CBSE Class 12 Physics

Sample Paper - 01 (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. Electric potential energy of two point charges q and q_0 is

a. $\frac{1}{4\pi\epsilon_0}\frac{qq_0}{r}$

b. $\frac{1}{4\pi\epsilon_0}\frac{qq_0}{r^2}$

c. $\frac{1}{4\pi\epsilon_0}\frac{q}{r}$

d. $\frac{1}{4\pi\epsilon_0}\frac{qq_0}{r^3}$

3. In a meter bridge, when galvanometer & cell positions are interchanged

   a. Can't predict the relation

   b. Inverse relation between four resistance is got

   c. Exactly same relation between four resistance is got

   d. No relation is got between four resistances

4. An electric bulb rated for 500 watts at 100 volts is used in a circuit having 200 volt supply. The resistance R that must be put in series with the bulb so that the bulb draws 500 watts is ________

   a. 20 Ω

   b. 10 ohms

   c. 100 ohms

5. A voltmeter has range V. What resistance should be connected in series with it to increase its range to nV. Initial resistance is R_0

   a. $\frac{R_0}{n}$

   b. $(n - 1)R_0$

   c. nR_0

   d. $(n + 1)R_0$

6. Two sources of light are coherent if they have

a. different frequency and with a constant phase relationship

b. same frequency and change phase randomly

c. different frequency and random phases

d. same frequency and with a constant phase relationship

7. Wavefront is

a. series of points on the wave with same amplitude

b. locus of all adjacent points at which the Electric field is the same

c. locus of all adjacent points at which the phase of vibration of a physical quantity associated with the wave is the same

d. series of points on the wave with same frequency

8. Light rays from a point object

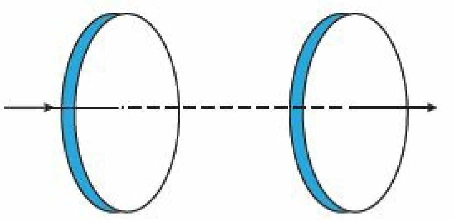
a. radiate in all directions

b. radiate only at the front

c. radiate only to the side

d. radiate in some lines

9. Figure shows a capacitor made of two circular plates each of radius 12 cm, and separated by 5.0 cm. The capacitor is being charged by an external source (not shown in the figure). The charging current is constant and equal to 0.15 A. Capacitance and the rate of charge of potential difference between the plates are



a. 74.1 $\mathrm{pF}, 1.87 \times 10^{9}\,\mathrm{Vs}^{-1}$

b. $67.1 \text{ pF}, 1.87 \times 10^9 \text{ Vs}^{-1}$

c. $80.1 \text{ pF}, 1.87 \times 10^9 \text{ Vs}^{-1}$

d. $70.1 \text{ pF}, 1.87 \times 10^9 \text{ Vs}^{-1}$

10. A photoelectric cell converts

a. light energy into electric energy

b. electric into light energy

c. light energy into heat energy

d. light energy into sound energy

11. Fill in the blanks:

The line of zero dip is called ________ line or magnetic equator.

12. Fill in the blanks:

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

13. Fill in the blanks:

The unit of self-inductance of a coil is ________.

OR

Fill in the blanks:

Lenz's law gives us the ________ of induced emf.

14. Fill in the blanks:

________ are the atoms of different elements which have the same atomic weight but different atomic numbers.

15. Fill in the blanks:

A ________ is an instrument used for comparing the luminous intensities of two sources of light.

16. Why is it found experimentally difficult to detect neutrinos in nuclear β-decay?

17. A nucleus $^{238}_{92}U$ undergoes through α-decay and transforms to thorium. What is

    i. the mass number
    ii. atomic number of the daughter nucleus produced?

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. In the photoelectric effect, why should the photoelectric current increase as the intensity of the monochromatic radiation incident on a photosensitive surface is increased? Explain.

20. What happens to the width of depletion layer of a p-n junction when it is

    i. forward biased?
    ii. reverse biased?

OR

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

Section B

21. Write an expression for the resistivity of a metallic conductor showing its variation over a limited range of temperatures.

22. A parallel plate capacitor has a capacity of $6\mu F$ in air and $60\mu F$ when dielectric medium is introduced. What is dielectric constant of medium?

23. Light of wavelength 488 nm is produced by an argon laser which is used in the photoelectric effect. When light from this spectral line is incident on the emitter, the stopping (cutoff) potential of photoelectrons is 0.38 V. Find the work function of the material from which the emitter is made.

24. i. Identify the part of the electromagnetic spectrum which is
    a. suitable for radar system used in aircraft navigation,
    b. produced by bombarding a metal target by high-speed electrons.
    ii. Why does galvanometer show a momentary deflection at time of charging and discharging a capacitor? Write the necessary expression to explain this observation.

25. A closely wound solenoid of 800 turns and area of cross section $2.5 \times 10^{-4} m^2$ carries a current of 3.0 A.

26. The energy of the electron in the ground state 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?

OR

An electron jumps from fourth to first orbit in an atom. How many maximum number of spectral lines can be emitted by the atom? To which series these lines correspond?

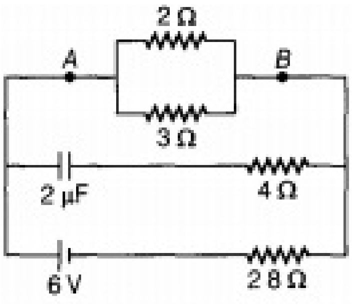
27. Using the concept of electron and hole current, write an expression for the conductivity of a semiconductor.

OR

Name two factors on which electrical conductivity of a pure semiconductor at a given temperature depends.

Section C

28. Calculate the steady current through the 2Ω resistor in the circuit shown in the figure.



29. Two moving coil meters, M_1 and M_2 have the following particulars: R_1 = 10Ω; N_1 = 30, A1 = 3.6$\times$ $10^{-3}m^2$, B_1 = 0.25T R_2 = 14Ω, N_2 = 42, A2 = 1.8 $\times$ $10^{-3}m^2$, B_2 = 0.50T
(The spring constants k are identical for the two meters).
Determine the ratio of (a) current sensitivity and (b) voltage sensitivity of M_2 and M_1.

