CBSE Class 12 Physics
Sample Paper - 02 (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.

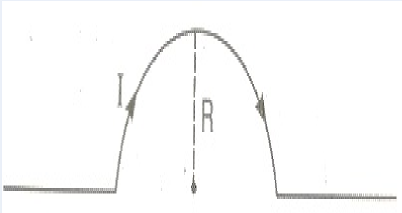
Section A

1. An electric field can deflect
   a. Neutrons
   b. γ - rays
   c. X rays
   d. α – rays
2. The electric dipole potential falls off, at large distance r
   a. as $\frac{1}{r^{1.8.9}}$
   b. as $\frac{1}{r^{3.0}}$
   c. as $\frac{1}{r^{1.4}}$
   d. as $\frac{1}{r^{2.0}}$
3. Two resistances are connected in the two gaps of a meter bridge. The balance points is 20 cm from the zero end. When a resistance of 15 ohm is connected in series with the

smaller of the two resistances, the null point shifts to 40 cm. The smaller of the two resistances has the value (in ohm)

a. 8
b. 10
c. 12
d. 9

4. Current density of a conductor is
   a. Is always zero
   b. the net charge flowing through the area
   c. the net current flowing through the area normally per unit time
   d. the net charge flowing through the area per unit time
5. A portion of a conducting wire is bent in the form of a semicircle of radius R as shown in the figure. At the centre of the semicircle, the magnetic induction will be:



   a. $\frac{\mu_0 I}{2\pi R}$
   b. $\frac{\mu_0 I}{2R}$
   c. $\frac{\mu_0 I}{4\pi R}$
   d. $\frac{\mu_0 I}{4R}$
6. In the single slit diffraction, every point on the slit acts-
   a. to increase the intensity
   b. to reduce the intensity
   c. as a secondary source
   d. inclined
7. 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 $\frac{4}{3}$.

   a. 0.12°

b. 0.15°
c. 0.14°
d. 0.13°

8. When a ray of light enters a glass slab from air
   a. its wavelength decreases
   b. neither wavelength nor frequency changes
   c. its wavelength increases
   d. its frequency increases
9. Part of the electromagnetic spectrum to which 5890 $\overset{0}{A}$ - 5896 $\overset{0}{A}$ [double lines of sodium] belongs is
   a. Microwave
   b. Visible
   c. Ultraviolet
   d. Gamma rays
10. If the threshold wavelength of radiations required to eject a photoelectron from a metal surface is 6 $\times 10^{-7}$ m, then work function of the metal is
    a. 3.4 $\times 10^{-19}$ J
    b. 3.5 $\times 10^{-19}$ J
    c. 3.3 $\times 10^{-19}$ J
    d. 3.6 $\times 10^{-19}$ J
11. Fill in the blanks: When a bar is placed near a strong magnetic field and it is repelled, then the material of bar is ________.
12. Fill in the blanks:

    Torque is ________ when the magnet lies along the direction of the magnetic field.

13. Fill in the blanks:

    The SI unit of mutual inductance is ________.

OR

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 ________.

14. Fill in the blanks:

________ are the nuclides which contain the same number of neutrons.

15. Fill in the blanks:

Focal length of a plane mirror is ________.

16. Which one is unstable among neutron, proton, electron and $\alpha-$ particle.

17. Draw a graph showing the variation of potential energy between a pair of nucleons as a function of their separation. Indicate the function in which the nuclear force is (i) attractive, (ii) repulsive.

18. Name the type of biasing of a p-n junction diode so that the junction offers very high resistance.

19. State de-Broglie hypothesis.

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

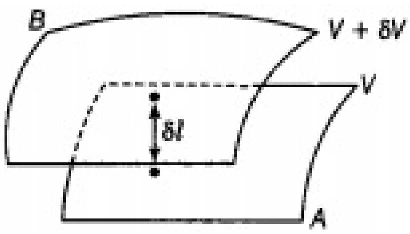
OR

A TV tower has height 75 m. What is the maximum distance and area upto which this transmission can be received? Take radius of earth is 6400 km.

Section B

21. Using the concept of drift velocity of charge carriers in a conductor, deduce the relationship between current density and resistivity of the conductor.

22. Two closely spaced equipotential surfaces A and B with potentials V and V + δV, (where δV is the change in V) are kept δl distance apart as shown in the figure. Deduce the relation between the electric field and the potential gradient between them. Write the two important conclusions concerning the relation between the electric field and electric potential.



23. Write three basic properties of photons which are used to obtain Einstein's photoelectric equation. Use this equation to draw a plot of maximum kinetic energy of the electrons emitted *versus* frequency of incident radiation.

24. How is the speed of electromagnetic waves in vacuum determined by the electric and magnetic fields?

25. The horizontal component of the earth's magnetic field at a place $\sqrt{3}$ is times its vertical component there. Find the value of the angle of dip at that place. What is the ratio of the horizontal component to the total magnetic field of the earth at that place?

26. Find out the wavelength of the electron orbiting in the ground state of hydrogen atom.

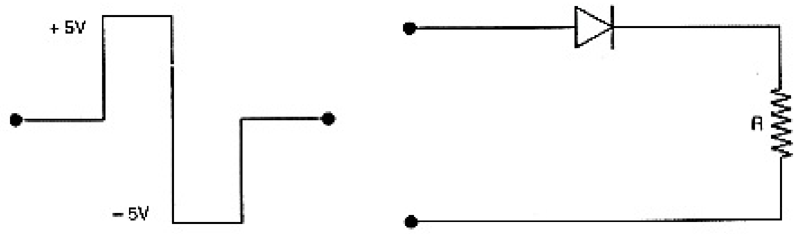
OR

In the Rutherford scattering experiment, the distance of closest approach for an a-particle is d_0 . If a-particle is replaced by a proton, then how much kinetic energy in comparison to α-particle will be required to have the same distance of closest approach d_0?

