CBSE Class 12 Physics
Sample Paper - 09 (2019-20)

Maximum Marks: 70
Time Allowed: 3 hours

General Instructions:

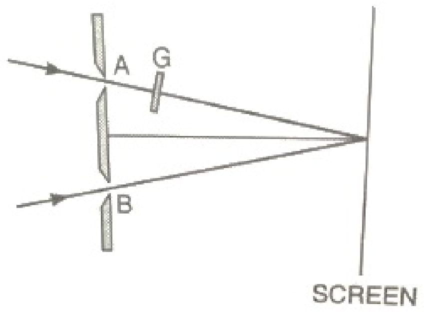
i. All questions are compulsory. There are 37 questions in all.
ii. This question paper has four sections: Section A, Section B, Section C and Section D.
iii. Section A contains twenty questions of one mark each, Section B contains seven questions of two marks each, Section C contains seven questions of three marks each, and Section D contains three questions of five marks each.
iv. There is no overall choice. However, internal choices have been provided in two questions of one mark each, two questions of two marks, one question of three marks and three questions of five marks weightage. You have to attempt only one of the choices in such questions.

Section A

1. Two insulated charged copper spheres A and B have their centres separated by a distance of 50 cm and have identical sizes. Both the spheres carries charge $6.5 \times 10^{-7}C$. A third sphere of the same size but uncharged is brought in contact with the first, then brought in contact with the second, and finally removed from both. What is the force of repulsion between A and B?
   a. 6.7×10^{-3}/N
   b. 3.7×10^{-3}/N
   c. 4.7×10^{-3}/N
   d. $5.7 \times 10^{-3}N$
2. For a parallel plate capacitor ______________ possible potential difference between the capacitor plates
   a. dielectric decreases the minimum
   b. dielectric increases the minimum

c. dielectric increases the maximum
d. dielectric decreases the maximum

3. Potentiometer measures the potential difference more accurately than a voltmeter, because
   a. It has a wire of low resistance.
   b. It draws a heavy current from external circuit.
   c. It does not draw current from external circuit.
   d. It has a wire of high resistance.
4. In a meter bridge experiment a balance point is obtained at a distance of 60 cm from the left end when unknown resistance R is in a left gap and 8 ohms resistor is connected in the right gap. When the position of R and 8 ohm resistor is interchanged the balance point will be at distance of ____________
   a. 50 cm
   b. 80 cm
   c. 40 cm
   d. 60 cm
5. In hydrogen atom, the electron is making 6.6×10^{15} rev./sec around the nucleus in an orbit of radius 0.528 Å .The magnetic moment (Am^2) will be
   a. 1×10^{-27}
   b. $\frac{1}{2} 1 \times 10^{-23}$
   c. 1×10^{-10}
   d. 1×10^{-15}
6. The refractive index of glass is 1.5 which of the two colors red and violet travels slower in a glass prism?
   a. red component of white light travels slower than the violet component
   b. violet component of white light travels slower than the red component
   c. both red and violet travel faster at the same speed
   d. both red and violet travel slower at the same speed
7. In Young's experiment, the monochromatic light is used to illuminate two slits A and B as shown. Interference fringes are observed on a screen placed in front of the slits. Now if a thin glass plate is placed normally in the path of beam coming from the slit A, then



a. fringe width will decrease
b. there will be no change in fringe width
c. fringe width will increase
d. fringes will disappear

8. A giant telescope in an observatory has an objective of focal length 19 m and an eye-piece of focal length 1.0 cm. In normal adjustment, the telescope is used to view the moon. What is the diameter of the image of the moon formed by the objective? The diameter of the moon is 3.5 $\times 10^6$ m and the radius of the lunar orbit round the earth is 3.8 $\times 10^8$ m
    a. 18.5 cm
    b. 19.5 cm
    c. 21.5 cm
    d. 17.5 cm
9. The small ozone layer on top of the stratosphere is crucial for human survival because
    a. It absorbs ultraviolet radiations from the sun and prevents it from reaching the earth's surface and causing damage to life.
    b. Layer on top of the stratosphere is crucial as it supplies oxygen to atmosphere
    c. It prevents water molecules from escaping into space
    d. None of these
10. If maximum velocity with which an electron can be emitted from a photo cell is 3.75 $\times 10^8 \text{cms}^{-1}$, then stopping potential is
    a. 50 volts
    b. 60 volts

c. 40 volts

d. 30 volts

11. Fill in the blanks:

    Susceptibility of a dimagnetic substance is ________.

12. Fill in the blanks:

    The lines joining the places of equal dip or inclination are called ________ lines.

13. Fill in the blanks:

    If the normal points is in the opposite direction of the magnetic field, then $\theta = 180^{\circ}$ and the flux is taken as ________.

    OR

    Fill in the blanks:

    S.I. unit of magnetic flux is ________.

14. Fill in the blanks:

    ________ energy of a nucleus is the energy with which nucleons are bound in the nucleus.

15. Fill in the blanks:

    The angle subtended by an object at the eye is called ________ angle.

16. Name the absorbing material used to control the reaction rate of neutrons in a nuclear reactor.

17. Write any two characteristic properties of nuclear force.

18. Is the ratio of number of conduction electrons and number of holes in a p-type semiconductor more than, less than or equal to unity?

19. Why should gases be insulators at ordinary pressures and start conducting at very

low pressures?

20. State two reasons why a common emitter amplifier is preferred to a common base amplifier?

OR

What should be the length of a dipole antenna for a carrier wave having frequency 3×10^8 Hz?

