PHYSICS

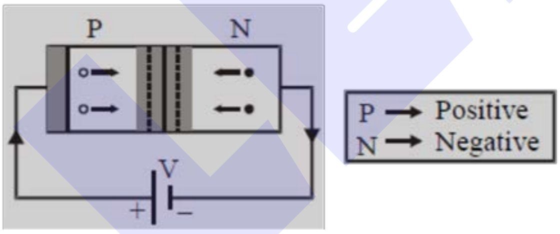
SOLUTION

SECTION – A

Q. No.	1	2	3	4	5	6	7	8	9	10
Ans.	B	B	C	C	D	D	D	A	A	C
Q. No.	**11**	**12**	**13**	**14**	**15**	**16**				
Ans.	C	A	B	A	C	A				

SECTION – B

17. In forward bias direction of applied voltage (V) is opposite to the barrier potential V_0. As a result, the depletion layer width decreases and barrier height is reduced. Due to the applied voltage, electrons from N-side cross the depletion layer and reach P-side. Similarly holes from P-side cross the junction and reach the N side. This motion of charge carriers on either side gives rise to current. The total diode forward current is sum of hole diffusion current and conventional current due to electron diffusion. The magnitude of P–N junction diode is usually in mA. **[2]**



18. Total energy of electron $E_e = mc^2$ and $\lambda = \dfrac{h}{mv} \Rightarrow m = \dfrac{h}{\lambda v}$

$\therefore \quad E_e = \dfrac{hc^2}{\lambda v}$

For energy of photon $E_P = \dfrac{hc}{\lambda}$ therefore $\dfrac{E_e}{E_P} = \dfrac{hc^2}{\lambda v} \times \dfrac{\lambda}{hc} = \dfrac{c}{v}$

$\because \quad c > v \quad$ So $\; E_e > E_p$ **[2]**

19. Here, ${}^a\mu_g = 1.33$, ${}^a\mu_w = 1.53$, $A = 60°$, ${}^w\mu_g = \dfrac{{}^a\mu_g}{{}^a\mu_w} = \dfrac{1.53}{1.33} = 1.15 \because {}^w\mu_g = \dfrac{\sin\dfrac{A+\delta_m}{2}}{\sin\dfrac{A}{2}}$

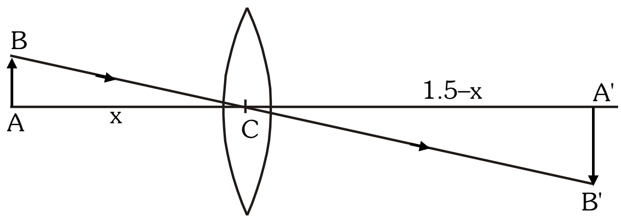
$\therefore \quad \dfrac{\sin(A+\delta_m)}{2} = {}^w\mu_g \times \sin\dfrac{A}{2} = 1.15\sin\dfrac{60°}{2} = 0.575 \Rightarrow \dfrac{A+\delta_m}{2} = \sin^{-1}(0.575) = 35.1°$

$\therefore \quad \delta_m = 35.1 \times 2 - 60 = 10.2°$ **[2]**

20. $\because \quad R_\theta = R_0(1 + \alpha\theta) \therefore 117 = 100(1 + \alpha\theta)$

$$\Rightarrow \quad \theta = \frac{117-100}{100\,\alpha} = \frac{17}{100\times1.7\times10^{-4}} = 1000°C$$ **[2]**

21. $m = \frac{h_2}{h_1} = -4$



Let the lens be placed at a distance x from the object.

Then $u = -x$, and $v = (1.5 - x)$

using $m = \frac{v}{u}$, we get $-4 = \frac{1.5-x}{-x} \Rightarrow x = 0.3$ m

The lens is placed at a distance of 0.3 m from the object (or 1.20 m from the screen)

For focal length, we may use

$$m = \frac{f}{f+u} \quad \text{or} \quad -4 = \frac{f}{f+(-0.3)} \Rightarrow f = \frac{1.2}{5} = 0.24 \text{ m}$$ **[2]**

OR

Here, $f_0 = 144$ cm; $f_e = 6.0$ cm, MP = ?, L = ?

