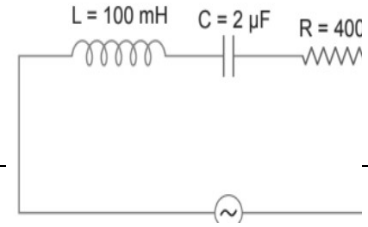
SECTION A

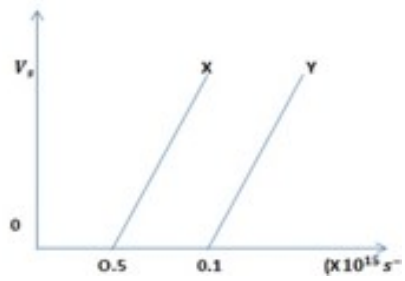
1.	A point charge Q_1exerts some force on a second point charge Q_2. If a 3rd point charge Q_3 is brought near, the force of Q_1 exerted on Q_2(Without changing their respective positions) a) increase b) decrease c) remain unchanged d) none of this	1
2.	Consider the following statements: **A.** The electric potential due to a dipole at its axial point is zero. **B.** The electric potential due to a dipole at its equatorial point is zero. **C.** The electric potential due to a dipole at its axial point is non-zero. **D.** The electric potential due to a dipole at its equatorial point is non-zero. **a) B and C is true** **b) A and B is true** **c) A and D is true** **d) B and D is true**	1
3.	Figure (a) and figure (b) both are showing the variation of resistivity (ρ) with temperature (T) for some materials. Identify the type of these materials.  a) conductor &semiconductor b) conductor & insulator c) Semiconductor & insulator d) both are conductor .	1
4.	Current sensitivity of a moving coil galvanometer is 5 div/mA and its voltage sensitivity (angular deflection per unit voltage applied) is 20 div/V. The resistance of the galvanometer is? a) 250 ohm b)50 ohm c)100ohm d)0	1
5.	A long straight wire with a circular cross-section having radius R, is carrying a steady current I. The current I is uniformly distributed across this cross-section. Then the variation of magnetic field due to current I with distance r(r < R) from its centre will be: B α r^2 b) B α r c) B α $1/r^2$ d) B α1/ r	1
6.	1. Which of the following parameter is used to assess the magnetic ability of a material? a) Magnetic flux density b) Magnetization c) Magnetic dipole moment d) Susceptibility	1
7.	A solenoid is connected to a battery so that a steady current flows through it. If an iron core is inserted into the solenoid, the current will **(a) increase** **(b) decrease** **(c) remain same** **(d) first increase then decrease**	1
8.	If $\vec{B}$ is the magnetic field vector and $\vec{E}$ is the electric field vector in an em wave, then which of the following relations is correct? Here c is the	1

	speed of light: (a) c = E/B (b) c = B/E (c) c = BE (d) c = 1/EB	
9	**A cylindrical bar magnet is rotated about its axis (Figure). A wire is connected from the axis and is made to touch the cylindrical surface through a contact. Then**  a) a direct current flows in the ammeter A. (b) no current flows through the ammeter A. (c) an alternating sinusoidal current flows through the ammeter A with a time period T = 2πω (d) a time varying non-sinusoidal current flows through the ammeter.	1
10	**The ratio of the amplitude of the two sources producing interference 3 : 5, the ratio of intensities at maxima and minima is** (a)25:6 (b) 5:3 (c) 16:1 (d) 25:9	1
11	**The stopping potential value is 0.6 V when the light source is kept at a distance of 20 cm. When the source is kept at 40 cm away, the stopping potential will be** (a)0.6 V (b) 0.4V (c) 1.2V (d) 2.4V	1
12	When a hydrogen atom is in its first excited level, what is the relation of radius and Bohr radius? a) Twice b) 4 times c) Same d) Half	1
13	The curve of binding energy per nucleon as a function of atomic mass number has a sharp peak for helium nucleus. This implies that helium (a) can easily be broken up (b) is very stable (c) can be used as fissionable material (d) is radioactive	1
14	Which of the following graphs represents the correct variation of inductive reactance X_L with frequency u?	1

		
15	A hollow metal sphere of radius 10cm is charged such that the potential on its surface becomes 80V. The potential at the centre of the sphere is? a) 80 V b)800V c)8 V d)ZERO	1
16.	two statements are given –one labelled Assertion (A) and the other labelled Reason(R). Select the correct answer to these questions from the codes (a),(b),(c) and (d) as given below. (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is NOT the correct explanation of A. (c) A is true but R is false. (d) A is false and R is also false Assertion: The electrical conductivity of n-type semiconductor is higher than that of p-type semiconductor at a given temperature and voltage applied. Reason: The mobility of electrons is higher than that of holes.	1
17	two statements are given –one labelled Assertion (A) and the other labelled Reason(R). Select the correct answer to these questions from the codes (a),(b),(c) and (d) as given below. (a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is NOT the correct explanation of A. (c) A is true but R is false. (d) A is false and R is also false Assertion (A): The resultant amplitude of all the secondary wavelets at any point on the backward wave front is zero. Reason (R): A backward wave front cannot exist	1
1 8	two statements are given –one labelled Assertion (A) and the other labelled Reason(R). Select the correct answer to these questions from the codes (a),(b),(c) and (d) as given below. (a) Both A and R are true and R is the correct explanation of A.	3

	(b) Both A and R are true but R is NOT the correct explanation of A. (c) A is true but R is false. (d) A is false and R is also false Assertion : The kinetic energy of photoelectrons emitted from metal surface does not depend on the intensity of incident photon. Reason : The ejection of electrons from metallic surface is not possible with frequency of incident photons below the threshold frequency.	
	SECTION B	3
19	(a) An em wave is travelling in a medium with a velocity $v = v_x i$. Draw a sketch showing the propagation of the em wave, indicating the direction of the oscillating electric and magnetic fields. (b) write wave equation for electric field for the above em wave	2
20	In what way is the behavior of a diamagnetic material different from that of a paramagnetic, when kept in an external magnetic field?	2
21	(a)Two nuclei have mass numbers in the ratio 1: 2. What is the ratio of their nuclear densities b)Plot a graph showing the variation of potential energy of a pair of nucleons as a function of their separation OR a) What is the maximum number of spectral lines emitted by a hydrogen atom when it is in the third excited state? b) The ground state energy of hydrogen atom is -13.6 eV. What are the kinetic and potential energies of electron in this state?	2
22	You are given three lenses L1, L2 and L3 each of focal length 20 cm. A object is kept at 40 cm in front of L1, as shown. The final real image is formed at the focus 'I' of L3. Find the separation between L1, L2 and L3.  	2
23	In the following circuit:	2