Section B

21. Sketch a graph showing variation of resistivity of carbon with temperature.

22. In a parallel plate capacitor, how is the capacity affected, when without changing the charge:

    i. the distance between the plates is doubled
    ii. the area of the plate is halved.

23. The work function for a certain metal is 4.2 eV. Will this metal give photoelectric emission for incident radiation of wavelength 330 nm?

24. About 5% of the power of a 100 W light bulb is converted to visible radiation. What is the average intensity of visible radiation.

    a. at a distance of 1 m from the bulb?
    b. at a distance of 10 m? Assume that the radiation is emitted isotropically and neglect reflection.

25. In which direction would a compass free to move in the vertical plane point to, if located right on the geomagnetic north or south pole?

26. Find the wavelength of the electron orbiting in the first excited state in hydrogen atom.

OR

Calculate the shortest wavelength in the Balmer series of hydrogen atom. In which region (infrared, visible, ultraviolet) of hydrogen spectrum does this wavelength lie?

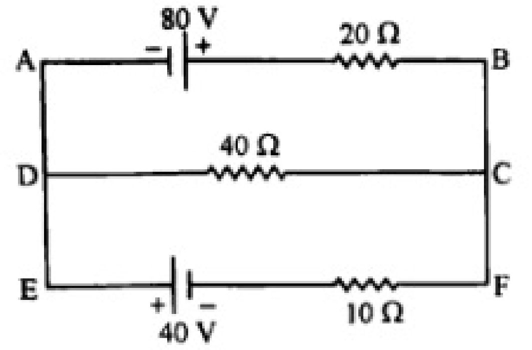
27. Name the semiconductor device that can be used to regulate an unregulated DC power supply. With the help of I-V characteristics of this device, explain its working principle.

OR

Distinguish between 'intrinsic' and 'extrinsic' semiconductors?

Section C

28. Using Kirchhoff's rules, calculate the current through the 40Ω and 20Ω resistors in the following circuit:



29. Two circular coils made of similar wires but of radii 20 cm and 40 cm are connected in parallel. What will be the ratio of the magnetic field at their centres?

30. An applied voltage signal consists of a superposition of a dc voltage and an a.c. voltage of high frequency. The circuit consists of an inductor and a capacitor in series. Show that the dc signal will appear across C and the ac signal across L.

31. Draw a diagram showing the propagation of an electromagnetic wave along the x direction indicating clearly the directions of the oscillating electric and magnetic fields associated with it.

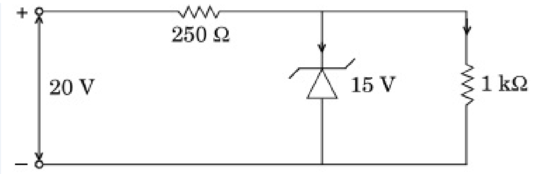
32. A beam of light consisting of two wavelengths 560 nm and 420 nm is used to obtain interference fringes in a Young's double-slit experiment. Find the least distance from the central maximum, where the bright fringes, due to both the wavelengths coincide. The distance between the two slits is 4.0 mm and the screen is at a distance of 1.0 m from the slits.

OR

i. State law of Malus.
ii. Draw a graph showing the variation of intensity(I) of polarised light transmitted by an analyser with angle (θ) between polariser and analyser.
iii. What is the value of refractive index of a medium of polarising angle 60^{0}?

33. Using Bohr's total postulates, derive the expression for the total energy of the electron in the stationary states of hydrogen atom.

34. Give reason to explain why n and p regions of a Zener diode are heavily doped. Find the current through the Zener diode in the circuit given below: (Zener breakdown voltage is 15 V)

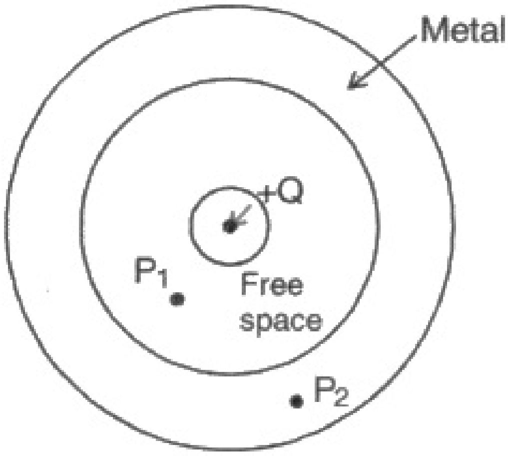


Section D

35. i. Use Gauss theorem to find the electric field due to a uniformly charged infinitely large plane thin sheet with surface charge density σ.
ii. An infinitely large thin plane sheet has a uniform surface charge density $+\sigma$. Obtain the expression for the amount of work done in bringing a point charge q from infinity to a point, distance r, in front of the charged plane sheet.

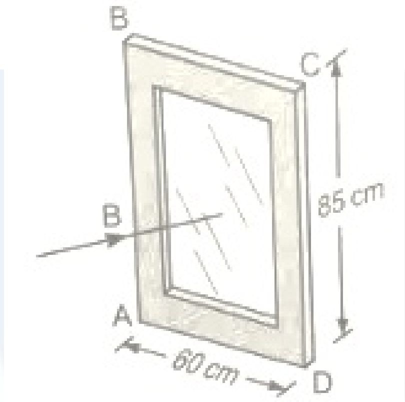
OR

a. Define electric flux. Write its SI unit.
b. A small metal sphere carrying charge +Q is located at the centre of a spherical cavity inside a large uncharged metallic spherical shell as shown in the figure. Use Gauss's law to find the expressions for the electric field at points P_1 and P_2.



c. Draw the pattern of electric field lines in this arrangement.