$MP = \frac{-f_0}{f_e} = \frac{-144}{6.0} = -24$ and $L = f_0 + f_e = 144 + 6.0 = 150.0$ cm.

SECTION – C

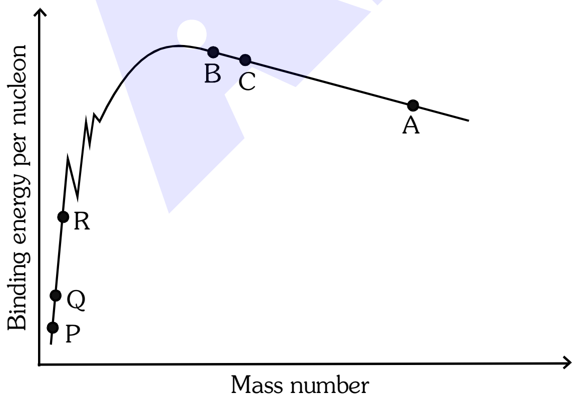
22. Number of atom in 1 gm of $U^{235} = \frac{N_A}{235}$

Energy released $= \frac{N_A}{235} \times 200 \text{ MeV} = \frac{6.023\times10^{23}}{235} \times 200 \text{ MeV} = 5\times10^{23}$ MeV

$= (5\times10^{23})(1.6\times10^{-13} \text{ J}) = 8\times10^{10}$ J

$= \frac{8\times10^{10}}{3.6\times10^{6}}$ kWH $= 2.22\times10^{4}$ kWH **[3]**

OR

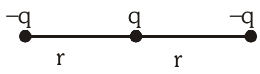


In fission : nucleus A breaks into B & C

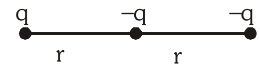
In fussion : P & Q fuse to result in nucleus R

In both cases the net B.E. increases resulting in energy release.

23. $U_1 = \frac{-kq^2}{r} + \frac{-kq^2}{r} + \frac{kq^2}{2r} = \frac{-3kq^2}{2r}$



$U_2 = \frac{-kq^2}{r} + \frac{kq^2}{r} - \frac{kq^2}{2r} = \frac{-kq^2}{2r}$ so $\frac{U_1}{U_2} = 3$



[3]

24. Wavelength in Hydrogen spectrum

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

For maximum wavelength in Balmer series

$n_1 = 2$, $n_2 = 3$

$$\frac{1}{\lambda_{max}} = R\left[\frac{1}{2^2} - \frac{1}{3^2}\right]$$

$$\lambda_{max} = \frac{36}{5R} \qquad ...(1)$$

For minimum wavelength

$n_1 = 2$, $n_2 = \infty$

$$\frac{1}{\lambda_{min}} = R\left[\frac{1}{2^2} - \frac{1}{\infty^2}\right]; \ \lambda_{min} = \frac{4}{R} \qquad ...(2)$$

Eq. $(1) \div (2)$

$$\boxed{\frac{\lambda_{max}}{\lambda_{min}} = \frac{9}{5}}$$

[3]

25. Terminal voltage of first cell

$V_1 = E_1 - Ir_1$ ...(1)

Terminal voltage of second cell

$V_2 = E_2 - Ir_2$ ...(2)

Potential difference on the ends of external resistance 'R'

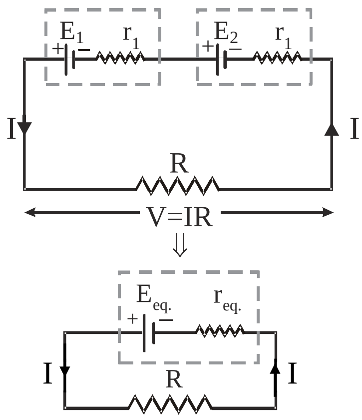
$V = V_1 + V_2$

$IR = (E_1 - Ir_1) + (E_2 - Ir_2)$

$IR = E_1 + E_2 - I(r_1 + r_2)$

$I[R + (r_1 + r_2)] = E_1 + E_2$

$$I = \frac{E_1 + E_2}{R + (r_1 + r_2)} \qquad ...(3)$$



Equivalent circuit

From equivalent circuit $I = \frac{E_{eq.}}{R + r_{eq}}$ ...(4)