27. What type of charge carriers are there in a p-type semiconductor?

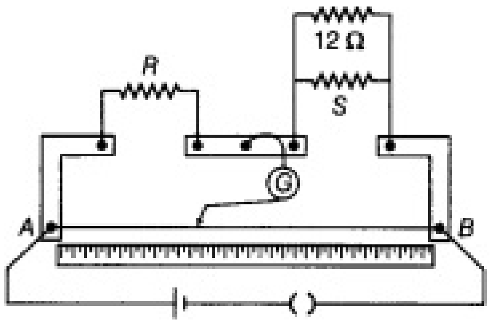
OR

Draw and explain the output waveform across the load resistor R, if the input waveform is as shown in the given figure.



Section C

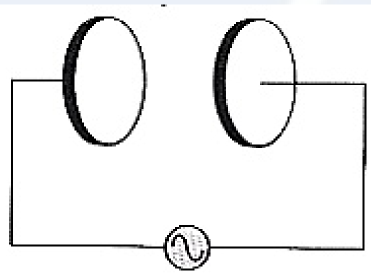
28. In a meter bridge, the null point is found at a distance of 40 cm from A. If a resistance of 12Ω is connected in parallel with S, then null point occurs at 50.0 cm from A. Determine the values of R and S.



29. Write the expression for Lorentz magnetic force on a particle of charge q moving with velocity v in a magnetic field B. Show that no work is done by this force on the charged particle.

30. The instantaneous current and voltage of an a.c circuit are given byi = 10 sin 314 t A and v = 50 sin (314 t + $\frac{\pi}{2}$) V.What is the power dissipation in the circuit?

31. A parallel plate capacitor made of circular plates each of radius R = 6.0 cm has a capacitance C = 100 pF. The capacitor is connected to a 230 V ac supply with a (angular) frequency of 300 rad s^{-1}.



   a. What is the rms value of the conduction current?
   b. Determine the amplitude of B at a point 3.0 cm from the axis between the plates.

32. A beam of light consisting of two-wavelength, 650 nm and 520 nm, is used to obtain interference fringes in a Young's double-slit experiment.

   a. Find the distance of the third bright fringe on the screen from the central maximum for wavelength 650 nm.

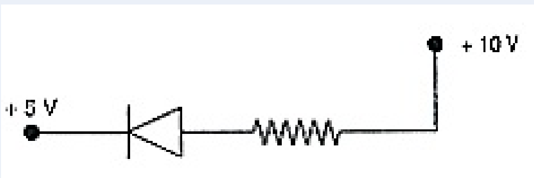
b. What is the least distance from the central maximum where the bright fringes due to both the wavelengths coincide?

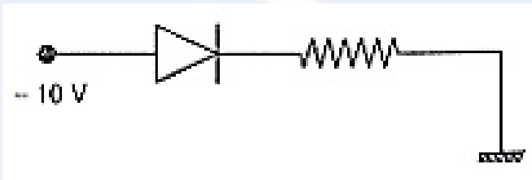
OR

In a Young's experiment, the width of the fringes obtained with light of wavelength $6000\overset{o}{A}$ is 2.0 mm. What will be the fringe width, if the entire apparatus is immersed in a liquid of refractive index 1.33?

33. Using Rydberg formula, calculate the wavelengths of the first four spectral lines in the Balmer series of hydrogen atom spectrum.

34. Explain, with the help of a circuit diagram, how the thickness of depletion layer in a p-n 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?





Section D

35. Two-point charges $q_A = 3\mu C$ and $q_B = -3\mu C$ are located 20 cm apart in vacuum,

a. What is the electric field at the midpoint O of the line AB joining the two charges?
b. If a negative test charge of magnitude $1\cdot5\times10^{-9}$ C is placed at this point, what is the force experienced by the test charge?

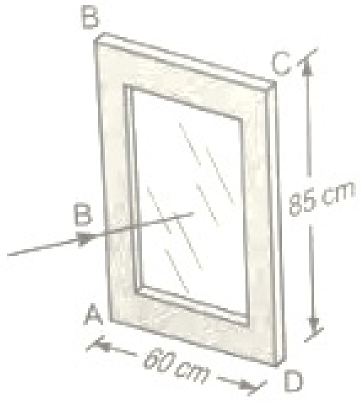
OR

A spherical capacitor has an inner sphere of radius 12 cm and an outer sphere of radius 13 cm. The outer sphere is earthed and the inner sphere is given a charge of $2.5\mu C$. The space between the concentric spheres is filled with a liquid of dielectric constant 32.

a. Determine the capacitance of the capacitor.
b. What is the potential of the sphere?
c. Compare the capacitance of this capacitor with that of an isolated sphere of radius

12 cm. Explain why the latter is much smaller.

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 inside 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. State and explain the law used to determine magnetic field at a point due to a current element. Derive the expression for the magnetic field due to a circular current carrying loop of radius R at its centre.
ii. A long wire with a small current element of length 1 cm is placed at the origin and carries a current of 10 A along the X-axis. Find out the magnitude and direction of the magnetic field due to the element on the Y-axis at a distance 0·5 m from it.

37. i. Draw a ray diagram for the formation of the image of a point object by a thin double convex lens having radii of curvatures R_1 and R_2 and hence, derive lens maker's formula.
ii. Define power of a lens and give its SI unit. If a convex lens of length 50 cm is

placed in contact coaxially with a concave lens of focal length 20 cm, what is the power of the combination?