30. An LCR series circuit with 100Ω resistance is connected to an a.c. source of 200 V and angular frequency 300 radians per second. When only the capacitance is removed, the current lags behind the voltage by 60°. When only the inductance is removed, the current leads the voltage by 60°. Calculate the current and power dissipated in LCR circuit.

31. Name the electromagnetic waves used for the following and arrange them in increasing order of their penetrating power.
    a. Water purification
    b. Rewrite sensing
    c. Treatment of cancer

32. Two coherent light sources of intensity ratio 25 : 4 are employed in an interference experiment what is the ratio of the intensities of the maxima and minima in the interference pattern?

OR

    i. Describe briefly, with the help of suitable diagram, how the transverse nature of light can be demonstrated by the phenomenon of polarisation?
    ii. When unpolarised light passes from air to a transparent medium, under what condition does the reflected light get polarised?

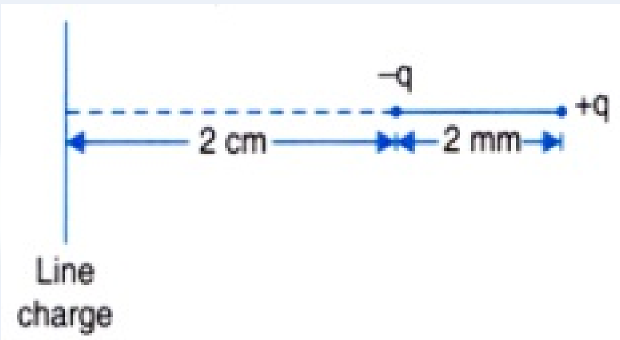
33. The ground state energy of hydrogen atom is - 13.6 eV. If an electron makes a

transition from an energy level - 0.85 eV to - 1.51 eV, calculate the wavelength of the spectral line emitted. To which series of hydrogen spectrum does this wavelength belong?

34. i. Why are Si and GaAs preferred materials for solar cells?
ii. Describe briefly with the help of a necessary circuit diagram, the working principle of a solar cell.

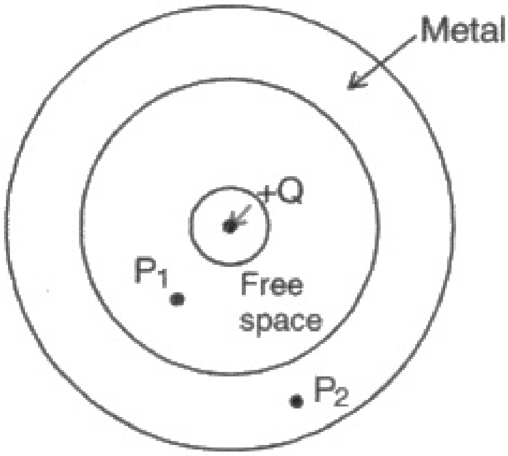
Section D

35. a. State Gauss's law in electrostatics. Use this law to derive an expression for the electric field due to an infinitely long straight wire of linear charge density $\lambda\ cm^{-1}$.
b. An electric dipole consists of charges of $2.0 \times 10^{-8} C$ separated by a distance of 2 mm. It is placed near a long line charge of density $4.0 \times 10^{-4} cm^{-1}$ as shown in the figure below, such that the negative charge is at a distance of 2 cm from the line charge. Calculate the force acting on dipole.



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. A 25.0 pF capacitor, a 0.10 H inductor and a 25.0 ohm resistor are connected in series with an ac source whose emf is E = 310 sin 314t.

i. What is the frequency of the emf?
ii. Calculate
   a. the reactance of the circuit
   b. the impedance of the circuit and
   c. the current in the circuit.

OR

For a circular coil of radius R and N turns carrying current I, the magnitude of the magnetic field at a point on its axis at a distance x from its centre is given by,

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

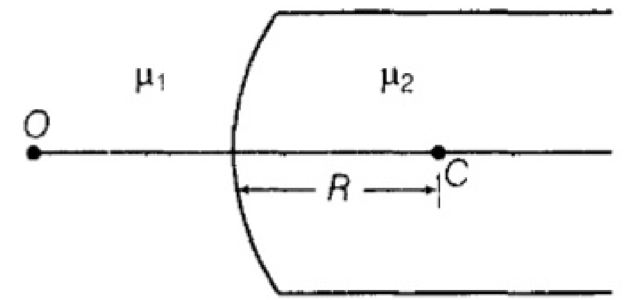
i. Show that this reduces to the familiar result for field at the centre of the coil.
ii. Consider two parallel co-axial circular coils of equal radius R, and number of turns N, carrying equal currents in the same direction, and separated by a distance R. Show that the field on the axis around the mid point between the coils is uniform over a distance that is small as compared to R, and is given by $B=0.72\frac{\mu_0 NI}{R}$ approximately

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

Figure shows a convex spherical surface with centre of curvature C separating the two media of refractive indices μ_1 and μ_2. Draw a ray diagram showing the formation of the image of a point object O lying on the principal axis. Derive the relationship between the object and image distance in terms of refractive indices of the media and the radius of curvature R of the surface.



Answer

Section A

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

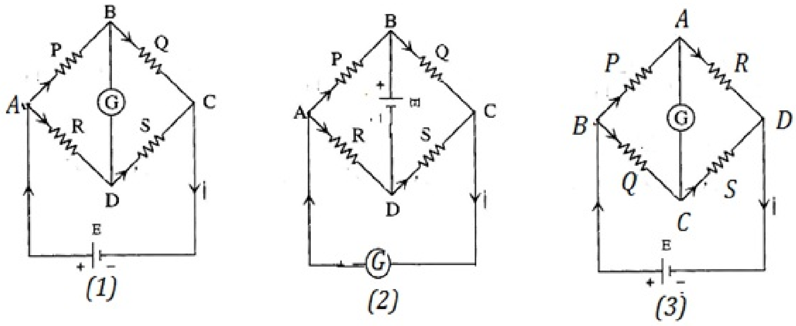
   Explanation: If A and B having charge $6.5 \times 10^{-7}C$ each and a third sphere C having charge = 0
   If C is in contact with A than new charge on A and C
   $q_A = q_C = \frac{6.5\times10^{-7}+0}{2} = 3.25 \times 10^{-7}C$
   Now C is put in contact with B so new charge on C and B
   $q_s = q_c = \frac{q_B+q_C}{2}$
   $= \frac{6.5\times10^{-7}+3.25\times10^{-7}}{2}$
   $= 4.8755 \times 10^{-7}C$
   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
   $F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1||q_2|}{r^2}$
   $= \frac{9\times10^9\times\left(3.25\times10^{-7}\times4.875\times10^{-7}\right)}{\left(50\times10^{-2}\right)^2}$
   $= 5.7 \times 10^{-3}N$