	 (I) Explain the flow of the current through resistor R, when an alternating voltage source is applied across the ends A and C (ii) Can we use the above given circuit to convert AC to DC?	
24	Light of wavelength 5000 A propagating in air gets partly reflected from the surface of water. How will the wavelengths and frequencies of the reflected and refracted light be affected?	2
25	Consider two hollow concentric spheres, S1 and S2, enclosing charges 2Q and 4Q respectively as shown in the figure.  (i) Find out the ratio of the electric flux through them. (ii) (ii) How will the electric flux through the sphere S1 change if a medium of dielectric constant 'ε_r ' is introduced in the space inside S_1, in place of air? Deduce the necessary expression.	2
	SECTION C	
26	Three long straight conductors are arranged parallel to each other in the same plane and carry currents of 1A, 2A and 3A all in the same direction. The distance between the first two conductors is x and the distance between the second and third conductors is y. If the middle conductor is in equilibrium, then find the ratio x:y ? And define 1 ampere.	3
27	Two identical coils, each of radius 'R' and number of turns 'N' are lying in perpendicular planes such that their centres coincide. Find the magnitude and direction of the resultant magnetic field at the centre of the coils, if they are carrying currents 'I' and $\sqrt{3}I$ respectively	3
28	(i) Find the value of the phase difference between the current and the voltage in the series LCR circuit shown below. Which one leads in phase: current or voltage? 	3

	(ii) Without making any other change, find the value of the additional capacitor, C1, to be connected in parallel with the capacitor C, in order to make the power factor of the circuit unity. **OR** An a.c. source having voltage E $=E_0 \sin\omega t$ is connected to a series combination of L, C and R derive expressions for impedance, instantaneous current and its phase relationship to the applied voltage.	
29.	The following graph shows the variant of stopping potential V_s with the frequency (v) of the incident radiation for two photosensitive metals X and$Y$. (iii) Which of the metals has larger threshold wavelength? Give reason. (iv) Explain Giving reason which metal gives out electrons having larger kinetic energy, for the same wavelength of the incident radiation. (v) If the distance between the light source and metal $X$is halved, what will be the kinetic energy of electrons emitted due to this change? Give reason.  OR Light of wavelength 2000 A^0 falls on a metal surface of work function 4.2 eV. (i) What is the kinetic energy (in eV) of the (a) fastest and (b) slowest electrons emitted from the surface ? (ii) What will be the change in the energy of the emitted electrons if the intensity of light with same wavelength is doubled ? (iii) If the same light falls on another surface of work function 6.5 eV, what will be the energy of emitted electrons ?	3
30	An electron of a stationary hydrogen atom passes from the fifth energy level to the ground level. What will be the velocity that the atom acquired as a result of photon emission?	3
	SECTION D	
31	a)derive the expression for the work done on an electric dipole of dipole moment p in turning it from its position of stable equilibrium to a position of unstable equilibrium in a uniform electric field E b) A parallel plate capacitor is charged by a battery. After some time, the	5

battery is disconnect ted and a dielectric slab of dielectric constant K is inserted between the plates. How would

(i) the capacitance,

(ii) the electric field between the plates and

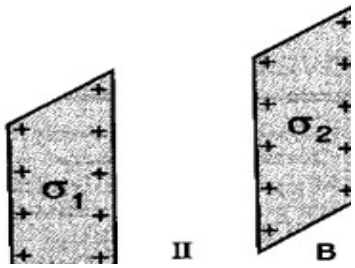
Iii)the energy stored in the capacitor,

be affected? Justify your answer

OR

a) State Gauss law on electrostatic and derive an expression for the electric field due due to a infinitely charged large plane sheet with surface charge density σ.

.b) Two infinitely large plane thin parallel sheets having the surface charge densities σ 1 and σ 2 (σ 1 >>>σ 2)as shown in the figure. Write the magnitudes and direction of the net electric field in the region marked II and III.

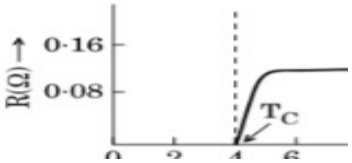


32 a) define drift velocity and relaxation time , 5

Two conducting wires X and Y of same diameter but different materials are joined in series across a battery. If the number density of electrons in X is twice that in Y, find the ratio of drift velocity of electrons in the two wires.

b) Plot a graph showing variation of voltage Vs the current drawn from the cell. How can one get information from this plot about the emf of the cell and its internal resistance?

c) The graph between resistance (R) and temperature (T) for Hg is shown in the figure explain the behavior of Hg near 4 K.

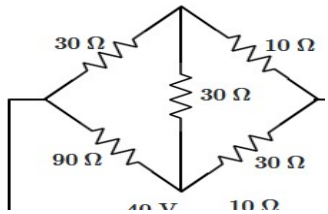


OR

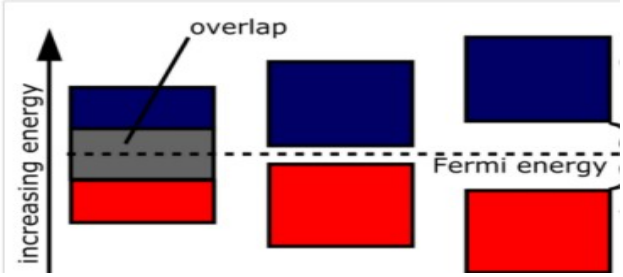
a)State and explain Kirchhoff's rules

b) when is a wheatstone brige said to be blanced?

b) in the circuit shown below calculate current supply by battery ?