OR

a. When a ray of light passes through a triangular glass prism, find out the relation for the total deviation, δ in terms of the angle of incidence, i and angle of emergence, e.
b. Plot a graph showing the variation of angle of deviation with the angle of incidence and obtain the condition for the angle of minimum deviation.

Answer

Section A

1. (d) α – rays

   Explanation: alpha particles (nucleus of helium atom) are charged particles so they will be affected by electric field. They will get deflected in direction of electric field as they are positively charged.

2. (d) as $\frac{1}{r^{2.0}}$

   Explanation: The potential due to a dipole at a point (r ,θ)from its center is for r>>d where d is sepration between charges that form a dipole

   $V = \frac{p\cos\theta}{4\pi\varepsilon_0 r^2}$

   therefore, $V \propto \frac{1}{r^2} \propto \frac{1}{r^{2.0}}$

3. (d) 9

   Explanation: Let the resistances be P and Q. When balanced,

   $\frac{P}{Q} = \frac{20}{80} = \frac{1}{4} \ldots . (i)$

   when another resistance is connected in series

   $\frac{P+15}{Q} = \frac{40}{60} = \frac{2}{3} \ldots . (ii)$

   from (i) and (ii)

   $\frac{P+15}{4P} = \frac{2}{3}$

   $\Rightarrow$ 3P + 45 = 8P

   $\Rightarrow$ 5P = 45

   $\Rightarrow P = 9\Omega$

4. (c) the net current flowing through the area normally per unit time

   Explanation: Current density J = I/A

   In electromagnetism, current density is the electric current per unit area of cross section. It is a vector and has a direction along the area vector.

5. (d) $\frac{\mu_0 I}{4R}$

   Explanation: $\frac{\mu_0 I}{4R}$

6. (c) as a secondary source

   Explanation: Every part of the wavefront at the slit acts as secondary sources because the incoming wavefront is parallel to the plane of the slit, these sources are in phase.
7. (b) 0.15°

   Explanation: use $\theta 1 = \frac{\theta}{\mu}$

   $\theta 1 = \frac{0.2}{1.33} = .15$

8. (a) its wavelength decreases

   Explanation: The energy of the light is related to the frequency; when the light enters the medium the apparent speed of light changes; if the frequency changed, the energy would not be conserved. The wavelength changes to balance the change in speed. When light enters from air to glass (from rarer to denser medium), its speed decreases as a consequence its wavelength also decreases.
9. (b) Visible

   Explanation: 5890 $\overset{0}{A}$ - 5896 $\overset{0}{A}$ [double lines of sodium] belongs to visible region of em-spectrum
10. (c) 3.3 $\times 10^{-19}$ J **Explanation:**

    $\phi_0 = \frac{hc}{\lambda_0} = \frac{6.6\times10^{-34}\times3\times10^{8}}{6\times10^{-7}} = 3.3 \times 10^{-19} J$

11. Diamagnetic

12. Minimum

13. Henry

OR

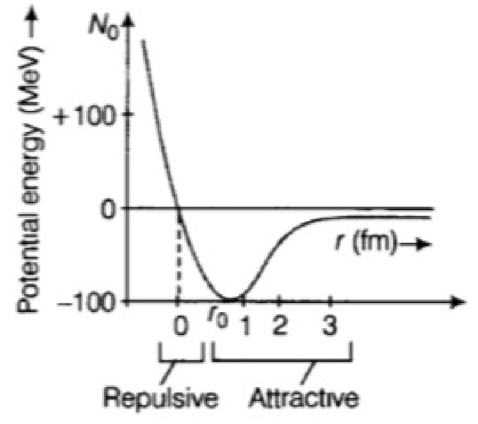
Negative

14. Isotones

15. Infinity

16. Neutron. It decays into proton and electron.

17. Plot of potential energy of a pair of nucleons as a function of their separation is given in the figure:



From the above graph it can be easily concluded that if distance between nucleons is greater than r_0, forces are attractive in nature while for separation less than r_0 , forces are attractive in nature.

18. Reverse biasing.

19. **De-Broglie hypothesis:** A moving object sometimes acts as a wave and sometimes as a particle or a wave is associated with the moving particle which controls this particle in every respect. This wave associated with the moving particle is called matter-wave or de-Broglie wave**.** Its wavelength is given by:

$\lambda = \frac{h}{mv}$

where, h =Planck's constant, m =mass of object,v =velocity of the object.

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

Here, R = 6400 km, h = 0.075 km

From the relation

d = $\sqrt{2hR}$ = $\sqrt{2 \times 6400 \times 0.075}$ = 30.98 km

Area covered

A = πd^2 = π $\times$ $(30.98)^2$ =3.14$\times$ $(30.98)^2$ = 3014 km^2

Section B

21. The average velocity attained by some particle such as an electron due to the influence of an electric field is termed as the drift velocity. The movement or the motion of the particles is assumed to be along a plane and hence the motion can also be referred to as the axial drift velocity. As we know that, I= $neAv_d$

    Also, current density J is given by

    J = I/A

    $\therefore \quad |J| = \frac{ne^2}{m}\tau|E| \quad \left[\because v_d = \frac{e\tau E}{m}\right]$

    or $J = (1/\rho)E \quad [\because \rho = m/ne^2\tau]$

22. Work done in moving a unit positive charge along an infinitesimal distance δl,

    $|E_I|\delta l = V_A - V_B = V - (V + \delta V) = -\delta V$ [since work done, w = $\vec{E}.\overrightarrow{\delta l}$ = q × (V_B - V_A) and charge,q = 1 unit here]

    or $E = -\frac{\delta V}{\delta l}$

    i. Electric field is in the direction in which the change in electrostatic potential decreases most. (This conclusion comes due to the negative sign of the above expression)
    ii. Magnitude of electric field is given by the change in the magnitude of electrostatic potential per unit displacement normal to the equipotential surface at the point.