Compare equation (3) and (4)

$\boxed{E_{eq} = E_1 + E_2}$ and $\boxed{r_{eq} = r_1 + r_2}$

If the cell terminal has to be reversed then $\boxed{E_{eq} = E_1 - E_2}$ where $E_1 > E_2$ and $\boxed{r_{eq} = r_1 + r_2}$ **[3]**

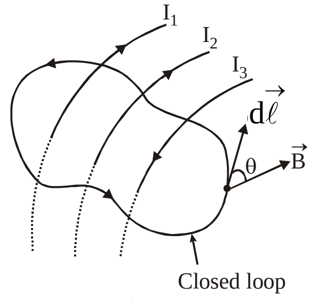
26. Ampere's Circuital law :

According to it, the line integral of magnetic field along a closed path is equal to μ_0 times the total current threading through it. i.e.

$$\oint \vec{B}.d\vec{\ell} = \mu_0 \Sigma I$$

$$\oint B d\ell \cos\theta = \mu_0 \Sigma I$$

$$\oint B d\ell \cos\theta = \mu_0 \left(I_1 + I_2 - I_3\right)$$



[1]

Magnetic field inside a long straight wire with circular cross-section :

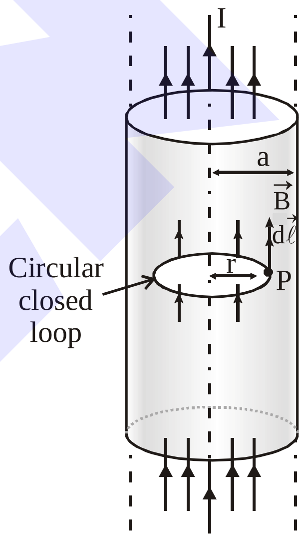
Let current I is uniformly distributed in whole cross section area of wire. Radius of wire is 'a'. Now we consider a circular loop of radius r passing through point P and applying Ampere's circuital law –

$$\oint \vec{B}.d\vec{\ell} = \mu_0 \Sigma I$$

$$\oint B d\ell \cos\theta = \mu_0 \frac{I}{a^2} r^2$$

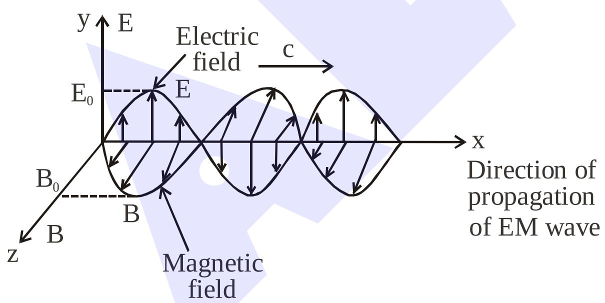
$$B \times 2\pi r = \frac{\mu_0 I}{a^2} \times r^2 \quad \left\{ \begin{array}{l} \theta = 0^o \\ B \Rightarrow \text{constant} \\ \Sigma I = \dfrac{Ir^2}{a^2} \end{array} \right.$$

$$\boxed{B_{in} = \left(\frac{\mu_0 I}{2\pi a^2}\right) r} \Rightarrow \boxed{B_{in} \propto r}$$



[2]

27.



[1]

Properties of electromagnetic waves :

(i) These waves are generated by accelerated charge. [1]

(ii) These waves have energy and momentum. These waves apply pressure, when incident on surface.

Amplitude of electric field : $E_0 = B_0 c$

$$E_0 = 50 \times 10^{-8} \times 3 \times 10^8$$

$$E_0 = 150 \text{ V/m}$$

[1]

28. Laws of Electromagnetic Induction :

(i) First law : Whenever there is a change in the magnetic flux linked with a given coil, an emf get induced in coil. The induced emf lasts as long as the magnetic flux linked with the coil changes.

(ii) Second law : Rate of change of magnetic flux linked with a coil is directly proportional to the induced emf in it.