33	a) Define the term wave front. Using Huygens's wave theory, verify the law of reflection. b) In a Young's double slit experiment, the slit are separated by 0.28mm and the screen is placed 1.4 m away. The distance between the central bright fringe and the fourth bright fringe is measured to be 1.2 cm. Determine the wavelength of light used in the experiment **OR** (a) A monochromatic source of light of wavelength λ illuminates a narrow slit of width d to produce a diffraction pattern on the screen. Obtain the conditions when secondary wavelets originating from the slit interfere to produce maxima and minima on the screen. (b) How would the diffraction pattern be affected when (i) the width of the slit is decreased? (ii) the monochromatic source of light is replaced by white light?	5
	SECTION E	
34.	A compound microscope is an optical instrument used for observing highly magnified images of tiny objects. The magnifying power of a compound microscope is defined as the ratio of the angle subtended at the eye by the final image to the angle subtended at the eye by the object when both the final image and the object are situated at the least distance of distinct vision from the eye. It can be given that: m = me × mo, where me is magnification produced by eye lens and mo is magnification produced by the objective lens 34.1 Consider a compound microscope that consists of an objective lens of focal length 1.0 cm and an eyepiece of focal length 2.00 cm separated by a distance of 20 cm Calculate the magnifying power of microscope if final image at the near point (a) 260 (b) 270 (c) 70 (d) 300 34.2 You are given 3 lenses having powers as P1 = 6D, P2= 3D and P3 = 12D Which two of lenses will you select to construct a microscope? (a) P1 = 6D , P2= 3D (b) P1 = 6D , P3 = 12D (c) P2= 3D , P3 = 12D (d) none of these 34.3 The magnifying power of a compound microscope increases when (a) The focal length of objective lens is increased and that of eye lens is decreased. (b) The focal length of eye lens is increased and that of objective lens is decreased. (c) Focal lengths of both objective and eye-piece are increased. (d) Focal lengths of both objective and eye-piece are decreased. 34.4 To increase the angular magnification of a simple microscope, one	4

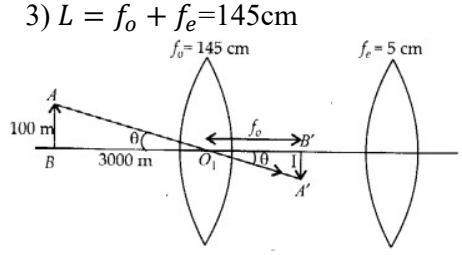
	should increase (a) The focal length of the lens (b) The power of the lens (c) The aperture of the lens (d) The object size	
35	A band gap is the distance between the valence band of electrons and the conduction band. Essentially, the band gap represents the minimum energy that is required to excite an electron up to a state in the conduction band where it can participate in conduction. The lower energy level is the valence band, and thus if a gap exists between this level and the higher energy conduction band, energy must be input for electrons to become free. The size and existence of this band gap allows one to visualize the difference between conductors, semiconductors, and insulators. These distances can be seen in diagrams known as band diagrams, shown in Fig. below  35.1 What is the value of the forbidden gap of insulator and semiconductor? 35.2 Where are the free electrons present in the semiconductor? 35.3 Arrange the following semiconductors in the increasing order of their energy gap. Te(tellurium), Ge(germanium) and Si(silicon) 35.4 The conduction band of a solid X is partially filled at absolute temperature. Will X be a conductor, a semiconductor or an insulator?	**4**

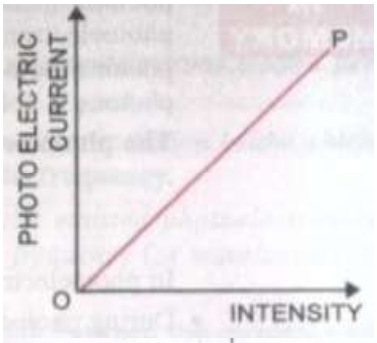
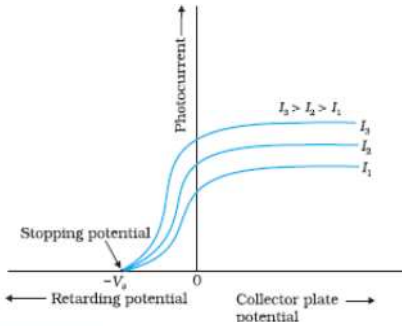
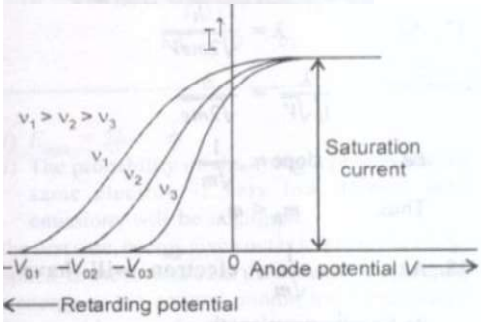
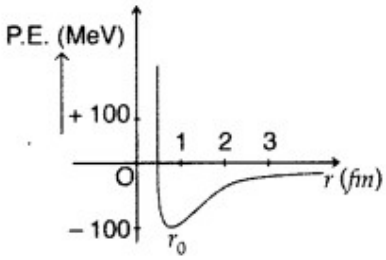
MARKING SCHEME
SAMPLE QUESTION PAPER 2

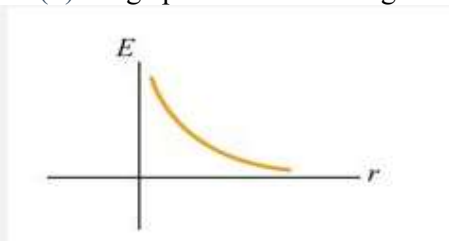
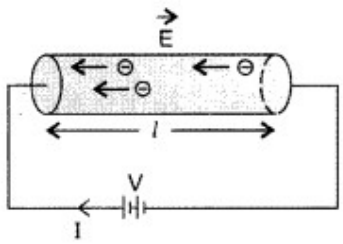
1-C
2-A
3-C
4-A
5-C
6-C
7-D
8-D
9-A
10-B
11-B
12-D
13-A
14-C
15-B
16-A
17-A
18-C
19- CORRECT DEFINITION 0.5
UNIT 0.5
CORRECT ANSWER 1
20- i) DECREASES
ii) DECREASES
21- CORRECT DIAGRAM OF EACH 1+1
22- CORRECT FORMULA 0.5
SOLUTION 1
CORRECT DIRECTION 0.5
23-L1 OBJECTIVE
L3 EYE PIECE
24- KE 13.6 ev PE – 27.2 ev
25- DIFFUSION AND DRIFT 1
CORRECT DIAGRAM 1
26- DERIVATION 2 MARK
DIAGRAM 1 MARK
27- CORRECT ANSWER EACH 1+1+1
28- DERIVATION OF INDUCED CURRENT 2
POWER DISSIPATION 1
29- CORRECT ANSWER EACH 1+1+1