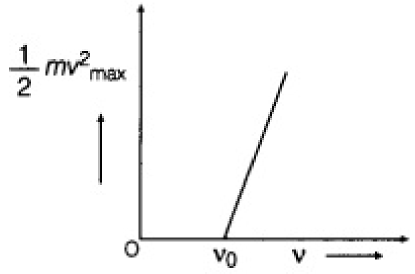
23. **Three basic properties of photons are**

    i. Photons are quanta or discrete carriers of energy and momentum
    ii. Energy of a photon is proportional to the frequency of light.
    iii. Rest mass of photon is zero

    Einstein's photoelectric equation

    $\frac{1}{2}mv_{\max}^2 = hv - \phi_0$

The plot is as shown as below



24. To determine speed of light in vacuum, we use the formula, c = E_0 / B_0 = $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$
    where, E_0 and B_0 are maximum electric field and magnetic field component respectively of electromagnetic waves. μ_0 and ϵ_0 are permeability and permittivity of vacuum or free space respectively.

25. According to the question, $B_H = \sqrt{3}\ B_V$

    where, B_H = the horizontal component of the earth's magnetic field.

    and B_V = vertical component of the earth's magnetic field.

    Assume, angle of dip at that place is δ, then
    $\tan\delta = B_V / B_H \quad [\because B_H = \sqrt{3}B_V]$
    $\tan\delta = B_V / \sqrt{3}\ B_V$
    $\tan\delta = \frac{1}{\sqrt{3}}$
    $so, angle\ of\ dip:\ \delta = \frac{\pi}{6}$
    $\because$ Horizontal component of the earth's magnetic field, $B_H = Bcos\delta$
    where, B = total magnetic field of the earth
    $\frac{B_H}{B} = \cos\delta$
    $\frac{B_H}{B} = \cos\frac{\pi}{6}$
    $\frac{B_H}{B} = \frac{\sqrt{3}}{2}$
    $\therefore \quad B_H : B = \sqrt{3} : 2$

26. Radius of ground state of hydrogen atom $= 0.53A^\circ = 0.53 \times 10^{-10}m.$
    According to de Broglie relation 2πr = nλ
    For ground-state n=1

$2 \times 3.14 \times 0.53 \times 10^{-10} = 1 \times \lambda$
therefore, $\lambda = 3.32 \times 10^{-10} m$
$\Rightarrow \lambda = 3.32 A^{\circ}$

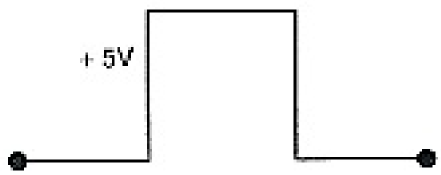
OR

Distance of closest approach
$d_0 = \frac{2kZe^2}{K.E} = \frac{4kZe^2}{mv^2}$
kinetic energy $\propto$ Z (atomic number)
$\Rightarrow \quad \frac{K_{\text{proton}}}{K_{\alpha}} = \frac{Z_{\text{proton}}}{Z_{\alpha}} = \frac{1}{2} \Rightarrow K_{\text{proton}} : K_{\alpha} = 1:2$

27. As opposed to n-type semiconductors, p-type semiconductors have a larger hole concentration than electron concentration. The term p-type refers to the positive charge of the hole. In p-type semiconductors, **holes are the majority carriers and electrons are the minority carriers**. P-type semiconductors are created by doping an intrinsic semiconductor with acceptor impurities (or doping an n-type semiconductor). A common p-type dopant for silicon is boron. For p-type semiconductors, the Fermi level is below the intrinsic Fermi level and lies closer to the valence band than the conduction band.

OR

When the input voltage is +5V, the diode gets forward biased, the output across R is +5V, as shown in figure. When the input voltage is -5V , the diode gets reverse biased. No output is obtained across R.



Section C

28. Meter bridge is based on the principle of Wheatstone bridge and it is used to find the resistance of an unknown conductor or to compare two unknown resistance.
A meter bridge consists of a wire of length 1m i.e. 100cm.
At balance condition:
$\frac{R}{S} = \frac{l}{100-l}$, where ' l ' is distance from one end to the null point.

i) Applying the condition of balanced Wheatstone bridge,

In a meter bridge, the null point is found at a distance of 40 cm from A.

l = 40cm

$\frac{R}{S} = \frac{l}{100-l} = \frac{40}{100-40} = \frac{40}{60} = \frac{2}{3}$

$\frac{R}{S} = \frac{2}{3}$ ...(i)

The equivalent resistance of resistors when connected in parallel combination is given by

$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots\ldots \frac{1}{R_n}$

The equivalent resistance of 12Ω and $S\Omega$ in parallel combination is

$\frac{1}{R_{eq}} = \frac{1}{12} + \frac{1}{S}$

$R_{eq} = \frac{12S}{12+S}\Omega$

In a meter bridge, A resistance of 12Ω is connected in parallel with S, then null point occurs at 50.0 cm from A.

l=50cm

Again, applying the condition

$\frac{R}{(12S/12+S)} = \frac{50}{50} = 1$

$\Rightarrow \quad R = \frac{12S}{12+S}$ ...(ii)

From Eqs. (i) and (ii), we get

$\frac{2}{3}S = \frac{12S}{12+S}$

$12 + S = 18 \Rightarrow S = 6\Omega$

$R = \frac{2}{3}S = \frac{2}{3} \times 6 = 4\Omega$

$R = 4\Omega$

29. The expression of Lorentz Magnetic Force is,

$F_m = q(\ v \times\ B)$ where F_m, v and B are vectors. Let θ is the angle between v and B.