36. The aluminium frame ABCD of a window measures 85cm $\times$ 60cm, as illustrated in fig.



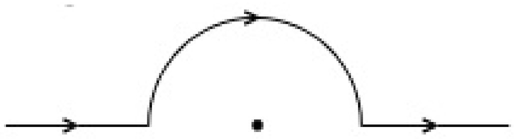
The window is hinged along the edge AB. When the window is closed, the horizontal component of the earth's magnetic field of flux density 1.8×10^{-4}T, is normal to the window.

i. Calculate the magnetic flux through the window.
ii. The window is now opened in a time of 0.20s. When open, the plane of the window is parallel to the earth's magnetic field. For the opening of the window, state the change in flux through the window and calculate the average e.m.f. induced in side CD of the frame.
iii. Suggest, with a reason, whether the e.m.f. calculated in (ii) gives rise to a current in the frame ABCD.

OR

i. Derive the expression for the magnetic field due to a current-carrying coil of radius R at a distance x from the centre along the X-axis.

ii. A straight wire carrying a current of 5 A is bent into a semicircular arc of radius 2 cm as shown in the figure. Find the magnitude and direction of the magnetic field at the centre of the arc.



37. How is the working of a telescope different from that of a microscope?
The focal lengths of the objective and eyepiece of a microscope are 1.25 cm and 5 cm respectively. Find the position of the object relative to the objective in order to obtain an angular magnification of 30 in normal adjustment.

OR

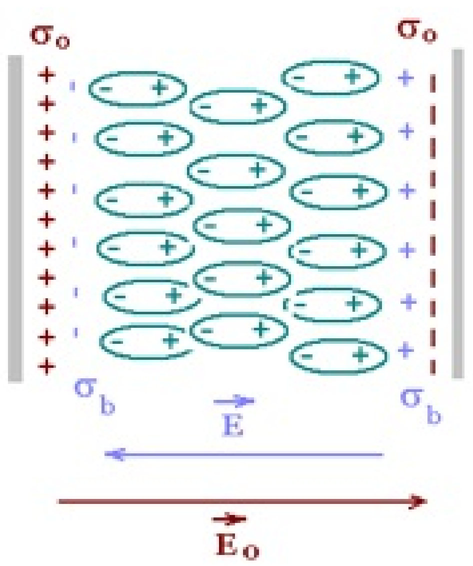
An angular magnification of 30X is desired using an objective of focal length 1.25 cm and an eyepiece of focal length 5 cm. How will you set up the compound microscope?

Answer
Section A

1. (d) $5.7 \times 10^{-3} N$

   Explanation: If A and B having charge $6.5 \times 10^{-7} C$ each and a third sphere C having charge = 0
   If C is in contact with A than new charge on A and C
   $q_A = q_C = \frac{6.5 \times 10^{-7} + 0}{2} = 3.25 \times 10^{-7} C$
   Now C is put in contact with B so new charge on C and B
   $q_s = q_c = \frac{q_B + q_C}{2}$
   $= \frac{6.5 \times 10^{-7} + 3.25 \times 10^{-7}}{2}$
   $= 4.8755 \times 10^{-7} C$
   Now new charge on A is $q_A = 3.25 \times 10^{-7} C$ and on B is $q_B = 4.875 \times 10^{-7} C$ and distance = 50 cm So
   $F = \frac{1}{4\pi\varepsilon_0} \frac{|q_1||q_2|}{r^2}$
   $= \frac{9 \times 10^9 \times \left(3.25 \times 10^{-7} \times 4.875 \times 10^{-7}\right)}{\left(50 \times 10^{-2}\right)^2}$
   $= 5.7 \times 10^{-3} N$

2. (d) dielectric decreases the maximum
   Explanation: When a dielectric is introduced between two charged plates of a capacitor having a charge Q and maintained at a potential difference of V, a reverse electric field is set up inside the dielectric due to dielectric polarization.



This reduces the electric field in between the plates. The potential is also reduced. Maximum potential is dependent on the charge on the plates. As the charge remains constant, the presence of the dielectric decreases the maximum potential between the plates.

3. (c) It does not draw current from external circuit.

Explanation: Potentiometer measures the potential difference using null deflection method, where no current is drawn from the cell; whereas voltmeter needs a small current to show deflection. So, accurate measurement of p.d is done using a potentiometer.

4. (c) 40 cm

Explanation: $\frac{R}{8} = \frac{l}{(100-l)}$

$\frac{R}{8} = \frac{60}{40}$

So, $\frac{8}{R} = \frac{40}{60}$

The balance point when 8Ω is in the left gap will be 40 cm.

5. (b) 1×10^{-23}

Explanation: Magnetic moment of the electron .

The current due to the orbiting electron

$I = \frac{e}{T} = ev$

$= 1.6 \times 10^{-19} \times 6.6 \times 10^{15}$

$= 1.056 \times 10^{-3} A$

The magnetic moment

$\mu_I = I \times A$

$= I \times \pi r^2$

$= 1.056 \times 10^{-3} \times 3.14 \times \left(0.528 \times 10^{-10}\right)^2$

$= 9.24 \times 10^{-24} \approx 1 \times 10^{-23} Am^2$

6. (b) violet component of white light travels slower than the red component

   Explanation: The refractive index and wavelength are inversely related.