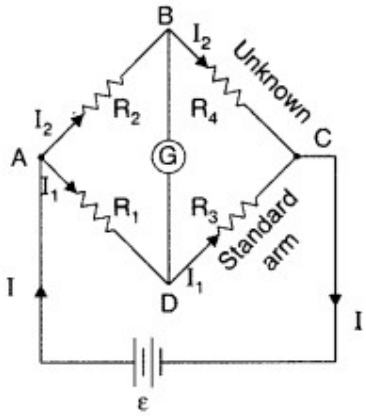
30- CORRECT CALCULATION OF ENERGY RELEASED 3
31- CORRECT DERIVATION 5
32- CORRECT DERIVATION 5
33- CORRECT DERIVATION 5
34- i) D
ii) D
iii) C
iv) C
35- i) A
ii)B
iii) C
iv) C

	MARKING SCHEME,SAMPLE PAPER 3	
	SECTION A	
1.	a. 2:1 $q_1 = 4\pi€or_1V$, $q_2 = 4\pi€or_2V$ $\sigma_1 = q_1/4\pi r_1^2$. , $\sigma_2 = q_2/4\pi r_2^2$ $\sigma_1/\sigma_2 = (q_1/q_2)(r_2^2/r_1^2) = (r_1/r_2)(r_2^2/r_1^2)$ = r_2 /r1= 10/5= 2:1	1
2.	a . normal to the surface at every point	1
3.	a. 16:1	1
4.	c. 1:1	1
5.	c. $2\pi\times10^{-5}$T	1
6.	a. Maximum when the conductor is perpendicular to the direction of magnetic field	1
7.	b.1mH	1
8.	b. In a dc circuit the inductor can conduct but not a capacitor	1
9,	2V	1
10.	b. 1.25	1
11.	c. 3.3×10^{-19} J	1
12.	b. 3.63 MeV	1
13.	c. all hot bodies and molecules	1
14.	a.The nuclear force becomes very strong if the nucleus contains a large number ofnucleons	1
15.	c. 6V /m along - x axis	1
16.	a) Both A and R are true and R is the correct explanation of A	1
17.	d) A is false and R is also false	1
18.	c) A is true but R is false	1
	SECTION B	2
19.	Ans. B_1 = 1.2 × 10–2 T, B_2 =? θ = 60° At stable equilibrium, θ_1 = 15°, θ_2 = 45°, $mB_1.\sin\theta_1 = mB_2.\sin\theta_2$ so $B_2 = mB_1\sin\theta_1/m.\sin\theta_2$ = 4.39 ×10–3 T	2
20.	The oscillation charge accelerates and hence equivalent to varying electric current which in turn changes the magnetic field and diagram.	2
21.	1. By coulomb's law force between two charges is $F = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r^2}$ where q_1 and q_2 are charges separated by distance r Here, to find the force on the charge at A by charge at B and C Force acting on charge q by -4q is Force acting on charge q by 2q is $F_2 = \frac{1}{4\pi\varepsilon_0}\cdot\frac{2q^2}{l^2}$ For the above diagram, the resultant force acting on charge at A is, $F_{net} = \sqrt{F_1^2 + F_2^2 + 2F_1F_2\cos(120)}$ here, $F_1 = 2F_2$ and $\cos 120^\circ = \frac{-1}{2}$	2

	$F_{net} = \sqrt{3}F_2$ So-net force on q is $F = \sqrt{3} \times \frac{1}{4\pi\varepsilon_0} \times \frac{2q^2}{l^2}$, b) The amount of the work done to separate the charges at infinite distance is equal to the potential energy of the system. The potential energy between two charges separated by a distance 'r' is $U = \frac{1}{4\pi\varepsilon_0}\frac{q_1q_2}{r}$ Here the potential energy of the system is, $U = \frac{1}{4\pi\varepsilon_0 \times l}\left[-4q^2 + 2q^2 - 8q^2\right]$ $U - \frac{1}{4\pi\varepsilon_0 \times l} \times \left(-10q^2\right)$ therefore, work done is $\frac{5q^2}{2\pi\varepsilon_0 l}$	
22.	As per Balmer series, wavelength is given by : $\frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{n^2}\right]$ Where, n = 3, 4, 5 For shortest wavelength, n = ∞ $\lambda = 4\times10^{-7}$ m **OR** $E = \frac{hc}{\lambda}$ = 4.5 ev For transition B	2
23.	1) $m = f_0/fe = 28$ 2) $\boldsymbol{m} = \frac{-f_0}{f_e}\left(1 + \frac{f_e}{D}\right) = 33.6$ 3) $L = f_o + f_e = 145$cm  4) A'B'= 140X100/3000 =4.7cm	2
24.	When the applied voltage is such that n-side is negative and p-side is positive, the applied voltage is opposite to the barrier potential. Hence, the effective barrier potential becomes VB - V, and the energy barrier across the junction decreases. Thus, the junction width decreases. i. p-n junction is forward biased. ii. p-n junction is reverse biased.	2
25.	i. Angular position of nth maximum $\theta_n = x_n / D = n\lambda / D$ Angular position of 10 th maximum $\theta_{10} = 6X10^{-3}$ radian ii. Separation between two adjacent minima i.e. fringe width, = $D\lambda / d$ = 0.6 mm	2
	SECTION C	