Thus, F_m = qvB sinθ Thus, Resultant Lorentz magnetic force always acts in the direction perpendicular to both velocity and magnetic field.

As F_m is perpendicular to v,

$\Rightarrow$ Force is perpendicular to displacement, d made by charged particle. So, work done W is, W = F_m . d = F_m d cos ϕ

where ϕ is the angle F and motion of charge Thus, W = F_m d cos90^o = 0 [$\because$ Force F and displacement d are perpendicular to each other]

$\Rightarrow \quad W = 0$

Hence proved, no work is done by Lorentz magnetic force on the charged particle.

30. Given, i = 10 sin 314 t A

v = 50 sin (314 t + $\frac{\pi}{2}$) V

$\therefore$ i_0 = 10, V_0 = 50 and $\phi = \frac{\pi}{2}$

Power dissipation in the circuit is given by

$P = E_v I_v \cos\phi$

$E_v = \frac{E_0}{\sqrt{2}} V_0 = \frac{V_0}{\sqrt{2}}$

$P = \left(\frac{50}{\sqrt{2}}\right)\left(\frac{10}{\sqrt{2}}\right)\cos\frac{\pi}{2}$

= 0 $\left[\because \cos\frac{\pi}{2} = 0\right]$

31. a. Here, a = 6.0 cm

C = 100 pF = $100 \times 10^{-12} F$

$\omega = 300\ rads^{-1}$

E_{rms} = 230V

$I_{rms} = \frac{E_{rms}}{X_C} = \frac{E_{rms}}{\frac{1}{\omega C}} = E_{rms} \times \omega C$

$\therefore I_{rms} = 230 \times 300 \times 100 \times 10^{-12}$

$= 6.9 \times 10^{-6} A = 6.9 \mu A$

b. Since,I = I_D whether I is steady d.c. or a.c. This is shown below:

$I_D = \varepsilon_0 \frac{d(\phi_E)}{dt} = \varepsilon_0 \frac{d}{dt}(EA) (\because \phi_E = EA)$

Or $I_D = \varepsilon_0 A \frac{dE}{dt}$

$= \varepsilon_0 A \frac{d}{dt}\left(\frac{Q}{\varepsilon_0 A}\right)\left(\because E = \frac{\sigma}{\varepsilon_0} = \frac{Q}{\varepsilon_0 A}\right)$

$I_D = \varepsilon_0 A \times \frac{1}{\varepsilon_0 A}\frac{dQ}{dt} = \frac{dQ}{dt} = I$

We know that

$B = \frac{\mu_0}{2\pi}\frac{r}{R^2} I_D$

This formula goes through even if I_D (and therefore B) oscillates in time. The formula shows that they oscillate in phase. Since I_D = I , we have

$B = \frac{\mu_0 r I}{2\pi R^2}$

If I = I_0 , the maximum value of current, then amplitude of B = maximum value of B

$= \frac{\mu_0 r I_0}{2\pi R^2} = \frac{\mu_0 r \sqrt{2}\ I_{rms}}{2\pi R^2} \left(\because I_0 = \sqrt{2}\ I_{rms}\right)$

$= \frac{4\pi\times10^{-7}\times0.03\times\sqrt{2}\times6.9\times10^{-6}}{2\times3.14\times(0.06)^2}T$

$= 1.63 \times 10^{-11}T$

32. Here, $\lambda_1 = 650\ nm = 650 \times 10^{-9}m$

$\lambda_2 = 520\ nm = 520 \times 10^{-9}m$

Suppose, d = distance between two slits

D = Distance of screen from the slits

a. For third bright fringe, n = 3

$x = n\ \lambda_1 \cdot \frac{D}{d}$

$= 3 \times 650 \times 10^{-7} \times \frac{120}{0.2} = 0.117cm = 1.17\ mm$

b. Let n fringes of wavelength 650 nm coincide with (n + 1) fringes of wavelength 520 nm.

c. $x = n\ \lambda_1 \frac{D}{d} = (n+1)\ \lambda_2 \frac{D}{d} \times \lambda_2$

or, $x = n \times 650 = (n+1) \times 520$

or, $\frac{n+1}{n} = \frac{650}{520} = \frac{5}{4}$

or $1 + \frac{1}{n} = \frac{5}{4} \Rightarrow \frac{1}{n} = \frac{5}{4} - 1 = \frac{1}{4}$

or n = 4

Hence $x = n \cdot \lambda_1 \frac{D}{d}$

$= 4 \times 650 \times 10^{-7} \times \frac{120}{0.2}$

= 1.56 mm

OR

$\omega = 2 \times 10^{-3}m, \lambda = 6000\overset{\text{o}}{\text{A}} = 6 \times 10^{-7}m$

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

$\Rightarrow = \frac{D}{d} = \frac{\omega}{\lambda} = \frac{2\times10^{-3}}{6\times10^{-7}} = \frac{1}{3} \times 10^4$

When the apparatus is immersed in liquid

Wavelength, $\lambda' = \frac{\lambda}{\mu} = \frac{6\times10^{-7}}{1.33}m$

Fringe width, $\omega' = \frac{D}{d}\lambda'$

$\Rightarrow \omega' = \frac{1}{3} \times 10^4 \times \frac{6\times10^{-7}}{1.33}m$

$= 1.5 \times 10^{-3}m$ = 1.5 mm

33. The Rydberg formula is $E = E_0 Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$

$$\frac{hc}{\lambda} = E_0 Z^2 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right]$$