   The wavelength of violet is least in the visible region so it bends the most.

7. (b) there will be no change in fringe width

   Explanation: there will be no change in fringe width

8. (d) 17.5 cm

   Explanation: Since moon is situated very far so its image is at the focal plane of objective lens.

   So angle subtended by diameter of moon is equal to angle subtended by the image,

   $\beta = \alpha$

   or $tan\beta = tan\alpha$

   or $\frac{d}{f_o} = \frac{D}{r}$; where D is diameter of moon and r is the distance of moon from the earth.

   $\therefore d = \frac{D \times f_o}{r} = \frac{3.5 \times 10^6 \times 19}{3.8 \times 10^8} = 17.5 \times 10^{-2} m = 17.5 cm$

9. (a) It absorbs ultraviolet radiations from the sun and prevents it from reaching the earth's surface and causing damage to life.

   Explanation: Ozone layer absorbs UV rays

10. (c) 40 volts

    Explanation: $eV_o = \frac{1}{2} m v_{max}^2$

    $V_o = \frac{m v_{max}^2}{2e}$

    putting vmax = 3.75 $\times$ 10^6 m/s, m = 9.1 $\times$ 10^{-31} kg and e = 1.6 $\times$ 10^{-19}C

    we get, V_o = 40 V

11. Negative

12. Isoclinical

13. Negative

OR

Weber

14. Binding

15. Visual

16. Heavy water

17. Nuclear force is the responsible force behind the stability of the nucleus. Its characteristics are-

    i. These are short-range forces.
    ii. These are the strongest forces of attractive nature upto a certain distance i.e upto 10^{-12} m.

18. In a p-type extrinsic semiconductor, the ratio of number of electrons to the number of holes is less than one.

19. At low pressures, ions have a chance to reach their respective electrodes and constitute a current. At ordinary pressures, ions have no chance to do so because of collisions with gas molecules and recombination.

20. The two reasons why a common emitter amplifier is preferred to a common base amplifier are:

    i. It has high current gain.
    ii. It has high voltage gain.

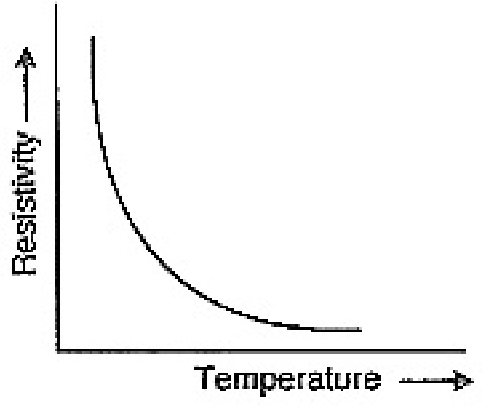
OR

Given, f = 3×10^8 Hz, therefore, the wavelength of the wave
$\lambda = \frac{c}{f} = \frac{3\times10^8}{3\times10^8}$ = 1 m.
Therefore, the length of the dipole antenna or half-wave dipole antenna,

$L = \frac{\lambda}{2} = \frac{1}{2}$ m

Section B

21. The resistivity of carbon decreases with increasing temperature as shown in figure below:



22. i. $C\alpha\frac{1}{d}$. When d is doubled, capacity is halved.
    ii. $C\alpha A$. When A is halved, capacity is halved.

23. $\phi_0 = 4.2eV = 4.2 \times 1.6 \times 10^{-19} J = 6.72 \times 10^{-19} J$
    $E = \frac{hc}{\lambda}$
    $\Rightarrow E = \frac{6.62 \times 10^{-34} \times 3 \times 10^8}{330 \times 10^{-9}} = 6.018 \times 10^{-19} J$
    As energy of incident photon $E < \phi_0$ hence no photoelectric emission will take place.

24. Power converted into visible radiation,
    $P = \frac{5}{100} \times 100W = 5w$ = 5 W
    Intensity $= \frac{Energy}{Area \times Time} = \frac{Power}{Area} = \frac{P}{4\pi r^2}$
    a. Intensity, $I = \frac{5}{4 \times 3.14 \times 1 \times 1} = 0.4\ Wm^{-2}$
    b. $I = \frac{5}{4 \times 3.14 \times 10 \times 10} Wm^{-2}$
    = 0.004 Wm^{-2}

25. A compass is free to move in a horizontal plane, while the earth's field is exactly vertical at the magnetic poles. So the compass can point in any direction there.

26. For electron in first excited state i.e. n = 2.

    So, if λ be its wavelength (De-Broglie), then we have n $\lambda = 2\pi r_n$ ...(i)

where, r_n is the radius of second orbit.

$$r_n \approx 0.5 \times n^2 (\text{ in } \overset{o}{A}) = 0.5 \times 4 = 2\overset{o}{A}$$

substitute r_n in Eq(i) , we get

$$\therefore \quad 2 \times \lambda = 2 \times \pi \times 2\overset{o}{A}$$
$$\Rightarrow \quad \lambda = 2\pi A = 6.28\overset{o}{A}$$

OR

we know that for Balmer series,

$$\frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{n_2^2}\right), n_2 = 3, 4, 5...$$