2. (a) $\frac{1}{4\pi\epsilon_0}\frac{qq_0}{r}$

   Explanation: Potential energy of a system of charges is the work done in assembling the charges from infinity to their respective positions. Force between two charges q and q0 placed at a distance r apart is $F = \frac{q_0q}{4\pi\varepsilon_0r^2}$ Potential energy of the charges is given by

3. (c) Exactly same relation between four resistance is got
   Explanation:

   The battery in the circuit(1) shown is connected between A and C, while the galvanometer is connected between B and D. In the bridge balanced condition, $\frac{P}{R}=\frac{Q}{S}$



When the battery and the galvanometer are interchanged, the circuit takes the form (2). The circuit (2) can be re drawn as circuit (3). The ratio of the resistances in the bridge balanced condition is $\frac{P}{Q}=\frac{R}{S}$ which is same as, $\frac{P}{R}=\frac{Q}{S}$

4. (a) 20 Ω

Explanation: Rating of electric bulb is 500 Watts and 100 Volts. Since power is given by,

$P=V\times I$
$\Rightarrow$ Current drawn by bulb $I_b=\frac{P}{V}$
$\Rightarrow I_b=\frac{500}{100}$
I_b = 5A

Also, $P=\frac{V^2}{R}$
$\Rightarrow R_b=\frac{100\times 100}{500}$
$\Rightarrow R_b=20\Omega$
Let R be the value of resistance to be connected in series to bulb. In series current through each component must be same. And current drawn by bulb to draw 500 watts is 5 Amperes.
Current through circuit must be I = 5A.
$\Rightarrow I=\frac{V}{R}$
$\Rightarrow 5=\frac{200}{(20+R)}$
$\Rightarrow 20+R=\frac{200}{5}$
$\Rightarrow$ R = 40 - 20
$\Rightarrow R=20\Omega$

5. (b) (n - 1)R_0

Explanation: For a range V, the current flowing is I, and V = IR_0 If a resistance R is connected in series, the range of the voltmeter increases to nV.

$$nV = I(R_0 + R) = \frac{V}{R_0}(R_0 + R)$$

$nR_0 = R_0 + R$

$R = (n - 1)R_0$

6. (d) same frequency and with a constant phase relationship

   Explanation: If the two sources are coherent, then the phase difference ϕ at any point will not change with time.
7. (c) locus of all adjacent points at which the phase of vibration of a physical quantity associated with the wave is the same

   Explanation: A locus of points, which oscillate in phase is called a wavefront; thus a wavefront is defined as a surface of constant phase. The speed with which the wavefront moves outwards from the source is called the speed of the wave.
8. (a) radiate in all directions

   Explanation: light waves emerging from point source radiates in all the directions.
9. (c) 80.1 $\mathrm{pF}, 1.87 \times 10^9 \mathrm{Vs}^{-1}$

   Explanation:

   Capacitance, $C = \frac{\epsilon_o A}{d} = \frac{\epsilon_o \pi r^2}{d} \approx 80.1 pF$

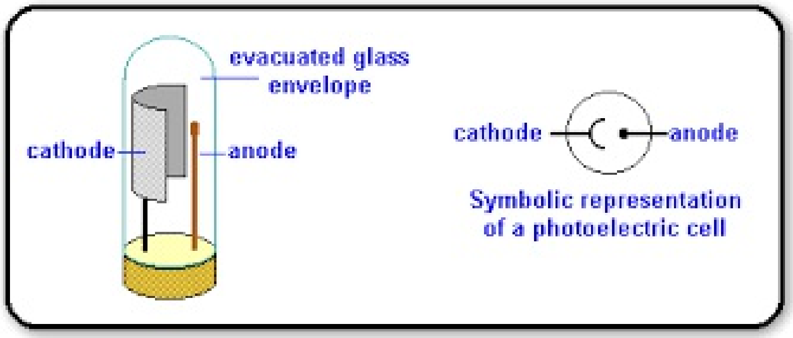
   q = CV

   Differentiating both the sides, $\frac{dq}{dt} = \frac{C\,dV}{dt}$

   or $I = \frac{C\,dV}{dt}$

   $\frac{dV}{dt} = \frac{I}{C} = \frac{0.15}{(80.01 \times 10^{-12})}$

   $= 1.87 \times 10^9 V/s.$
10. (a) light energy into electric energy

Explanation: 

A photo cell is a device which converts light energy into electric energy.

11. Aclinic
12. Maximum
13. volt s A^{-1}

OR

Direction

14. Isobars
15. Photometer
16. A neutrino is a subatomic particle that is very similar to an electron but has no electrical charge and a very small mass. Because they have very little interaction with matter. However, they are incredibly difficult to detect.
17. When any nucleus goes through α-decay, the mass number of parent nucleus decreases by 4 units and atomic number decreases by 2 units.

$$\therefore \quad {}^{238}U_{92} \xrightarrow{\alpha - decay} {}^{234}Th_{90} + {}_2He^4$$

i. Mass number of the nucleus produced = 238 - 4 = 234
ii. Atomic number of nucleus produced = 92 - 2 = 90

So daughter nucleus can be expressed as ${}_{90}Th^{234}$.

18. In a p-type extrinsic semiconductor, the ratio of number of electrons to the number of

holes is less than one.

19. When the intensity of radiation incident on the surface increases the number of photons per unit area unit time increases. Hence, the photo electrons ejected will be large, which in turn, will contribute to the increase in photoelectric current.

20. i. During forward bias, carriers come close to junction and width of depletion layer decreases.
    ii. During reverse bias, the carriers get away from the junction and width of depletion layer increases.

OR

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.

Section B

21. The resistivity of a metallic conductor is given by
$\rho_T = \rho_0 [1 + \alpha (T - T_0)]$
Where P_T be the resistivity at temperature T and ρ_0 be the resistivity at temperature T_0 and α be the temperature coefficient.