E_0 = -13.6 eV = $-13.6 \times 1.6 \times 10^{-19} J = -21.76 \times 10^{-19} J$

$$\frac{hc}{\lambda_{n_1 2}} = 21.76 \times 10^{-19} \left[\frac{1}{2^2} - \frac{1}{n_1^2}\right]$$

$$\therefore \lambda_{n_1 2} = \frac{hc}{21.76 \times 10^{-19} \times \left(\frac{1}{4} - \frac{1}{n_1^2}\right)}$$

$$\lambda_{n_1 2} = \frac{6.63 \times 10^{-34} \times 3 \times 10^8 \times 4n_1^2}{21.76 \times 10^{-19} \times (n_1^2 - 4)}$$

$$\lambda_{n_1 2} = \frac{3.653 n_1^2}{(n_1^2 - 4)} \times 10^{-7} m = \frac{3653 n_1^2}{(n_1^2 - 4)} \overset{o}{A}$$

The wavelengths of the first four lines in the Balmer series correspond to transitions from n_1 = 3, 4, 5, 6, to n_2 = 2.

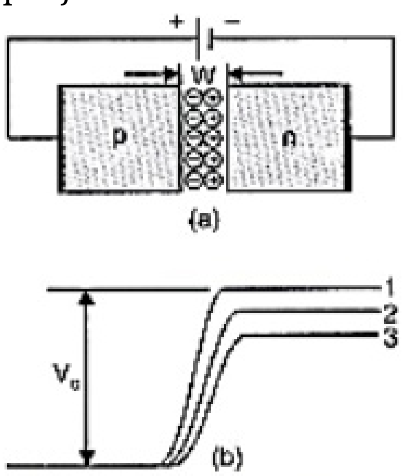
Substituting n_1 = 3, 4, 5, and 6, we get

$\lambda_{32} = 6575 \overset{o}{A}, \lambda_{42} = 4870 \overset{o}{A}$

$\lambda_{52} = 4348 \overset{o}{A}$ and $\lambda_{62} = 4109 \overset{o}{A}$

34. 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 V_B - 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.



   a. p-n junction diode under forward bias.
   b. Barrier potential

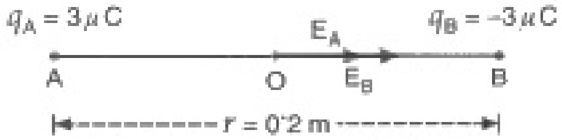
1. without battery
2. Low voltage battery, and
3. High voltage battery.

Section D

35. Here, $q_A = 3\mu C = 3 \times 10^{-6}$ C ;

$q_B = -3\mu C = -3 \times 10^{-6}$ C and r = 20 cm = 0·2 m

Let O be the mid-point of the line AB as shown in Fig.



Then, OA = OB = $\frac{r}{2} = \frac{0{\cdot}2}{2}$ = 0·1 m

a. The electric field at point O due to q_A

$$E_A = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_A}{(OA)^2} = 9 \times 10^9 \times \frac{3\times10^{-6}}{(0{\cdot}1)^2}$$

= $2{\cdot}7 \times 10^6$ NC^{-1} (along OB)

The electric field at point O due to q_B,

$$E_B = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q_A}{(OB)^2} = 9 \times 10^9 \times \frac{3\times10^{-6}}{(0{\cdot}1)^2}$$

= $2{\cdot}7 \times 10^6$ NC^{-1} (along OB)

Therefore, net electric field at point O due to the charges q_A and q_B,

$E = E_A + E_B = 2{\cdot}7 \times 10^6 + 2{\cdot}7 \times 10^6$

= $5{\cdot}4 \times 10^6$ N C^{-1} (along OB)

b. Force on a negative charge of magnitude $1{\cdot}5 \times 10^{-9}$ C placed at point O,

$F = qE = 1{\cdot}5 \times 10^{-9} \times 5{\cdot}4 \times 10^6$

= $8{\cdot}1 \times 10^{-3}$ N (along OA)

The force on the negative charge acts in a direction opposite to that of the electric field.

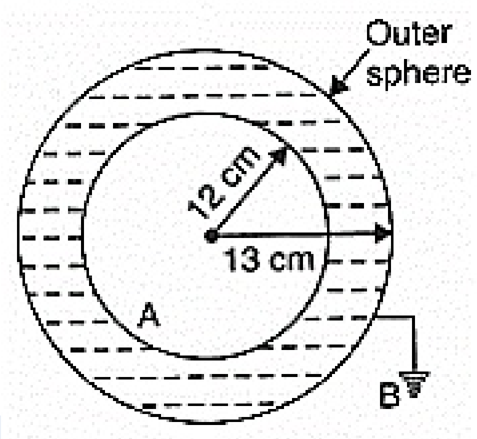
OR

Given,

$r_1 = 12cm = 12 \times 10^{-2}m$

$r_2 = 13cm = 13 \times 10^{-2}m$
$q = 2.5\mu C = 2.5 \times 10^{-6}C$
k = 32

a. From formula,



$C = kC_0$
$C = k.4\pi\varepsilon_0 \frac{r_1 r_2}{r_2 - r_1}$
$= \frac{32\times13\times10^{-2}\times12\times10^{-2}}{9\times10^9(13\times10^{-2}-12\times10^{-2})}\left[\therefore 4\pi\varepsilon_0 = \frac{1}{9\times10^9}\right]$
$= \frac{32\times13\times12}{9} \times 10^{-11} = \frac{1644}{3} \times 10^{-11}$
$= 5.54 \times 10^{-9}F$

b. Potential of inner sphere,
$V = \frac{q}{C} = \frac{2.5\times10^{-6}}{5.54\times10^{-9}} = 4.5 \times 10^2 V$

c. Capacitance of sphere
$= 4\pi\varepsilon_0$
$= \frac{12\times10^{-2}}{9\times10^9} = 1.33 \times 10^{-11}F$
Total potential in case of concentric spheres is distributed over two spheres and the potential difference between the two spheres becomes smaller that is why the capacitance of an isolated sphere is much small than that of concentric spheres. Since the capacitance is inversely proportional to the potential difference $\left(C = \frac{Q}{V}\right)$.