26.	$F=\mu_0 I_1 I_2 l(\frac{1}{r1}-\frac{1}{r2})=5.3X10^{-7}N$ Direction of force is towards infinitely long straight wire.	3
27.	The induced emf = $Bwl^2 / 2 = 3.14x10^{-5}$ V	3
28.	i. Angular frequency at resonance = 50rad/sec ii. Current at resonance= 4A iii. V_{rms} = 2000v OR Correct derivation $P_1/P_2 = 1/\sqrt{2}$	3
29.	(i) Metal X (ii) Metal X (iii) No change OR    	3
30.	(a) When nucleons approach each other to form a nucleus, they strongly attract each other. Their potential energy decreases and becomes negative. It is this potential energy which holds the nucleons together in the nucleus. The decrease in' potential energy results in the decrease in the mass of the nucleons inside the nucleus. (b)  OR Nuclear reaction $^{238}_{92}U \rightarrow ^{234}_{90}Th + ^{4}_{2}He + Q$ Energy released, $Q = \Delta mC^2$ $= (M_U - M_{Th} - M_{He})C^2$ $= 0.00456 \times 931.5$ MeV **= 4.25 MeV**	

	SECTION D	
31	(i) Correct derivation (ii)The graph is as shown in figure  iii) Work done in bringing charge $=\int_{r1}^{r2} F.dr$ $=\int_{r1}^{r2} (\lambda q / 2\pi\epsilon_o r)\, dr \cos 0^0$ $=(q\lambda / 2\epsilon_o) \ln (r_1 / r_2)$ **OR** Correct derivation	5
33.	<u>Definition</u>- Drift velocity is defined as the velocity with which free electrons in a conductor get drifted in a direction opposite to the direction of the applied field. Its unit is ms^{-1} and dimensions $[LT^{-1}]$  Expression : The magnitude of electric field set up across the conductor is given by E = Vl Let n be the number of free electrons per unit volume of the conductor. Then, total number of free electrons in the conductor = n × Volume of the conductor Hence, Q = (nAl)e Time taken by the charge to cross the conductor length l is given by $t = \frac{1}{v_d}$ where [v_d is drift velocity of electrons $\therefore \quad I = \frac{Q}{t} = \frac{nAle}{\frac{l}{v_d}} = neAv_d \quad \therefore \boxed{I = neAv_d}$ **OR** Conditions for the balance condition in a Wheatstone bridge :	



Applying Kirchhoff's loop rule to closed loop ADBA,

$$-I_1R_1 + 0 + I_2R_2 = 0 \quad (I_g = 0) \quad \ldots(i)$$

For loop CBDC,

$$-I_2R_4 + 0 + I_1R_3 = 0 \quad (I_g = 0) \quad \ldots(ii)$$

From equation, (*i*)

$$\frac{I_1}{I_2} = \frac{R_2}{R_1}$$

From equation, (*ii*)

$$\frac{I_1}{I_2} = \frac{R_4}{R_3} \quad \therefore \quad \frac{R_2}{R_1} = \frac{R_4}{R_3} \quad \text{or} \quad \frac{R_1}{R_2} = \frac{R_3}{R_4}$$

This is the required balance condition in a Wheatstone bridge arrangement

34.	(i) Correct derivation (ii) Correct graph (iii)For minimum deviation i=e $A+\delta_{min} = i+r$, For δ_{min} , i+r , μ = sini/sinA/2 , i=45° **OR** I Coherent sources: Two sources are said to be coherent in nature if they emit light of same frequency and of a stable path difference. The essential condition, which must be satisfied for the sources to be coherent are: a. The two light waves should be of same wavelength. b. The two sources must be very close to each other. c. The two light waves should either be with same phase or should have a constant phase difference. d. The two sources should preferably have the same amplitude. e. The sources should emit light waves continuously ii Two sources of emitting light waves of same frequency or wavelength and of a stable phase difference are required to see interference pattern, and we can obtain such nature of light waves from coherent source. So, we require coherent sources to produce the interference of light. iii. $\beta_1 = 8.1\times10^{-3}$ m , $\beta_2 = 7.2\times10^{-3}$ m , $\lambda_1 = 630\times10^{-9}$ m $\beta = D\lambda / d$, $\beta_1/\beta_2 = \lambda_1 / \lambda_2$, λ_2 = 560nm	5
	SECTION E	
34.	(I) unidirectional flow of current (II) Input frequency = 50 HzFor a half-wave rectifier, the output frequency is equal to the input frequency. ∴ Output frequency = 50 Hz For a full-wave rectifier, the output frequency is twice the input frequency.	4

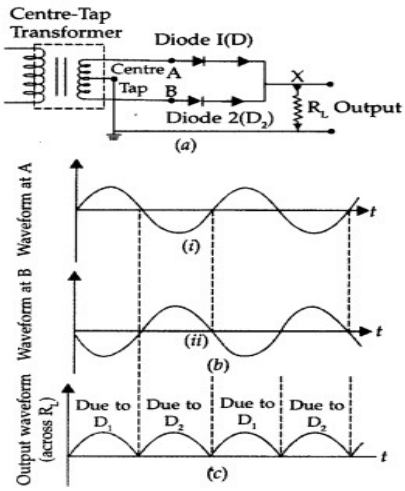
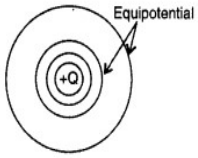
	∴ Output frequency =2×50=100 Hz (III) (a) decrease (b) increase **OR** Diffusion and drift	
35.	(i) 90° (ii) 0.62 (iii) Optical fibres or fibre optics have applications in a variety of fields, such as communications to transmit telephone signals, cable signals, TV signals, the internet, and medical signals. These fibres are very thin, which allows light to enter from one side and strike the inside of the fibre with an angle greater than the critical angle, which causes them to travel through the fibre and exit it at the same angle as the entry angle. OR The conditions required for total internal reflection (TIR) to occur are: (I) the light must be travelling from a more dense medium into a less dense medium (ie glass to air) (II) the angle of incidence must be greater than the critical angle.	4