22. $K = \frac{C_m}{C_0} = \frac{60}{6} = 10$

23. Given,
Wavelength $\lambda = 488nm = 448 \times 10^{-9}m$
Stopping potential, V_0 = 0.38 V
As, $eV_0 = hv - \phi_0$
$\Rightarrow eV_0 = h\frac{c}{\lambda} - \phi_0$
$\Rightarrow \phi_0 = \frac{hc}{\lambda} - eV_0$
$= \left(\frac{6.63 \times 10^{-34} \times 3 \times 10^8}{488 \times 10^{-9} \times 1.6 \times 10^{-19}} - \frac{1.6 \times 10^{-19} \times 0.38}{1.6 \times 10^{-19}}\right)$
= (2.55 - 0.38)eV
= 2.17 eV.

24. i. a. Microwaves are suitable for radar system used in aircraft navigation because of its shorter wavelength and frequency range from 1 GHz to 300 GHz.
b. X-rays are produced by bombarding a metal target by high-speed electrons inside a Coolidge tube or X-ray tube by applying huge potential difference between the anode(metal target) and the cathode(electron gun).

ii. During charging and discharging of a capacitor, a conduction current is produced due to the flow of charges from battery to the plates and vice-versa via connecting wires. Due to this, galvanometer shows a momentary deflection. Now, when the capacitor is fully charged, the conduction current stops flowing. Also during charging and discharging, there is zero conduction current between the plates. But it was found that an electric field exist in between the plates, therefore indicating existence of magnetic field which leads to inconsistency in the Ampere's circuital law. To account this problem, the concept of displacement current was introduced by Maxwell. He changed the Ampere's circuital law, $(\oint \mathbf{B}, dl = \mu_0 I)$, to a modified form which is given as $\oint \mathbf{B} dl = \mu_0 (I + I_D)$, where, I_D is the displacement current produced due to change of electrostatic flux with time in between the two plates of the capacitor and is expressed as I_D = $\epsilon_0 \frac{d\phi_E}{dt}$.

25. Given, N = 800, $A = 2.5 \times 10^{-4} m^2$
I = 3.0 A
Magnetic dipole moment, M = NIA
Putting values, $M = 800 \times 3.0 \times 2.5 \times 10^{-4}$
= 0.6 JT^{-1}

26. According to the question,
The energy of the electron in the ground state of hydrogen atom is -13.6 eV.

i. The negative sign imply that electrons are bound to the nucleus by means of electrostatic force of attraction.
ii. Energy of electron in nth orbit of hydrogen atom is given by, $E_n = -\frac{13.6}{n^2} \text{eV}$
For first excited state, n = 2
$E_2 = -\frac{13.6}{2^2} \text{eV} = -\frac{13.6}{4} = -3.4 \text{eV}$

Energy is required = 3.4 eV- (-13.6 eV) = 10.2 eV

OR

The maximum number of spectral lines obtained when electron on fourth orbital jumps to ground state can be found as:

$n_2 - n_1 = 4 - 1 = 3$

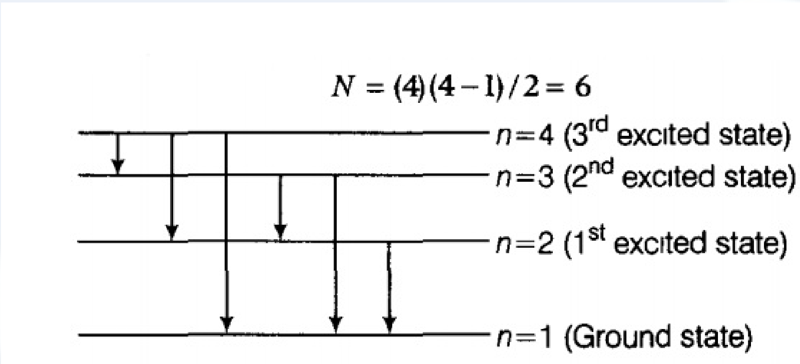
The electron can make a transition from

4→3, 4→2, 4→1 = 3

3→2, 3→1 = 2

2→1 = 1

Total Number of spectral lines = 3 + 2 + 1 = 6 lines.



These line corresponds to Paschen series.

27. In a Semi-Conductor of length (ℓ) and area of Cross-Section. Let ne and nh be the no. of electrons and holes with drift velocities Ve and Vh respectively. So, the total current in the semi-conductor will be the sum of current due to electrons as well as holes, i.e. I = $I_e + I_h$ .....(i)$I = I_e + I_h \quad ....(i)$

As we know that I = n_eAV_d $I = n_eAV_d$

$I_e = n_eeAV_e$ And $I_h = n_heAV_h$ $I_e = n_eeAV_e \; And \; I_h = n_heAV_h$

I = $n_eeAV_e + n_heAV_h$ $I = n_eeAV_e + n_heAV_h$

I = $eA[n_eV_e + n_hv_h]$ $I = eA[n_eV_e + n_hv_h]$

$\frac{I}{A} = e[n_eV_e + n_hV_h]$ ......(ii)

As we know that E = $\frac{V}{l}$ (in magnitude)

Also, $R = \rho\frac{l}{A}\rho = \frac{RA}{l}$ or

Where ρ is resistivity and R is resistance

or $\frac{E}{\rho} = \frac{\frac{V}{l}}{\rho}$

or $\frac{E}{\rho} = \frac{V}{l} \times \frac{l}{RA}$

or $\frac{E}{\rho} = \frac{I}{A}$ ...(iii)

Put (3) in (2) we get,

$\frac{E}{\rho} = e[n_e V_e + n_h V_h]$

$\Rightarrow \frac{1}{\rho} = \frac{e}{E}[n_e V_e + n_h V_h]$

$\Rightarrow \sigma = e[n_e \frac{V_e}{E} + n_h \frac{v_h}{E}]$

Here, mobility (m) = $\frac{Drift\ velocity}{Electric\ field}$

$\sigma = e[n_e m_e + n_h m_h]$

This is the derivation and expression for the conductivity of a semiconductor.