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,

ϕ = 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

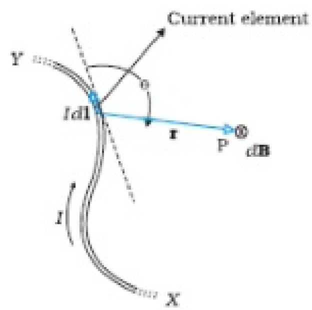
iii. Since the frame of the window is a closed circuit and arm CD acts as a source of e.m.f., a current will flow in the frame.

OR

i. Biot Savart law is the law that is used to determine the magnetic field at a point due to a current element.

Let finite conductor XY carrying current I as shown in Figure. Let dl be the infinitesimal element of the conductor. The magnetic field, dB due to a current element, dl at a point P which is at a distance r, is given by

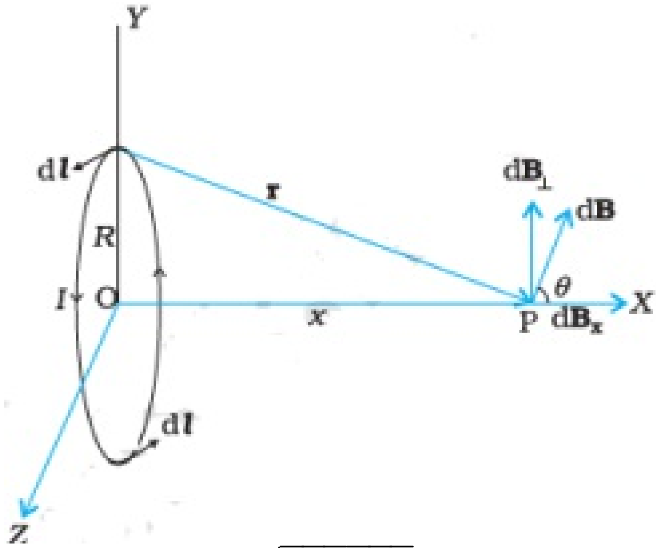
$\overrightarrow{dB}$ = $\frac{\mu_o}{4\pi} I \frac{\overrightarrow{dl}\times\vec{r}}{r^3}$



The magnitude of this field is,

$\left|d\overrightarrow{B}\right| = \frac{\mu_o}{4\pi}\frac{Idl\ \sin\theta}{r^2}$

Now, to calculate the magnetic field on the axis of a circular current loop of radius R, consider the figure below:



Now here, $r = \sqrt{R^2 + x^2}$. Also $|dl \times r| = r\ dl$

So, the magnitude of dB due to dl is,

$\left|d\overrightarrow{B}\right| = \frac{\mu_o}{4\pi}\frac{Idl}{x^2+R^2}$

Now dB has two components. The perpendicular component gets cancelled and only x-component survives. So,

$dB_x = dB\cos\theta$

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

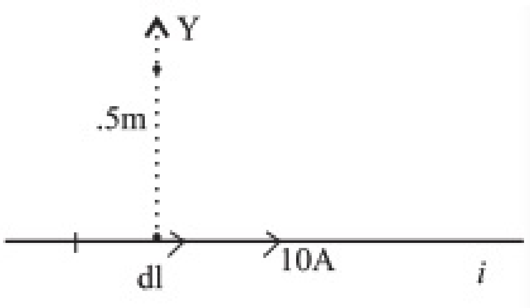
Thus, $dB_x = \frac{\mu_o Idl}{4\pi}\frac{R}{(x^2+R^2)^{3/2}}$

Therefore, field due to the whole circular loop is,

$|\vec{B}| = \int dB_x = \frac{\mu_o I}{4\pi}\frac{R}{(x^2+R^2)^{3/2}}\int dl = \frac{\mu_o I}{4\pi}\frac{R}{(x^2+R^2)^{3/2}} \times 2\pi R = \frac{\mu_o I R^2}{2(x^2+R^2)^{3/2}}$

At the centre of loop, x = 0, thus

$|\vec{B}| = \frac{\mu_0 I}{2R}$

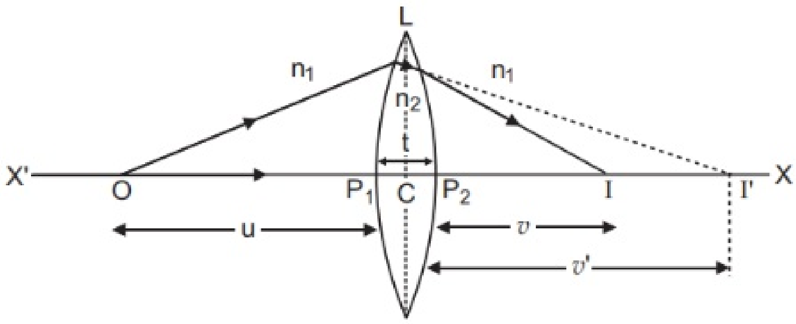
ii. 

$|\overrightarrow{dB}| = \frac{\mu_o}{4\pi}\frac{Idl\sin\theta}{r^2}$

$= \frac{4\pi\times10^{-7}}{4\pi} \times \frac{10\times\left(1\times10^{-2}\right)\times\sin 90^\circ}{(0.5)^2} = 4\times10^{-8}$ T

And the field is directed perpendicular to the plane and directed into it.