If ϕ_1 is the initial flux at t_1

If ϕ_2 is the final flux at t_2

$$\therefore \qquad \frac{\phi_2 - \phi_1}{t_2 - t_1} \propto \varepsilon$$

$$\frac{\Delta\phi}{\Delta t} = K\varepsilon$$

K = proprotionality constant

For all practical purpose, K = 1

$$\frac{\Delta\phi}{\Delta t} = \varepsilon$$

For small time,

$$\lim_{\Delta t \to 0} \frac{\Delta\phi}{\Delta t} = \varepsilon$$

$$\therefore \qquad \frac{d\phi}{dt} = \varepsilon$$

In above equation, direction of induced emf is not well defined & emf without direction is useless. **[1½]**

The direction of included emf was given by Lenz.

Lenz's Explanation : Emf induced in a coil opposes its cause. In other words, direction of an induced emf is opposite to the change in magnetic flux responsible for its production.

The induced emf in a circuit equal to the rate of change of magnetic flux through the circuit.

Mathematically, the induced emf is given by

$$\varepsilon = \frac{-d\phi_B}{dt}$$

The negative sign indicates the opposition of an induced emf. In case of a closely wound coil of N turns, change of flux associated with each turn is same. Therefore total induced emf is given by

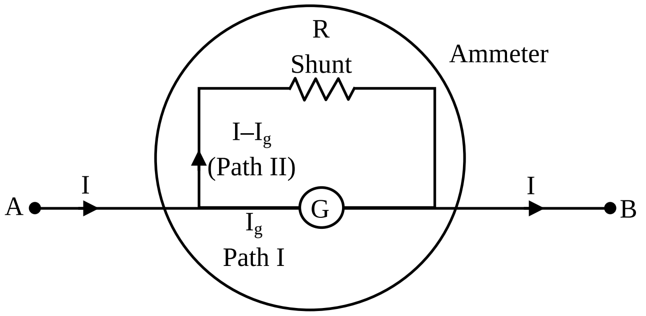
$$\varepsilon = -N\frac{d\phi_B}{dt}$$

The induced emf can be altered by altering the number of N turns. **[1½]**

OR

Conversion of MCG into Ammeter

An ammeter is a device that measures current in an electric circuit. For an ideal ammeter, resistance is almost zero. A MCG can be converted into an ammeter by connecting a low resistance called 'Shunt in parallel with it. In parallel grouping of resistances, potential must be equal



$$V_{\text{path I}} = V_{\text{path II}}$$

$$I_gG = (I - I_g) R$$

$$\boxed{R,\ \text{shunt} = \left(\frac{I_g}{I - I_g}\right)G}$$ **[1½]**

Conversion of MCG into Voltmeter :

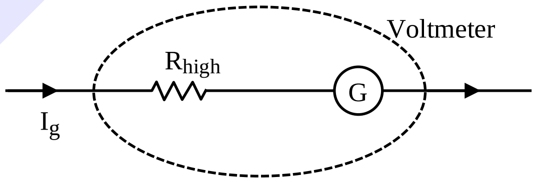
A voltmeter is a device that measures potential difference across two points. For ideal voltmeter, it's resistance is inifinite.

A moving coil galvanometer can be converted into a voltmeter by connecting a very high resistance in series with it.

$$V = I_g R_h + I_g G$$

$$V = I_g (R_h + G)$$

$$\frac{V}{I_g} = R_h + G$$



$$\boxed{R_h = \frac{V}{I_g} - G}$$

Characteristics of MCG :

(i) It's sensitivity is very high.

(ii) It has linear scale because electric current is directly proportional to deflection produced in the coil.

(iii) A MCG can be converted into ammeter or a voltmeter. **[1½]**

SECTION – D

29. (i) (b)

Voltage drop across R.