OR

Electrical conductivity of a pure semiconductor depends upon:

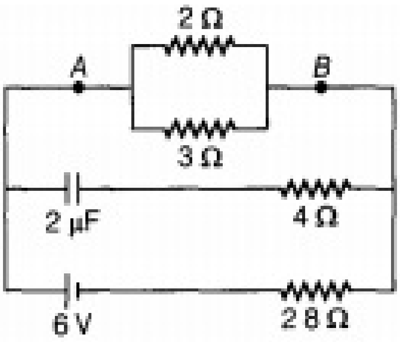
(i) The width of the forbidden band

(ii) Intrinsic charge carrier concentration.

Section C

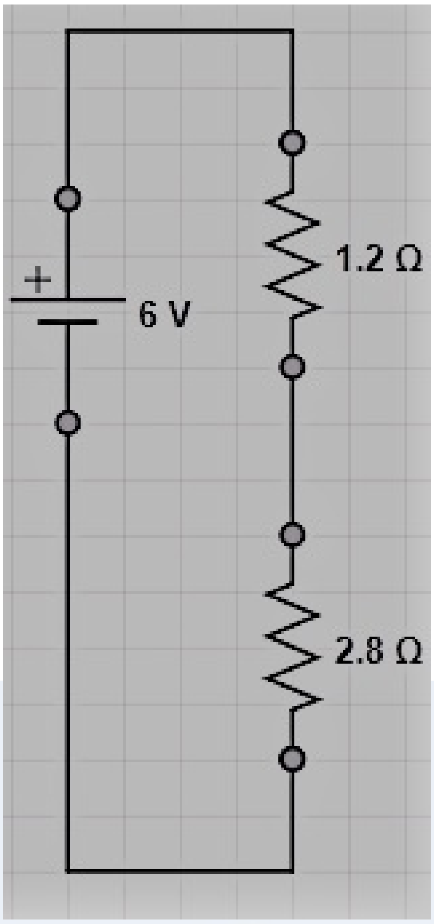
28. In DC circuit, initially capacitor is in steady state i.e. it offers infinite resistance. Therefore, no current flows through capacitor and 4Ω resistance, so resistance will produce no effect.

$\therefore$ In circuit AB the Effective resistance between 2Ω *and* 3Ω which are connected in parallel combination is given by



$R_{AB} = \frac{2\times3}{2+3}$

$= 1.2\Omega \left[\because \frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} \Rightarrow R = \frac{R_1 R_2}{R_1+R_2}\right]$



Total resistance of the circuit = 1.2+ 2.8 = 4Ω [∵ these two are connected in series combination]

Net current drawn from the cell,

Given ,

Voltage =6v

total resistance(R)$= 4\Omega$

$$I = \frac{V}{R(\text{ total resistance })} = \frac{6}{4} = \frac{3}{2} = 1.5\text{A}$$

∴ Potential difference between A and B

$$V_{AB} = IR_{AB} = 1.5 \times 1.2 \Rightarrow V_{AB} = 1.80\text{V}$$

Current through 2Ω resistance,

we know that V=I'R

$$I' = \frac{V_{AB}}{2}\Omega = \frac{1.8}{2} = 0.9\text{A}$$

29. a. Current sensitivity of first meter

$$I_s = \frac{\theta}{I} = \frac{BAN}{k}$$

$$A = \frac{\theta}{I} = \frac{B_1A_1N_1}{k} = \frac{0.25\times3.6\times10^{-3}\times30}{k}$$

$$= \frac{27\times10^{-3}}{k} \text{ ...(i)}$$

Current sensitivity of second meter

$B = \frac{\theta}{I} = \frac{B_2 A_2 N_2}{k} = \frac{0.50 \times 1.8 \times 10^{-3} \times 42}{k}$

$= \frac{37.8 \times 10^{-3}}{k}$ ...(ii)

Ratio of current sensitivity $\left(\frac{B}{A}\right) = \frac{37.8 \times 10^{-3}}{k}$ / $\frac{27 \times 10^{-3}}{k}$ = 1.4

b. Voltage sensitivity of first meter

$= \frac{\theta}{V} = \frac{\theta}{I \cdot R} = \frac{27 \times 10^{-3}}{k \times 10} = \frac{2.7 \times 10^{-3}}{k}$

Voltage sensitivity of second meter

$= \frac{\theta}{R \cdot I} = \frac{37.8 \times 10^{-3}}{k \times 10} = \frac{2.7 \times 10^{-3}}{k}$

Hence, the ratio of voltage sensitivity = 1.

30. $\tan 60^\circ = \frac{\omega L}{R}$

or $\tan 60^\circ = \frac{\frac{I}{\omega C}}{R}$

$\because \omega L = \frac{1}{\omega C}$

Impedance of circuit,

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

Current in the circuit,

$I_0 = \frac{V_0}{Z} = \frac{V_0}{R} = \frac{200}{100}$

= 2 amp.

Average power, $P = \frac{1}{2} V_0 I_0 \cos \phi$

But $\tan \phi = \frac{\omega L - \left(\frac{I}{\omega C}\right)}{R} = 0 \ (\cos \phi = 1)$

Now, $P = \frac{1}{2} \times 200 \times 2 \times 1 = 200\ watt$ = 200 watt

31. Following are the electromagnetic waves used for;

a. Water purification - Ultra violet waves
b. Rewrite sensing - Micro waves
c. Treatment of cancer - Gamma rays

In increasing order of penetration of given waves can be written as, (b) remote sensing < (a) water purification < (c) treatment of cancer.

32. Let I_1 and I_2 be the intensities of the two coherent beams and A_1 and A_2 their

respective amplitudes.
Now,
Intensity ratio, $\frac{I_1}{I_2} = \frac{25}{4}$ therefore $\frac{A_1}{A_2} = \sqrt{\frac{I_1}{I_2}}$
Amplitude ratio $\frac{A_1}{A_2} = \sqrt{\frac{25}{4}} = \frac{5}{2}$
i.e. A_1 = 5 units