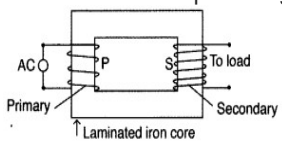
MARKING SCHEME
SAMPLE QUESTION PAPER 4

MM : 70 **TIME : 3 Hours**

QUESTION NO	EXPECTED ANSWER	MARKS	TOTAL MARKS
1	(c) always a force and a torque	1	1
2	(c) $C^2N^{-1}m^{-2}$	1	1
3	(b)	1	1
4	(d)energy will be provided by external source displacing the charge.	1	1
5	(c) –q LE	1	1
6	(a) –q	1	1
7	(d) |M x B| and 0.	1	1
8	(a) 1.47	1	1
9	(a) red colour	1	1
10	(b) UV rays	1	1
11	(d) velocity increases.	1	1
12	(c) 4:1	1	1
13	(a)0.2V,0.1A	1	1
14	(b) 1:1	1	1
15	(a)Infrared region	1	1
16	(d) $1/n^2$	1	1
17	(b)	1	1
18	(a)	1	1
19	The plate area of C_2> plate area of C_1 but C α Area , so C_2> C_1 , C=q/V,Slope of line A > Slope of line B , hence line A represent C_2 and line B represent C_1 .	1,1	

	(OR) Since $\frac{R_5}{R_1} = \frac{R_3}{R_4}$, the current through $R_2 = 5\ \Omega$ is zero and so is electrically absent. (R_1, R_5) and (R_3, R_4) are in series to give $3\ \Omega$ and $6\ \Omega$ respectively. They are themselves in parallel to form $R_{eq} = \frac{3\times 6}{3+6} = \frac{18}{9} = 2\ \Omega$ $\therefore$ Current drawn from the battery, $I = \frac{V}{R_{eq}} = \frac{4}{2} = 2\ A$	½ ½ ½ ½	2
20	Lenz's law. Curerent in the coil will be anti-clockwise, when seen from the left, therefore plate A will become + ve (positive) and plate B will be negative.	1 1	2
21	(i) Mutual Induction. (ii) Bulb X dimmer. Justification.	½ ½ 1	2
22	Statement of Huygens's wave theory, Verification of the laws of reflection diagram. (OR) 1. Radio wave < Microwaves < X rays < Gamma rays. And any two uses of any one wave.	½ 1 1/2 1 ½+1/2	2
23	Energy of photon wavelength 275 nm $E = \frac{hc}{\lambda} = \frac{6.63\times 10^{-34}\times 3\times 10^{8}}{275\times 10^{-9}\times 1.6\times 10^{-19}}.eV = 4.5\ eV$ This componds to transition 'B'. (i) *Element A* has radiation of maximum wavelength *621 nm*. (ii) *Element D* has radiation of minimum wavelength *155 nm*.	1 ½,1/2	2
24	$E_K = \frac{p^2}{2m}$ where E_K = Kinetic energy, p = momentum, m = mass of the particle de-Broglie wavelength, $\lambda = \frac{h}{p}$ ...where [h = Planck's constant $\therefore \lambda = \frac{h}{\sqrt{2mE_K}}$ $\because$ Both the particles have the same de-Broglie wavelength ...[Given $\therefore \frac{h}{\sqrt{2m_eE_{Ke}}} = \frac{h}{\sqrt{2m_\alpha E_{K\alpha}}}$ or $\frac{m_e}{m_\alpha} = \frac{E_{K\alpha}}{E_{Ke}}$ where m_e = mass of electron, m_α = mass of alpha particle, E_{Ke} = K.E. of electron, $E_{K\alpha}$ = K.E. of α-particle As $m_\alpha > m_e$ $\therefore$ $K.E_{Ke} > E_{K\alpha}$	½ ½ ½ ½	2

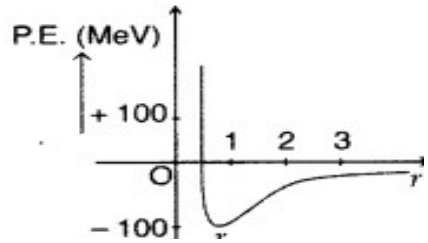
25		1 ½ ½	2
26	(a) Properties of equipotential surfaces (any two) (i) No work is done in moving a test charge over an equipotential surface. (ii) No two equipotential surfaces can inter-sect each other. (iii) Equipotential surface due to an isolated point charge is spherical. (iv) The electric field at every point is normal to the equipotential surface passing through that point. .  Equipotential surface due to an isolated charge As $E = \frac{-dV}{dr}$ or $dr = \frac{-dV}{E}$ For the same charge in the value, V, i.e., when dV = constant, we have dr ∝1E Hence, equipotential surface gets closer as the distance between the equipotential surface and the source charge decreases. (OR) Definition of drift velocity Derivation of $j = env_d$	½+1/2 1 1 1 2	3
27	(a)The susceptibility of a magnetic material is 0.09853,so it is positive but small.Therefore the material is paramagnetic in nature. (b)any two examples of paramagnetic substances. (OR) (a)Definition of mutual inductance and unit-Henry (b) M_{12} is called the mutual inductance of solenoid S_1 with respect to solenoid S_2. The magnetic field due to the current I_2 in S_2	1 2 1	3