$V_R = V_B - V_N = 5 - 0.7 = 4.3$ V

Here, $I_{min} = 1 \times 10^{-3}$ A

$$R_{max} = \frac{V_R}{1_{min}} = \frac{4.3}{1\times10^{-3}} = 4.3\times10^3\Omega = 4.3\text{k}\Omega$$ **[1]**

(ii) **(b)** **[1]**

$I = 6\text{ mA} = 6 \times 10^{-3}$ A;

$V_R = V_b - V_N = 5 - 0.7 = 4.3$ V

$$R = \frac{V_R}{I} = \frac{4.3}{6\times10^{-3}} = 717\Omega$$ **[1]**

(iii) **(d)**

Here, $V_B = 6V$; $V_N = 0.7$ V,

$V_R = 6 - 0.7 = 5.3$ V

Power dissipated in $R = I \times V_R$

$= (6 \times 10^{-3}) \times 5.3 = 31.8 \times 10^{-3}$ W

$= 31.8$ mW **[1]**

(iv) **(b)**

$V_t = V_{bi} + V_R = 0.63 + 6 = 6.63$ V **[1]**

OR

(c)

In the given circuit the junction diode is forward biased and offers zero resistance.

$\therefore$ The current, $I = \dfrac{3V - 1V}{200\Omega} = \dfrac{2V}{200\Omega} = 0.01A$

30. **(i)** **(d)**

Path difference product is

$$\Delta x = \frac{3}{2}\pi R - \frac{\pi}{2}R = \pi R$$

For maxima : $\Delta x = n\lambda$

$\therefore$ $n\lambda = \pi R$

$\Rightarrow$ $\lambda = \dfrac{\pi R}{n}$, $n = 1, 2, 3, \ldots$

Thus, the possible value of λ are $\pi R, \dfrac{\pi R}{2}, \dfrac{\pi R}{3}$ **[1]**

(ii) **(d)**

$$\frac{I_{max.}}{I_{min.}} = \frac{\left(\sqrt{I_1} + \sqrt{I_2}\right)^2}{\left(\sqrt{I_1} - \sqrt{I_2}\right)^2}$$

$$\frac{I_{max.}}{I_{min.}} = \frac{\left(\sqrt{49} + \sqrt{1}\right)^2}{\left(\sqrt{49} - \sqrt{I}\right)^2} = \frac{(7+1)^2}{(7-1)^2} = \frac{64}{36} = \frac{16}{9}$$ **[1]**

(iii) **(b)**

Maximum intensity, $I_{max} = \left(\sqrt{I_1} + \sqrt{I_2}\right)^2$

Here, $I_1 = I_2 = I_0/2$ (given)

$$I_{max} = \left(\sqrt{\frac{I_0}{2}} + \sqrt{\frac{I_0}{2}}\right)^2 = 2I_0$$ **[1]**

(iv) (d)

Phase difference $\phi = \frac{2\pi}{\lambda} \times \text{path diference}$

$\phi = \frac{2\pi}{\lambda} \times \frac{\lambda}{6} = \frac{\pi}{3} = 60°$ As $I = I_{max} \cos^2 \frac{\phi}{2}$

$I = I_0 \cos^2 \frac{60^0}{2} = I_0 \times \left(\frac{\sqrt{3}}{2}\right)^2 = \frac{3}{4} I_0$

$\Rightarrow \frac{I}{I_0} = \frac{3}{4}$ **[1]**

OR

(iv) (c)

Here $A^2 = a_1^2 + a_2^2 + 2a_1a_2 \cos\delta$ $\because a_1 = a_2 = a$

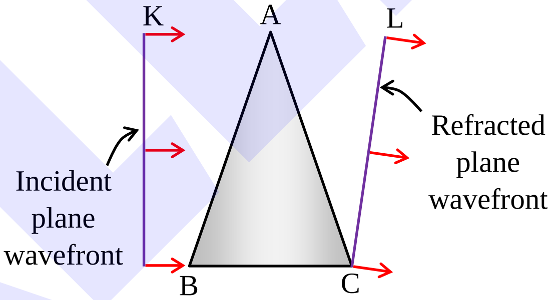
$A^2 = 2a^2 (1 + \cos\delta) = 2a^2 (1 + 2\cos^2 \frac{\delta}{2} - 1)$