and A_2 = 2 units

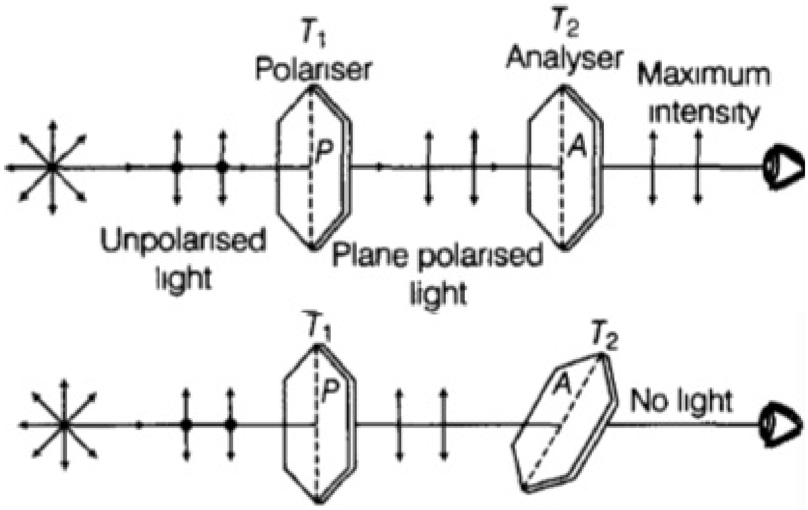
At maxima : $A_{max} = A_1 + A_2$ = 7 units

At minima : $A_{min} = A_1 - A_2$ = 3 units

Hence, $\frac{I_{\max}}{I_{\min}} = \frac{A_{\max}^2}{A_{\min}^2}$
$\Rightarrow \frac{I_{\max}}{I_{\min}} = \frac{(7)^2}{(3)^2}$
$\Rightarrow I_{\max} : I_{\min} = 49 : 9$

OR

i. When an unpolarised light incident on a tourmaline crystal T_1 (polariser), then intensity of transmitted light passing through T_1, cut to its half. Let, another crystal, T_2 be placed in the path of transmitted light by T_1 and one full rotation is given to it. Gradually change in intensity of the transmitted light is observed with the rotation of the second crystal. The intensity of the transmitted light is maximum when the axes of the two crystals, T_1 and T_2 are parallel to each other and minimum when their axes are perpendicular to each other.
Since, the intensity of polarised light on passing through a tourmaline crystal changes with the relative orientation of its crystallographic axis with that of polariser, which implies that light wave must be of transverse in nature. Because a transverse wave containing electric and magnetic filed components vibrating perpendicular to each other and also perpendicular to the direction of propagation of the wave, can only be polarised.



ii. It happens when angle of incidence is equal to the polarising angle falling on a transparent surface, then reflected light is completely polarised. In this situation, refractive index of the refracting surface is given by $\mu = \tan i_p$. This is also called Brewster's law, which states that the tangent of the polarising angle for a transparent medium is equal to the refractive index of the medium. Also, the reflected and refracted light wave are mutually perpendicular to each other.

33. According to Bohr's theory of hydrogen energy of photon released, $E_2 - E_1 = hv$

Given, $E_1 = -1.51$ eV

$E_2 = -0.85$

$E_2 - E_1 = -0.85 - (-1.51) = 1.51 - 0.85 = 0.66$ eV

So, the wavelength of emitted spectral line,

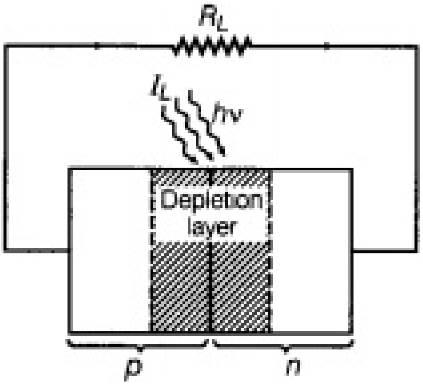
$$\lambda = \frac{1242\text{eV}-\text{nm}}{\text{E(ineV)}} = \frac{1242\text{eV}-\text{nm}}{0.66\text{eV}} = 1.88 \times 10^{-6}\text{m}$$

The wavelength belongs to Paschen series of hydrogen spectrum

34. i. The energy for the maximum intensity of the solar radiation is nearly 1 5 eV. In order to have photo excitation , the energy of radiation ($h\nu$) must be greater than energy band gap (E_g), i.e. $h\nu > E_g$ Therefore , the semiconductor with energy band gap about 1.5 eV or lower and with higher absorption coefficient, is likely to give better solar conversion efficiency.

The energy band gap for Si is about 1.1 eV, while for GaAs, it is about 1.43 eV. The gas GaAs is better inspite of its higher band gap than Si because it absorbs relatively more energy from the incident solar radiations being of relatively higher absorption coefficient

ii. When light of frequency, v such that hν > E_S (band gap) is incident on junction, then electron-hole pair liberated in the depletion region drifts under the influence of potential barrier. The gathering of these charge carriers make p-type as positive electrode and n-type as negative electrode and hence, generating photo-voltage across solar cell

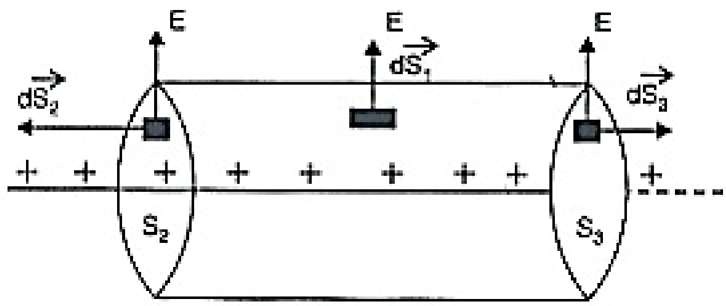


Section D

35. a. Gauss's law in electrostatics: It states that total electric flux over the closed surface S in vacuum is $\frac{1}{\varepsilon_0}$ times the total charge (q) contained in side S.

$$\therefore \phi_E = \oint_S \overrightarrow{E} \cdot \overrightarrow{dS} = \frac{q}{\varepsilon_0}$$

Let an infinitely long line charge having linear charge density λ. Assume a cylindrical Gaussian surface of radius r and length l coaxial with the line charge to determine its electric field at distance r.