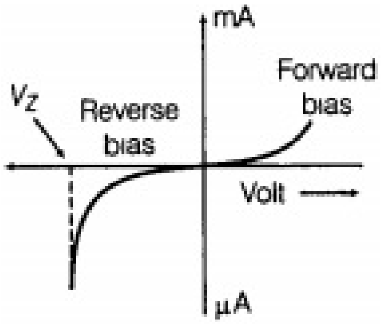
For shortest wavelength, the spectral series is given by $n_1 = 2$ and $n_2 = \infty$

$$\Rightarrow \quad \frac{1}{\lambda} = R\left(\frac{1}{2^2} - \frac{1}{\infty^2}\right)$$
$$\Rightarrow \quad \frac{1}{\lambda} = R \times \frac{1}{4} \Rightarrow \frac{1}{\lambda} = \frac{R}{4} \Rightarrow \lambda = \frac{4}{R}$$
$$\lambda = \frac{4}{1.097 \times 10^7}\left[\because R = 1.097 \times 10^7 \text{m}^{-1}\right]$$
$$\Rightarrow \lambda = 3.64 \times 10^{-7}\text{m}$$

wavelength lies in visible region.

27. Zener diode is used for regulating the unregulated voltage supply

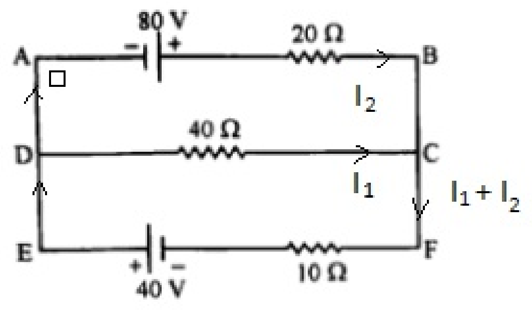
Principle:- After breakdown a large current can be produced this is reverse breakdown region. The voltage across it remains constant, equal to the breakdown voltage for large reverse current.



OR

Intrinsic semiconductor	Extrinsic semiconductor
It is a pure semiconductor and has no impurity atoms.	It is prepared by adding some impurity atoms in the pure semiconductor.
The number of free electrons and holes are always equal.	The number of free electrons and holes are not equal.

Section C

28. 

In Loop ABCDA using the Kirchoff's 2nd law,

$80 - 20\ I_2 + 40\ I_1 = 0$

$4 = I_2 - 2I_1$ .....(1)

In Loop DCFED, using the Kirchoff's 2nd law,

$-40\ I_1 - 10\ (I_1 + I_2) + 40 = 0$

$-50\ I_1 - 10\ I_2 + 40 = 0$

$5I_1 + I_2 = 4$ ....(2)

Solving (1) and (2) we get,

$I_1 = 0$ A and $I_2 = 4$ A

Thus, the current through the 40 ohm resistor is 0 A and 20 ohm resistor is 4 A.

29. Magnetic field at the centre of circular coil of radius r, turns N, and current I passing in coil is

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

$$B = \frac{\mu_0 N}{2r} \frac{V}{R}$$ [R = resistance of coil]

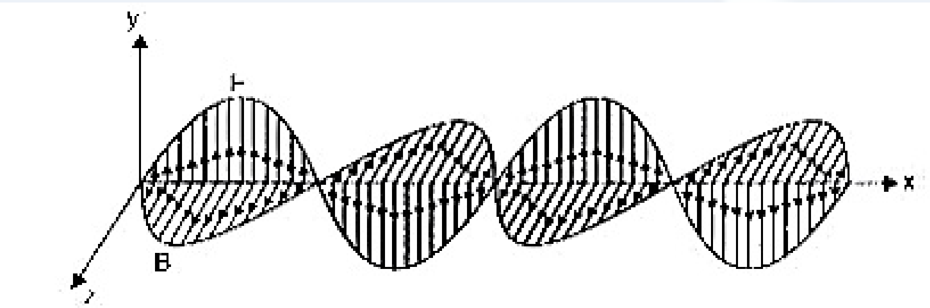
$$B = \frac{\mu_0 N}{2r} \frac{V}{2\pi rx}$$ [x is resistance per unit length]

$$B = \frac{\mu_0 NV}{4\pi r^2}$$

As coils are is parallel so potential difference 'V' are equal in both coils

$\therefore V \propto \frac{1}{r^2}$
or $\frac{B_L}{B_2} = \frac{r_2^2}{r_1^2}$
$\frac{B_1}{B_2} = \left(\frac{40}{20}\right)^2$
$\frac{B_1}{B_2} = 4$ or $B_1 : B_2 = 4 : 1$

30. For high frequency, the inductive reactance for a.c. $X_L = \omega L = \infty$ and capacitance of reactance $X_C = \frac{1}{\omega C} = 0$. Hence, capacitor does not offer any resistance for a.c.. Thus a.c. components of voltage appears across L only.
Consequently X_L for d.c. $X_L = \omega L = 0$ and
e $X_C = \frac{1}{\omega C} = \infty$
Therefore, d.c. components of voltage appears across C only.

31. 

32. Given,

D = distance of screen from the slits = 1 m ,

d = distance between two slits $= 4 \times 10^{-3}\text{m}$

$\lambda_1 = 560\text{nm}$ and

$\lambda_2 = 420\text{nm}$.