	is $\mu_0 n_2 I_2$. The resulting flux linkage with coil S_1 is, $N_1\phi_1 = (n_1 l)\ (\pi r_1^2)\ (\mu_0 n_2 I_2)$ $= \mu_0 n_1 . n_2 \pi r_1^2 l I_2$ ...(ii) **where [$n_1 l$ is the total number of turns in solenoid S_1** Thus $M_{12} = \mu_0 n_1 n_2 \pi r_1^2 l$ ...(iii) We now consider the reverse case : A current I_1, is passed through the solenoid S_1 and the flux linkage with coil S_2 is, $N_2\phi_2 = M_{21} I_1$ ...(iv) M_{21} is called the mutual inductance of the solenoid S_2 with respect to solenoid S_1	2	
28	A transformer is an electrical device for converting an alternating current at low voltages into that at high voltage or vice versa. If it increases the input voltage, it is called step- up-transformer.  Principle : It works on the principle of mutual induction i.e., "when a changing current is passed through one of the two inductively coupled coils, an induced emf is set up in the other coil." $V_P = -N_P \frac{d\phi}{dt}$ and $V_S = -N_S \frac{d\phi}{dt}$ $\therefore \frac{V_S}{V_P} = \frac{N_S}{N_P}$ ...(i) $\frac{V_S}{V_P} = \frac{I_P}{I_S}$ ...(ii) From (i) and (ii), we get $\frac{I_P}{I_S} = \frac{V_S}{V_P} = \frac{N_S}{N_P}$	1 1/2 1+1/2	3
29	For minima , asinθ =nλ For maxima ,asinθ=(n+1/2) First order minima(n=1) asinθ =λ , tanθ=y_1/D therefore y_1 = ΛD/a also 3rd order maxima y_3 =7/2(ΛD/a) Distance between first order minima and 3rd order maxima = y_3-y_1= =7.75x10^{-4} m	½ ½ ½ ½ 1	3
30	(a) The pairs (2, 4) and (1, 3) have same intensity but different material. (b) Metal 'A', because of higher threshold frequency for it.	1.5 1.5	
31	(a) Derivation of B = μ_0nI (b) When the currents are in the same direction, the resultant field at point O is, $B = B_1 + B_2 = \frac{\mu_0 N I a^2}{2(r^2+a^2)^{3/2}} + \frac{\mu_0 N 2 I a^2}{2(r^2+a^2)^{3/2}}$ $= \frac{3\mu_0 N I a^2}{2(r^2+a^2)^{3/2}}$ **where [a is the radius of loop.]** (OR) (a)Calculation of F using correct formula (b)any two properties of para and dia-magnetic substances.	3 3 2	5

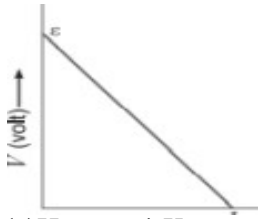
32	AC Generator Principle ad working with diagram Obtaining expression for induced emf using Faradays law (OR) **(a)** When dc source is connected, the condenser is charged but no current flows in the circuit, therefore, the lamp does not glow. No change occurs even when capacitance of capacitor is increased. When ac source is connected, the capacitor offers capacitive reactance Xc=1/ωC. The current flows in the circuit and the lamp glows. On increasing capacitance, X_c decreases. Therefore, glow of the bulb increases. (b)Finding expression for induced emf across the rod $\varepsilon = B \times \frac{d}{dt}\left[\frac{1}{2}R^2\theta\right] = \frac{1}{2}BR^2\frac{d\theta}{dt} = \frac{B\omega R^2}{2}$	3 2 3 2	5
33	(a) derivation of expression for the torque. (b)Ratio of flux Electric flux through the sphere S_1 decreases with the introduction of dielectric inside it OR Field Out side and Inside the shell using Gauss law Interpretation with graph	3 1 1 3 2	5
34	(i) (d) 90° (ii) (a) decreases (iii) (b) Snell's law of refraction cannot be satisfied (iv)correct explaination. (OR) Correct definition	1 1 1 1	4
35	(i) (d) 10^{-6} (ii) (c) (iii) Reverse biased (iv) correct reason (OR) From P to N	1 1 1 1	4

MARKING SCHEME
SAMPLE QUESTION PAPER 5

1	c) remain unchanged	**1**
2	a) B and C is true	**1**
3	**a) conductor &semiconductor**	**1**
4	**a) 250 ohm**	**1**
5	**b)** B α r by using ampere's law	**1**
6	**Answer: d** **Explanation: Magnetic susceptibility is a measure to quantify the ability of a material to undergo magnetization in an applied magnetic field. It is the ratio of magnetization (M) to the applied magnetic field intensity (H).**	**1**
7	(b) decrease	**1**
8	**a) E/B**	**1**
9	**(a)** a direct current flows in the ammeter A.	**1**
10	c) A_{max}/A_{min} =(3+5)/(5-3) = 8/2 intensity is directly proportional to the square of amplitude $\mathbf{I_{max}/I_{min} = (A_{max}/A_{min})^2 = 16/1}$	**1**
11	**a) O.6V**	**1**
12	**b)** **For the first excited level, n = 2.** $\mathbf{r_2 = (2)^2 r_0 = 4r_0}$. **So, when a hydrogen atom is in its first excited level, its radius is** 4 times of the Bohr radius.	**1**
13	b) is very stable	**1**
14	b) 	**1**

15	a) 80 V	**1**
16	a)	**1**
17	b)	**1**
18	b)	**1**
19	Graph Equation	**1** **1**
20	1. A diamagnetic specimen would move towards the weaker region of the field; while a paramagnetic specimen would move towards the stronger region. 2. A diamagnetic specimen is repelled by a magnet while a paramagnetic specimen moves towards the magnet. 3. The paramagnetic gets aligned along the field and the diamagnetic perpendicular to the field.	**2**
21	ratio 1:1  OR a)third excited state, $n_2 = 4$, and $n_1 = 3, 2, 1$ Hence there are 3 spectral lines. b)Kinetic energy, K_e = + T.E. = 13.6 eV Potential energy, P_e = 2 T.E. = 2 (-13.6) = – 27.2 eV	**2**
22	Here f1 = f2 = f3 = 20 cm u1 = −40 cm so object at R mage will from at R V_1=40 cm Here, image by L3 is formed at focus. So, the object should lie at infinity for L3. Hence, L2 will produce image at infinity. So, we can conclude that object for L2 should be at its focus. But, we have seen above that image by L1 is formed at 40 cm right of L1 which is at 20 cm left of L2(focus of L2). So X1 = distance between L1 and L2 = (40 + 20) cm = 60 cm Again distance between L2 and L3 does not matter as the image by L2 is formed at infinity so X2 can take any value	**2**
22	Here f1 = f2 = f3 = 20 cm u1 = −40 cm so object at R mage will from at R V_1=40 cm Here, image by L3 is formed at focus. So, the object should lie at infinity for L3. Hence, L2 will produce image at infinity. So, we can conclude that object for L2 should be at its focus. But, we have seen above that image by L1 is formed at 40 cm right of L1 which is at 20 cm left of L2(focus of L2). So X1 = distance between L1 and L2 = (40 + 20) cm = 60 cm	**2**