Total flux through the cylindrical surface,

$$\oint \overrightarrow{E} \cdot \overrightarrow{ds} = \oint_{S_1} \overrightarrow{E} \cdot \overrightarrow{dS_1} + \oint_{S_2} \overrightarrow{E} \cdot \overrightarrow{dS_2} + \oint_{S_3} \overrightarrow{E} \cdot \overrightarrow{dS_3}$$

$$= \oint_{S_1} E\, dS_1 \cdot \cos 0^\circ + \oint_{S_2} E\, dS_2 \cdot \cos 90^\circ + \oint_{S_3} E\, dS_3 \cdot \cos 90^\circ$$

$$= E \oint dS_1 = E \times 2\pi r l$$

Since λ is the charge per unit length and l is the length of the wire,

Thus, the charge enclosed

$q=\lambda l$

According to Gaussian law,

$$\oint_S \overrightarrow{E} \cdot \overrightarrow{dS} = \frac{q}{\varepsilon_0}$$

or, $E \times 2\pi rl = \frac{\lambda l}{\varepsilon_0}$

$\therefore E = \frac{\lambda}{2\pi\varepsilon_0 r}$

b. Electric field intensity at a distance r from line charge of density λ is

$E = \frac{\lambda}{2\pi\varepsilon_0 r}$

$\therefore$ Field intensity on negative charge (r = 0.02 m)

$$E_1 = \frac{4\times10^{-4}\times9\times10^9\times2}{0.02} = 3.6\times10^8 N/C$$

Force on negative charge

$$F_1 = qE_1 = 2\times10^{-8}\left(3.6\times10^8\right) = 7.2N$$

It is directed towards the line charge.

Similarly field intensity at positive charge (r = 0.022 m)

$$E_2 = \frac{4\times10^{-4}\times9\times10^9\times2}{0.022} = 3.27\times10^8 N/C$$

Force on positive charge

$$F_2 = qE_2 = 2\times10^{-8}(3.27\times10^8) = 6.54N$$

It is directed away from the line charge.

$\therefore$ Net force on the dipole,

$F = F_1 - F_2 = (7.2 - 6.54)N = 0.66$ N

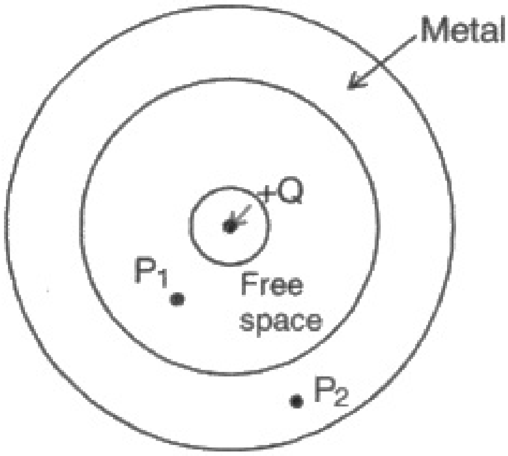
F is towards the line charge.

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

$$\oint \overrightarrow{\mathrm{E}} \cdot d\overrightarrow{\mathrm{A}} = \frac{Q}{\varepsilon_0}$$

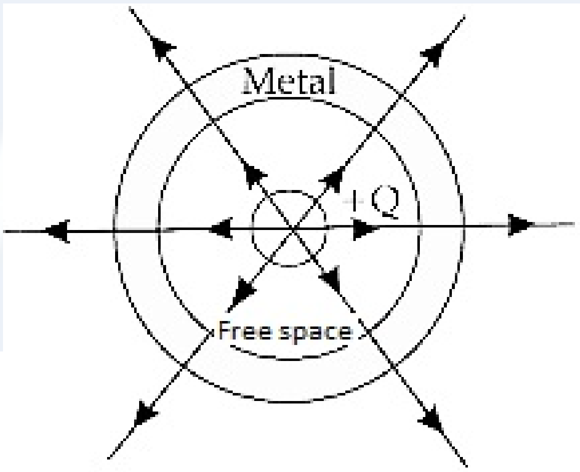


Since E and dA are in the same direction, therefore, we have,

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. Given, C = 25 pF = 25 $\times$ 10^{-6} F, L = 0.10 H, R = 25.0 ohm, E_0 = 310 V

i. E = 310 sin 314t

Comparing with the equation E = E_0 sin ωt

ω = 314

$2\pi f$ = 314

Frequency, f = $\frac{314}{2\pi}$ = 50 Hz

ii. a) X_L= $2\pi fL$ = 2 $\times$ 3.14 $\times$ 50 $\times$ 0.10 =2 $\times$ 3.14 $\times$ 5 = 31.4 ohm

X_C = $\frac{1}{2\pi fC}$

$= \frac{1}{2\times3.14\times50\times25\times10^{-6}}$ = 127.4 ohm

Thus the reactance of the circuit is,

$X_C - X_L$ = 127.4 - 31.4 = 96 ohm

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

Z = $\sqrt{(25)^2 + (96)^2}$ = 99.2 ohm

c) Current, I = $\frac{E_{rms}}{Z}$

Now, E_{rms} = $\frac{E_o}{\sqrt{2}}$

Thus, I = $\frac{310}{\sqrt{2}\times99.2}$ = 2.21 A

OR

a. Given, that $B = \frac{\mu_0 IR^2 N}{2(x^2+R^2)^{3/2}}$ (Axial line)

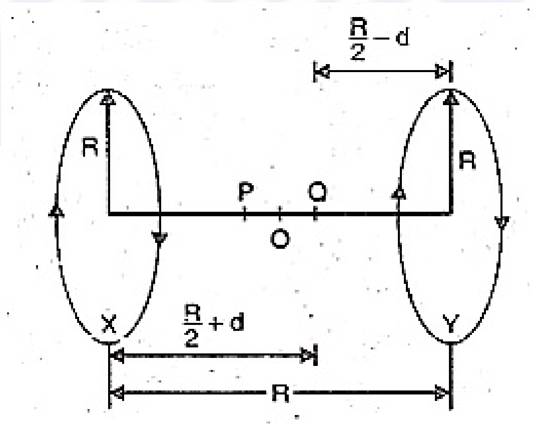
Putting x = 0 (centre of coil)

$B = \frac{\mu_0 IR^2 N}{2R^3}$

or $B = \frac{\mu_0 IN}{2R}$

which is same as the standard result

b. In figure O is a point which is midway between the two coils X and Y.