Let n^{th} order bright fringe of λ_1 coincides with $(n+1)^{th}$ order bright fringe of λ_2
$\Rightarrow \quad \frac{Dn\lambda_1}{d} = \frac{D(n+1)\lambda_2}{d}$
$\Rightarrow \quad n\lambda_1 = (n+1)\lambda_2$
$\Rightarrow \quad \frac{n+1}{n} = \frac{\lambda_1}{\lambda_2}$
$1 + \frac{1}{n} = \frac{560 \times 10^{-9}}{420 \times 10^{-9}} \Rightarrow 1 + \frac{1}{n} = \frac{4}{3}$
$\Rightarrow \quad \frac{1}{n} = \frac{1}{3}$

$\Rightarrow n = 3$

$\therefore$The Least distance from the central fringe where bright fringe of two wavelengths coincides

= Distance of 3rd order bright fringe of λ_1

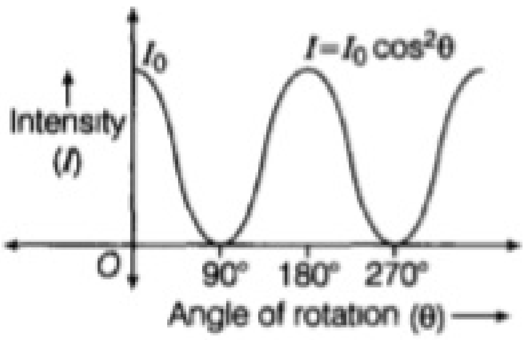
$\Rightarrow \quad y_n = \frac{3D\lambda_1}{d} = \frac{3\times1\times560\times10^{-9}}{4\times10^{-3}}$

$y_n = 420 \times 10^{-6}\text{m} = 0.42 \times 10^{-3}\text{m}$

$\therefore \quad y_n = 0.42\text{mm}$

Thus, 3^{rd} bright fringe of λ_1 and 4^{th} bright fringe of λ_2 coincide at 0.42 mm from central fringe.

OR

i. Law of Malus states that when a completely plane polarised light beam is incident on an analyser, the intensity of the emergent light varies as the square of the cosine of the angle between the plane of transmission of the analyser and the polariser.
   i.e. $I \propto \cos^2\theta$
   This rule is also called cosine square rule.
   $\therefore \quad I = I_0 \cos^2\theta$
   Where, I_0 is the intensity of the polarised light after passing through P_1
ii. Variation of intensity of polarised light transmitted by an analyser (I) with angle θ
   

iii. According to the Brewster's law,
   we have $\mu = \tan I_p$
   where, I_P= polarising angle,
   μ = refractive index
   given ,

$$I_P = 60^\circ$$
$$\mu = \tan 60^\circ$$
$$\mu = \sqrt{3}$$
The refractive index of the material is 1.73 .

33. According to Bohr's postulates, in a hydrogen atom, as single-electron revolves around a nucleus of charge +e. For an electron moving with a uniform speed in a circular orbit of a given radius, the centripetal force is provided by coulomb force of attraction between the electron and the nucleus. The gravitational attraction may be neglected as the mass of electron and proton is very small.So,

$mv^2/r = ke^2/r^2$ (where, $k = 1/4\pi\varepsilon_0$)

or $mv^2 = ke^2/r$............(i)

where, m =mass of electron

r = radius of electronic orbit

v = velocity of electron

Again, by Bohr's second postulates

$mvr = nh/2\pi$

where, n =1, 2, 3, ... or $v = nh/2\pi mr$

Putting the value of v in Eq. (i)

$$m\left(\frac{nh}{2\pi mr}\right)^2 = \frac{ke^2}{r} \Rightarrow r = \frac{n^2h^2}{4\pi^2 kme^2} \text{....(ii)}$$

Kinetic energy of electron ,

$$E_K = \frac{1}{2}mv^2 = \frac{ke^2}{2r}\left(\because \frac{mv^2}{r} = \frac{ke^2}{r^2}\right)$$

Using Eq(ii), we get

$$E_K = \frac{ke^2}{2}\frac{4\pi^2 kme^2}{n^2h^2} = \frac{2\pi^2k^2me^4}{n^2h^2}$$

Potential energy of electron ,

$$E_P = -\frac{k(e)\times(e)}{r} = -\frac{ke^2}{r}$$

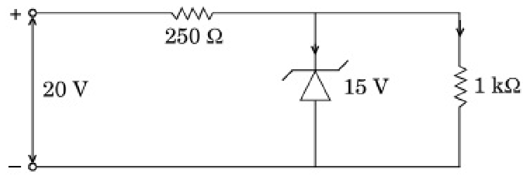
Using Eq(ii), we get

$$E_P = -ke^2 \times \frac{4\pi^2 kme^2}{n^2h^2} = -\frac{4\pi^2k^2me^4}{n^2h^2}$$

Hence, total energy of the electron in the n^{th} orbit

$$E = E_P + E_K = -\frac{4\pi^2k^2me^4}{n^2h^2} + \frac{2\pi^2k^2me^4}{n^2h^2}$$
$$= -\frac{2\pi^2k^2me^4}{n^2h^2}$$

34. Zener diodes are designed to work in breakdown region.Due to heavy doping the depletion layer becomes very thin and electric field, across the junction, becomes extremely high even for a small reverse bias voltage. A heavily doped diode has a low Zener breakdown voltage, while a lightly doped diode has a high Zener breakdown voltage.