	Again distance between L2 and L3 does not matter as the image by L2 is formed at infinity so X2 can take any value	
23	(i)When an AC signal is applied across the given circuit, terminal A becomes positive during the positive half cycle while terminal C becomes negative. This results in diodes D1 and D2 becoming forward biased while D3 and D4 becoming reverse biased. The current flow through resistor R during the positive half cycle is from B to D. During the negative half-cycle, terminal C becomes positive while terminal A becomes negative. This causes diodes D3 and D4 to become forward biased and diode D1 and D2 to be reverse biased. The current flow through resistor R during the negative half cycle is from B to D. (ii) Yes, we can use this circuit to convert AC into DC.	**2**
24	For reflected light : Wavelength remains same and frequency remains the same. For refracted light : Wavelength decreases, but frequency remains the same.	**2**
25	We know electric flux $(\phi) = \frac{Q}{\varepsilon_0}$ Thus, ϕ_1 due to $S_1 = \frac{2Q}{\varepsilon_0}$, ϕ_2 due to $S_2 = \frac{2Q+4Q}{\varepsilon_0} = \frac{6Q}{\varepsilon_0}$ $\frac{\phi_2}{\phi_1} = \frac{6Q/\varepsilon_0}{2Q/\varepsilon_0} = \frac{3}{1}$ $\therefore$ Ratio =	**3**
26	$F=(\mu_0 i_1 \cdot i_2 dl)/2\pi r$ in equilibrium F21=F23 X:y =1:3 Definition of1 ampere	**2** **1**
27	Obtaining B_1 and B_2 and their resultant $B^2=B_1^2+B_2^2= \mu_0 NI/R$ Direction of Magnetic field-Clockwise	
28	I)$X_C=1/\omega C=500\Omega$, $X_L=\omega L=100\Omega$, $\tan\phi=(X_L-X_C)/R$ = -1 phase value is negative so current leads voltage II)Power factor is given by $\cos\phi=1$ $X_C=X_L=100\Omega$ C=10μF Hence an 8μF capacitor need to be connected in parallel with the given capacitor Or **Correct derivation**	**3**
29	**Ans. (i) metal X with correct reason (ii) Metal X with correct reason (iii) No change with correct reason** OR **Ans: (i) (a) K.E. of fastest electron =2 eV (b) K.E. of slowest electron = 0 eV** **(ii) No change in the energy of emitted electrons as it does not depend on intensity** **(iii) no emission as E(4.2 eV) < W (6.5 eV)**	**3**

30	According to Rydberg formula c) $\frac{1}{\lambda} = R\left[\frac{1}{n_f^2} - \frac{1}{n_i^2}\right]$ Here, $n_f = 1, n_i = 5$ $\therefore \frac{1}{\lambda} = R\left[\frac{1}{1^2} - \frac{1}{5^2}\right]$ $= R\left[\frac{1}{1} - \frac{1}{25}\right] = \frac{24}{25}R$ According to conservation of linear momentum, we get	**3**
31	a) Correct derivation with diagram b)Let C be the capacitance and V be the potential difference. The charge on the capacitor plates will then be Q = CV. The electric field between the plates, E = V d, and the energy stored $E_n = \frac{Q^2}{2C}$ or $\frac{1}{2}($ As the dielectric (K) is introduced after disconnecting the battery We have the new values of charge, Q' = Q Capacitance C' = KC (i) New capacitance is K times its original (ii)$New\ electric\ field\ field = \frac{V'}{d} = \frac{V}{Kd} = \frac{E}{K}\ i.e. \frac{1}{K}$ Times of the (iii) $New\ energy = \frac{Q^2}{2C'} = \frac{Q^2}{2KC} = \frac{1}{K}(E_n) i.e. \frac{1}{K}$ Times the origina **OR** a)STATEMENT Correct derivation b) Net electric field in region II = $1/2\varepsilon_0 (\sigma_1 - \sigma_2)$ Direction of electric field in from sheet A to sheet B (ii) Net electric field in region III = $1/2\varepsilon_0 (\sigma_1 + \sigma_2)$ Direction is away from the two sheets i.e. towards right side	**5**
32	a) definition n the series arrangement, the **current** remains the same – ix=iy For the same diameter, the cross-sectional area will remain the same. Therefore, $n_xeAv_x=n_yeAv_y$ V_x/V_Y=ny/2ny= 1/2 **Therefore, vx:vy=1:2** b) the intercept on y axis gives emf of the cell and the slop of the graph is equal to internal resistance  (c)Here at 4 K temperature the resistance of Hg becomes zero which is the characteristic shown by superconductors. So we can say that Hg behaves as superconductors at the temperature of 4K	**5**

	OR A) CORRECT STATEMENT B) CORRECT CONDITION C) R =40 OHM I = 1 A	
33	33 a) definition , diagram, derivation 33 b) Given: d= 0.28 mm = 0.28×10^{-3} m D= 1.4 m, x = 1.2 cm = 1.2 x 10-2 m, n = 4,λ = ? As we know x = nλD/ d λ=xd/nD = 6×10^{-7} m = 600 nm OR Correct derivation (b)(i) Linear width of central maxima W = 2Dλ/ d Angular width of central maxima, θn=W /D =2λ/ d So, when the width of the slit (d) is decreased, the angular width θn increases, and the diffraction pattern is spread out Ii) When a monochromatic source of light is replaced by a source of white light, the following changes are observed in the diffraction pattern: Diffraction pattern is coloured. As the fringe width is directly proportional to the wavelength, so, the fringe width of red colour is wider than that of violet colour. The central maximum is white	**5**
34	Ans 34.1 (b) , 34.2 (b) 35.3 (d) 34.4 (b)	
35	Ans. 35.1- In insulator, energy gap is > 3 eV In conductor, separation between conduction and valence bands is zero and in the insulator, it is greater than 1 eV. Hence in semiconductors the separation between conduction and valence band is 1 eV. 35.2- Conduction band 35.3- Si <Ge<Te 35.4- X will be conductor	