Let B_X be the magnetic field at Q due to coil X

Then $B_x = \frac{\mu_0 NIR^2}{2\left[\left(\frac{R}{2}+d\right)^2+R^2\right]^{3/2}}$

If B_y is the magnetic field at Q due to coil Y, then

$By = \frac{\mu_0 NIR^2}{2\left[\left(\frac{R}{2}-d\right)^2+R^2\right]^{3/2}}$

The currents in both the coils X and Y are flowing in the same direction. So, the resultant field is given by

$B = B_x + B_y$

$$B=\frac{\mu_0 NIR^2}{2\left[\left(\frac{R}{2}+d\right)^2+R^2\right]}+\frac{\mu_0 NIR^2}{2\left[\left(\frac{R}{2}-d\right)^2+R^2\right]^{3/2}}$$

$$B=\frac{\mu_0 NIR^2}{2}\left[\frac{1}{\left[\left(\frac{R}{2}+d\right)^2+R^2\right]^{3/2}}+\frac{1}{\left[\left(\frac{R}{2}-d\right)^2+R^2\right]^{3/2}}\right]$$

$$B=\frac{\mu_0 NIR^2}{2}\left[\frac{1}{\left[\frac{R^2}{4}+d^2+Rd+R^2\right]^{3/2}}+\frac{1}{\left[\frac{R^2}{4}+d^2-Rd+R^2\right]^{3/2}}\right]$$

$$B=\frac{\mu_0 NIR^2}{2}\left[\frac{1}{\left[\frac{5R^2}{4}+Rd\right]^{3/2}}+\frac{1}{\left[\frac{5R^2}{4}-Rd\right]^{3/2}}\right]\because d^2<<R^2$$

$$B=\frac{\mu_0 NIR^2}{2\left(\frac{5}{2}R^2\right)^{3/2}}\left[\frac{1}{\left[1+\frac{4}{5}\frac{d}{R}\right]^{3/2}}+\frac{1}{\left[1-\frac{4}{5}\frac{d}{R}\right]^{3/2}}\right]$$

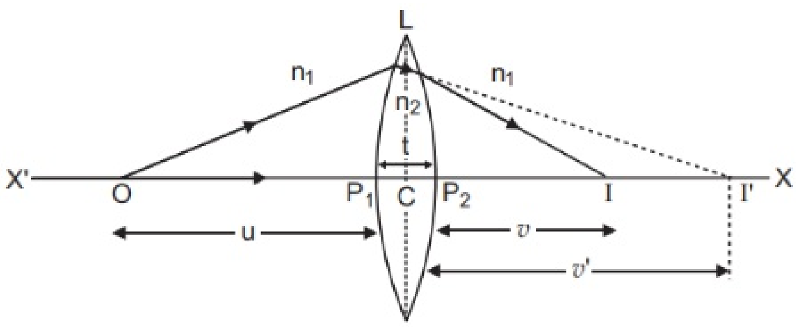
$$=\frac{\mu_0 NIR^2}{2\left(\frac{5}{4}\right)^{3/2}R^3}\left[\left[1-\frac{3}{2}\times\frac{4}{5}\times\frac{d}{R}\right]+\left[1+\frac{3}{2}\cdot\frac{4}{5}\cdot\frac{d}{R}\right]\right]$$

$$=\frac{\mu_0 NI\cdot 2}{2\left(\frac{5}{4}\right)^{3/2}R}$$

$$=\frac{\mu_0 NI}{R}\left(\frac{5}{4}\right)^{3/2}$$

$=0.72\frac{\mu_0 NI}{R}$ (approx)

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

$\therefore$ Power of combination of lenses in contact

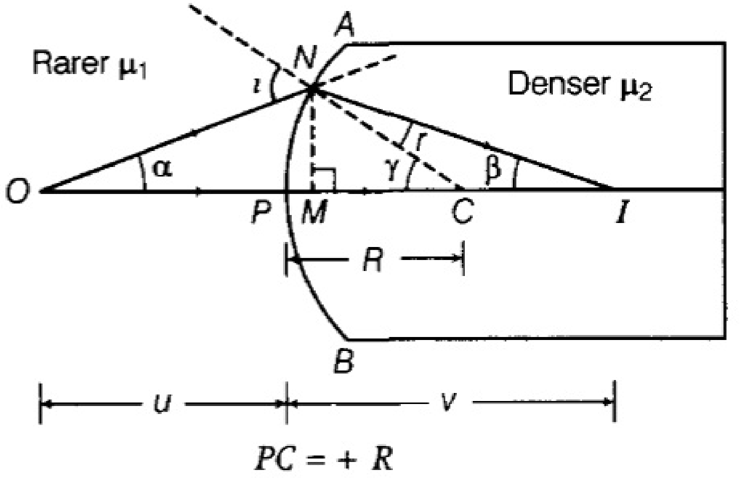
P = $P_1 + P_2$ = 2 - 5 = -3 D

OR

The ray diagram is shown in the figure:

Let, NM = h

The convex spherical refracting surface forms the image of object O at I. The radius of curvature is R



Here $PI = +v\ and\ PO = -u$

In $\triangle NCO \quad i = \gamma + \alpha$ ...(i)

In $\triangle NCI, \quad \gamma = r + \beta$

$\Rightarrow \quad r = \gamma - \beta$ ...(ii)

For small angles α, β and γ and assuming M is very close to P, we have

$\alpha = \tan\alpha = \frac{MN}{MO} = \frac{MN}{PO} = \frac{+h}{-u}$

$\beta = \tan\beta = \frac{MN}{MI} = \frac{MN}{PI} = \frac{h}{v}$

$\gamma \approx \tan\gamma = \frac{MN}{MC} = \frac{MN}{PC} = \frac{h}{+R}$

By Snell's law, $\frac{\mu_2}{\mu_1} = \mu = \frac{\sin i}{\sin r}$

For small i and r,

$\frac{\mu_2}{\mu_1} = \frac{i}{r}$ or $r\mu_2 = i\mu_1$

$\mu_2(\gamma - \beta) = (\alpha + \gamma)\mu_1$ [From Eqs. (i) and (ii)]

$(\mu_2 - \mu_1)\gamma = \mu_1 a + \mu_2\beta$

$(\mu_2 - \mu_1)\left(\frac{h}{R}\right) = \mu_1\left(\frac{h}{-u}\right) + \mu_2\left(\frac{h}{v}\right)$

$\Rightarrow \quad \frac{\mu_2}{v} - \frac{\mu_1}{u} = \frac{\mu_2 - \mu_1}{R}$