37. i. Consider the figure. Suppose L is a thin lens. The thickness of lens is t, which is very small. O is a point object on the principal axis of the lens. The distance of O from pole P_1 is u. The first refracting surface forms the image of O at I' at a distance v' from P_1. From the refraction formula at spherical surface:



$\frac{n_2}{v'}$ - $\frac{n_1}{u}$ = $\frac{n_2 - n_1}{R_1}$ ....(i)

The image I' acts as a virtual object for second surface and after refraction at second surface, the final image is formed at I. The distance of I from pole P_2 of second surface is v. The distance of virtual object (I') from pole P_2 is (v' - t).

For refraction at second surface, the ray is going from second medium (refractive index n_2) to first medium (refractive index n_1), therefore from refraction formula at spherical surface

$\frac{n_1}{v}$ - $\frac{n_2}{(v' - t)}$ = $\frac{n_1 - n_2}{R_2}$ .....(ii)

For a thin lens, t is negligible as compared to v', therefore from (ii),

$\frac{n_1}{v} - \frac{n_2}{(v')} = -\frac{n_2 - n_1}{R_2}$ .....(iii)

Adding equations (i) and (iii), we get

$\frac{n_1}{v} - \frac{n_1}{u} = (n_2 - n_1)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$

or $\frac{1}{v} - \frac{1}{u} = \left(\frac{n_2}{n_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$ .....(iv)

If the object O is at infinity, the image will be formed at second focus i.e. if u = ∞, v = f_2 = f

Therefore from equation (iv)

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

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

This is the formula of refraction for a thin lens. This formula is called Lens-

Maker's Formula.

ii. **Power of a Lens:** The power of a lens is its ability to deviate the rays towards its principal axis. It is defined as the reciprocal of focal length in metres.

Power of a lens, P = $\frac{1}{f(\text{ in metres })}$ diopters $= \frac{100}{f(\text{ in cm})}$ diopters

The SI unit for power of a lens is dioptre (D).

Power of convex lens, P_1 = $\frac{1}{F_1} D = \frac{1}{0 \cdot 50} = 2$ D

Power of concave lens, P_2 = $\frac{1}{F_2}$ D $= \frac{1}{-0 \cdot 20} = -5$ D

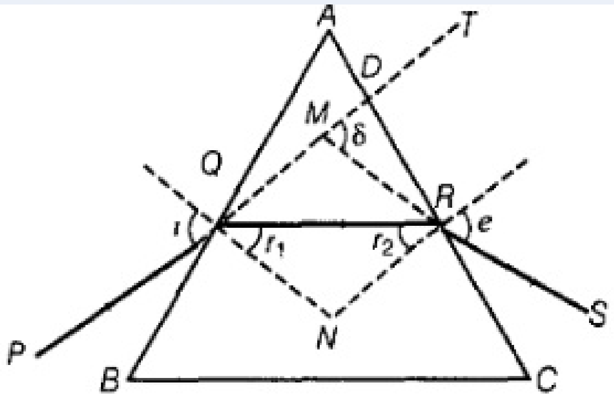
∴ Power of combination of lenses in contact

P = P_1 + P_2 = 2 - 5 = -3 D

OR

a. Let PQ and RS are incident and emergent rays. Let incident ray get deviated by δ by the prism. i.e. $\angle TMS = \delta$

Let δ_1 and δ_2 are deviation produced at refractions taking place at AB and AC, respectively.



∴ $\delta = \delta_1 + \delta_2 = (i - r_1) + (e - r_2)$

= (i + e) - (r_1 + r_2)

But in $\triangle$FNR,

$\angle QNR + \angle RQN + \angle QRN = 180^{\circ}$

or $\angle QNR = 180^{\circ} - (r_1 + r_2)$

In $\square$QARNF, $\angle$AQN and $\angle$ARN are right angle.

So, $\angle QNR = 180^{\circ} - A$

where, A is angle of prism.

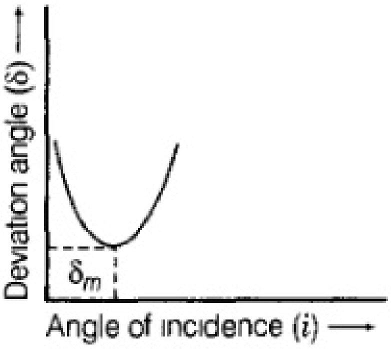
From Eqs. (i) and (iii), we have

A = r_1 + r_2

From Eqs. (i) and (iv), we have

$\delta=(i+e)-A$

b. $i-\delta$ graph is shown in the figure



The conditions for the angle of minimum deviation are given as below:

i. Angle of incidence (i) and angle of emergence (e) are equal, i.e. $\angle i=\angle e$

ii. In equilateral prism, the refracted ray is parallel to base of prism.

iii. The incident and emergent rays are bent on same angle from refracting surfaces of the prism, i.e. $\angle r_1=\angle r_2$

For minimum deviation position,

Putting r = r_1 = r_2

and i = e in Eq. (iv)

$2r=A \Rightarrow r=\frac{A}{2}$ ...(vi)

From Eq. (i), $\delta_m=2i-A$

$i=\frac{A+\delta_m}{2}$ ...(vii)

$\therefore$ Refractive index of material of prism is

$\mu=\frac{\sin i}{\sin r}$

From Eqs. (vi) and (vii), we get

$$\Rightarrow \quad \mu=\frac{\sin\left(\frac{A+\delta m}{2}\right)}{\sin \frac{A}{2}}$$