As, zener diode and load resistance, 1kΩ are parallel, so

Voltage across 1 kΩ = Voltage across zener diode = 15V

Thus, Potential drop across 250 ohm resistance = 20 - 15 = 5V

So, current in the circuit is,

$I_S = \frac{V}{R} = \frac{5}{250} = 20$ mA

Current through resistor of 1 kΩ is,

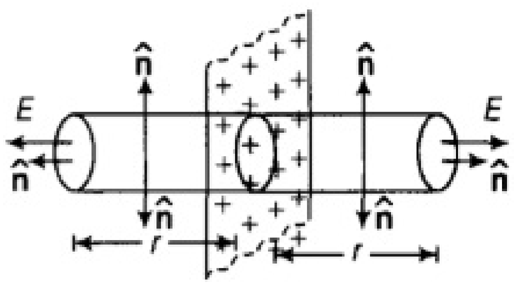
$I_L = \frac{15}{1000} = 15$ mA

As zener diode and 1kΩ resistor are in parallel, so applying current junction rule, the current through the zener diode is,

$I_Z = 20 - 15 = 5$ mA

Section D

35. According to the question, σ is the surface charge density of the sheet. From symmetry, E on either side of the sheet must be perpendicular to the plane of the sheet, having same magnitude at all points equidistant from the sheet We take a cylinder of cross-sectional area A and length 2r as the Gaussian surface. On the curved surface of the cylinder, E and $\hat{n}$ are perpendicular to each other. Therefore, the flux through the curved surface of the cylinder = 0.



Electric flux through both the surfaces are positive as Electric field lines are originating from them and net electric flux will be the sum of these individual fluxes.

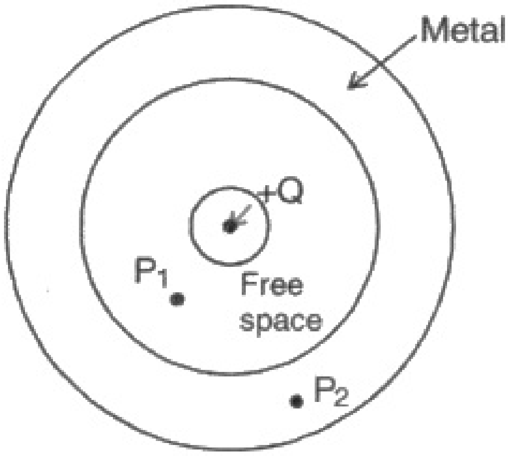
Net Flux = EA + EA = 2 EA

i. $\phi_E = 2EA$
   Total charge enclosed by the cylinder, $q = \sigma A$ According to Gauss's law,
   $\oint \mathbf{E} \cdot d\mathbf{A} = \phi_E = \frac{q}{\varepsilon_0} \Rightarrow 2AE = \frac{\sigma A}{\varepsilon_0}$ or $E = \frac{\sigma}{2\varepsilon_0}$
   E is independent of r, the distance of the point from the plane charged sheet E at any point is directed away from the sheet for positive charge and directed towards the sheet in case of negative charge.
ii. Surface charge density of the uniform plane sheet which is infinitely large $= +\sigma$.
   The electric potential (V) due to infinite sheet of uniform charge density
   $V = -\frac{\sigma r}{2\varepsilon_0}$
   The amount of work done in bringing a point charge q from infinite to point, at distance r in front of the charged plane sheet will be product of charge and the potential difference through which it is moved.
   $W = q' \times V = q' \cdot \frac{-\sigma r}{2\varepsilon_0} = -\frac{\sigma r \cdot q'}{2\varepsilon_0}$ Joule

   here, negative work shows that work will be obtained when positive charge 'q' will be brought from infinity to any point.

OR

a. It is defined as the total number of electric field lines crossing a given area normal to its surface. It can be practically obtained by taking the dot product of the electric field vector and area vector. Its SI unit is Nm^2C^{-1}.
b. For point P_1, using Gauss law, we have
   $\oint \overrightarrow{E} \cdot d\overrightarrow{A} = \frac{Q}{\varepsilon_0}$

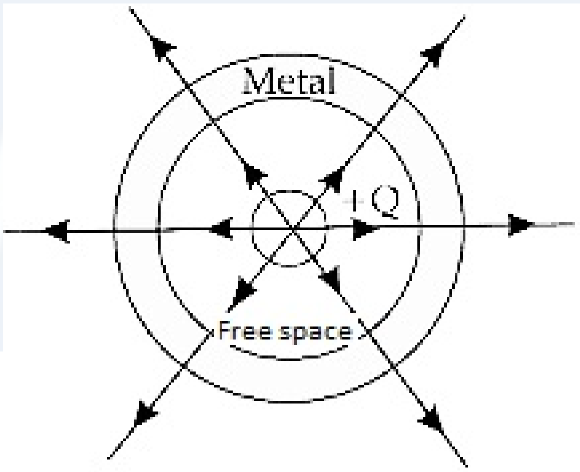


Since E and dA are in the same direction, therefore, we have,

$E = \frac{Q}{\varepsilon_0 A}$

Point P_2 lies inside the metal, therefore Gaussian surface drawn at P_2 does not include a charge because charge always resides on the outer surface of the sphere, hence the electric field at P_2 is zero.

c. The electric field lines are shown in the following figure:



36. i. Here, $B = 1.8 \times 10^{-4}$T,

Area of the window, $A = 85 \times 60\ cm^2 = 85 \times 60 \times 10^{-4}\ m^2$

Now, magnetic flux through the window,

$\phi = BA = 1.8 \times 10^{-4} \times 85 \times 60 \times 10^{-4}$

$= 9.18 \times 10^{-5}$T

ii. When the window is open, the plane of the window is parallel to the earth's magnetic field. Therefore, the magnetic flux through the window zero.