$A^2 \propto \cos^2 \frac{\delta}{2}$

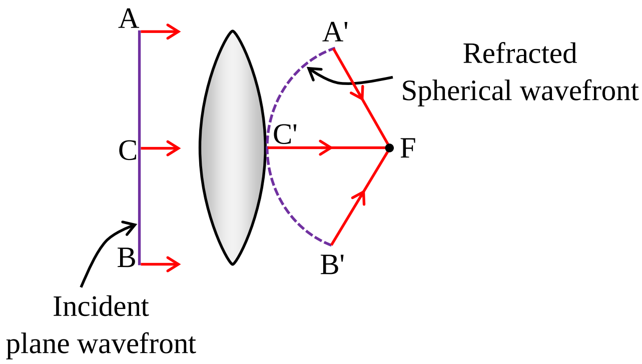
Now $I \propto A^2 \because I \propto A^2 \cos^2 \frac{\delta}{2} \Rightarrow I \propto \cos^2 \frac{\delta}{2}$

SECTION – E

31. (a) (i) **Refraction of Plane Wavefront through prism :** When plane wavefront incident on thin prism, then refracted wavefront is also a plane, but tilted towards the base of the prism.

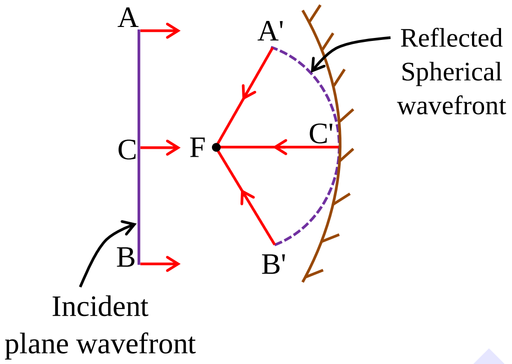


(ii) **Refraction of plane wavefront by a convex lens :** In this case when plane wavefront (ACB) incident on convex lens, then the refracted wavefront is spherical and converges to the focus (F) of convex lens.



Radius of spherical wavefront = Focal length of convex lens

(iii) **Reflection of a plane wavefront by a concave mirror :** The incident plane wavefront on concave mirror becomes spherical wavefront after reflection and converges to the focus (F) of concave mirror.



Radius of spherical wavefront = Focal length of concave mirror

$$= \frac{\text{Radius of concave mirror}}{2}.$$ **[3]**

(b) $y_1 = a \cos \omega t$ ....(1)

$y_2 = a \cos (\omega t + \phi)$ ....(2)

Resultant displacement will be given by -

$y = y_1 + y_2$

$y = a [\cos\omega t + \cos(\omega t + \phi)]$ $\quad \left\{\cos C + \cos D = 2\cos\left(\frac{C+D}{2}\right)\cos\left(\frac{C-D}{2}\right)\right\}$

$y = 2a \cos(\phi/2) \cos(\omega t + \phi/2)$

Amplitude of resultant wave :

$\boxed{R = 2a\cos(\phi/2)}$

Resultant intensity :

$I = KR^2 \Rightarrow I = K[4a^2 \cos^2(\phi/2)]$

$I_1 = I_2 = I_0 = Ka^2$

$\boxed{I = 4 I_0 \cos^2(\phi/2)}$

For constructive interference :

$\phi = 0, 2\pi, 4\pi, \ldots\ldots\ldots\ldots = 2n\pi$

$\boxed{R = 2a}$

$I = K(4a^2) \Rightarrow I = 4I_0$

For destructive interference :

$\phi = \pi, 3\pi, 5\pi, \ldots\ldots\ldots\ldots = (2n-1)\pi$

$\boxed{I = 0}$

Average intensity :