Change in magnetic flux through the window,

$\Delta\phi = 9.18 \times 10^{-5} - 0 = 9.18 \times 10^{-5}$ Wb

Time in which window is opened, Δt = 0.20s

Therefore, e.m.f. induced in the side CD,

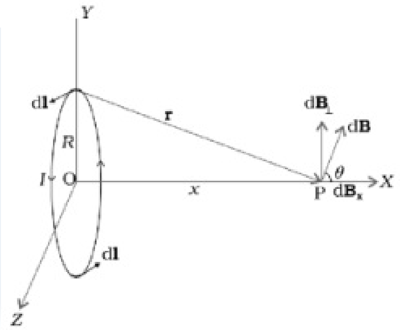
$e = \frac{\Delta\phi}{\Delta t} = \frac{9.18\times10^{-5}}{0.20}$

= 4.59 $\times$ 10^{-4} V

iii. Since the frame of the window is a closed circuit and arm CD acts as a source of e.m.f., a current will flow in the frame.

OR

i. Consider a circular loop having current I of radius R in y-z plane. Let O be the origin. Let P be the point on x-axis at the distance x from the origin O where the magnetic field is to be calculated. Consider dl element of the loop.



According to Biot Savart Law, the magnitude dB of the magnetic field due to dl is given by,

$|\overrightarrow{\mathrm{dB}}| = \frac{\mu_0}{4\pi}\frac{I\ dl\ \sin 90^\circ}{r^2}$

Where r = $\sqrt{x^2 + R^2}$

$|\overrightarrow{dB}| = \frac{\mu_0}{4\pi}\frac{I\ dl}{(x^2+R^2)}$

The direction of $\overrightarrow{dB}$ is perpendicular to $\overrightarrow{dl}$ and $\overrightarrow{r}$.

It has components dB_x and $\mathrm{dB}_\perp$. The components $\mathrm{dB}_\perp$ due to the whole coil cancel out in pairs.

Net field B = $\int$ dB_X = $\int$ dB cos θ

Now, cos $\theta = \frac{R}{(x^2+R^2)^{1/2}}$

Therefore, dB_X = $\frac{\mu_0\ I\ dl}{4\pi}\frac{R}{(x^2+R^2)^{3/2}}$

The summation of elements dl over the circular loop yields the circumference, $2\pi R$

Thus, net magnetic field (in vector form),

$\vec{B} = \frac{\mu_0 I R^2}{2\left(x^2+R^2\right)^{\frac{3}{2}}} \hat{i}$

At, x = 0,

$B = \frac{\mu_o\ I}{2R}\ \hat{i}$

ii. From above, for circular loop, the magnitude of magnetic field B is

$B = \frac{\mu_o\ I}{2R}$

For the semi-circular loop, the magnitude of the net magnetic field, B = $\frac{\mu_0 I}{4R}$ i.e. half of the circular loop

= $\frac{4\pi\times10^{-7}\times5}{4\times2\times10^{-2}}$

= 7.85×10^{-5} T

And the field is directed inwards perpendicular to the plane of the page.

37. Working Differences:

i. The objective of a telescope forms the image of a very far off object at, or within, the focus of its eyepiece. The microscope does the same for a small object kept just beyond the focus of its objective.
ii. The final image formed a telescope is magnified relative to its size as seen by the unaided eye, while the final image formed by a microscope is magnified relative to its absolute size.
iii. The objective of a telescope has large focal length and large aperture, while the corresponding for a microscope have very small values.

Given: f_0 = 1.25 cm, f_e = 5 cm

M = -30 (Magnifying power is negative)

We know,

$M = \frac{v_0}{u_0}\left(1 + \frac{D}{f_e}\right)$

Where, v_0 = Distance of image from objective, u_0 = Distance of object from objective, D = Distance of least distinct vision

Thus,

$-30 = \frac{v_0}{u_0}\left(1 + \frac{25}{5}\right)$

v_0 = -5 u_0

Using lens formula,
$$\frac{1}{f_0} = -\frac{1}{u_0} + \frac{1}{v_0}$$
$$\frac{1}{1.25} = -\frac{1}{u_0} - \frac{1}{5u_0}$$
u_0 = -1.5 cm

Thus the distance of object from objective is 1.5 cm.

OR

In normal adjustment, image is formed at least distance of distinct vision,

d = 25 cm

Angular magnification of eyepiece $= \left(1 + \frac{D}{f_e}\right)$
$$= \left(1 + \frac{25}{5}\right) = 6$$
Since the total magnification is 30, magnification of objective lens,
$$m = \frac{30}{6} = 5$$
$$\therefore m = -\frac{v_0}{u_0} = 5 \text{ or } v_0 = -5u_0$$
As $\frac{1}{v_0} - \frac{1}{u_0} = \frac{1}{f_0}$
$$\therefore \frac{1}{-5u_0} - \frac{1}{u_0} = \frac{1}{1.25}$$
$$-\frac{6}{5u_0} = \frac{1}{1.25}$$
$$u_0 = -\frac{6 \times 1.25}{5} = -1.5cm$$
i.e. object should be held at 1.5 cm in front of objective lens.

As v_0 = -5u_0
$$\therefore v_0 = -5\left(-1.5\right) = 7.5cm$$
From $\frac{1}{v_e} - \frac{1}{u_e} = \frac{1}{f_e}$
$$\frac{1}{u_e} = \frac{1}{v_e} - \frac{1}{f_e} = \frac{1}{-25} - \frac{1}{5} = -\frac{6}{25}$$
$$u_e = -\frac{25}{6} = -4.17cm$$
Separation between the objective lens and eyepiece $= |u_e| + |v_0|$

= 4.17 + 7.5 = 11.67 cm