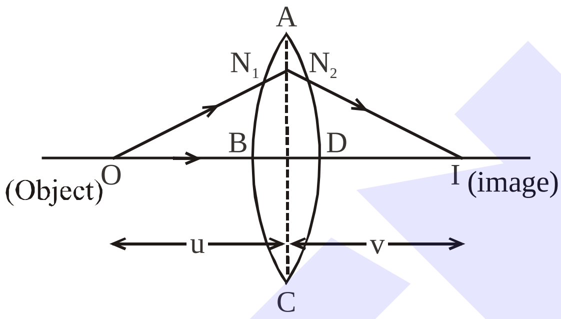
$$< I > = 4I_0 < \cos^2\phi/2 >$$

$$< I > = 4I_0\left(\frac{1}{2}\right)$$

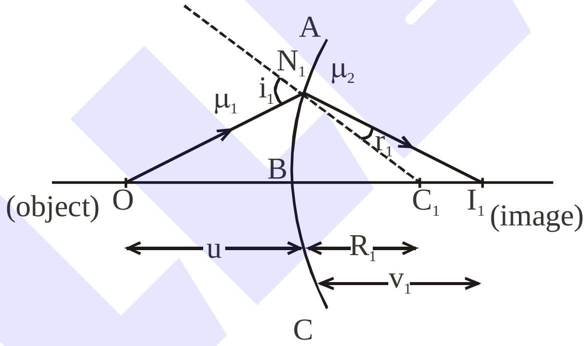
$$< I > = 2I_0$$ **[2]**

OR

(a) **Lens maker's formula :** Lens maker's formula gives the relation between focal length of lens, refractive index of it's material (μ) and radii of curvature of it's two surfaces.



(i) **Refraction through spherical surface ABC –**



Applying refraction formula -

$$\frac{{}_1\mu_2}{v_1} - \frac{1}{u} = \frac{{}_1\mu_2 - 1}{R_1} \qquad \text{...(1)}$$

(ii) **Refraction through spherical surface ADC –**

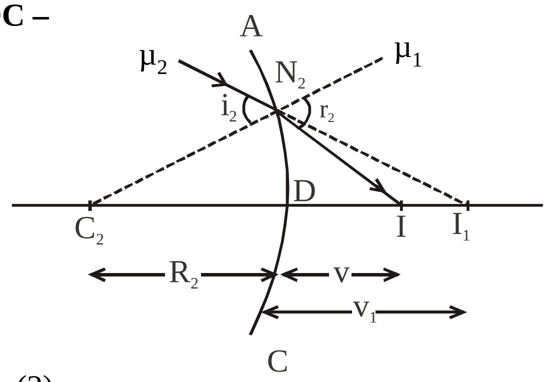
$I_1 \Rightarrow$ virtual object

$I \Rightarrow$ final image

From refraction formula -

$$\frac{{}_2\mu_1}{v} - \frac{1}{v_1} = \frac{{}_2\mu_1 - 1}{R_2}$$

or $$\frac{1}{v} - \frac{{}_1\mu_2}{v_1} = \frac{1 - {}_1\mu_2}{R_2} \qquad \text{...(2)}$$



Adding eq. (1) and (2)

$$\boxed{\frac{1}{v}-\frac{1}{u}=\left({}_1\mu_2-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)}$$

or $$\boxed{\frac{1}{f}=\left({}_1\mu_2-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)}$$ $\{{}_1\mu_2 = n$

$$\boxed{\frac{1}{f}=\left(n-1\right)\left(\frac{1}{R_1}-\frac{1}{R_2}\right)}$$ This is lens maker's formula.

If lower half of the concave mirror's reflecting surface is covered with an opaque material then the intensity of image formed by mirror will become half. **[3]**

(b) Two Reasons :

(i) There is no chromatic aberration in reflecting type telescope.

(ii) Resolving power of reflecting type telescope is greater than refracting type telescope.

Focal length of both the lenses :

Magnifying Power,

$M=\dfrac{f_0}{f_e}$, $M=8$, $L=f_0+f_e=18$ $\begin{cases} f_0 = \text{Focal length of objective lens} \\ f_e = \text{Focal length of eyepiece}\end{cases}$

$8=\dfrac{f_0}{f_e}\Rightarrow f_0=8f_e$ ...(1)

and $18 = f_0 + f_e$ ...(2)

$\Rightarrow \quad 18=8f_e+f_e\Rightarrow \boxed{f_e=2\text{cm}}$

and $\boxed{f_0=16\,\text{cm}}$ **[2]**

32. **(a)** (i) Equivalent capacitance in series combination

$C_s = \dfrac{C}{n}$, $C = 10\mu F$ and $n = 10$

$C_s = \dfrac{10}{10}\mu F \Rightarrow \boxed{C_s=1\mu F}$

Equivalent capacitance in parallel combination

$C_p = nC \Rightarrow C_p = 10 \times 10\mu F \Rightarrow \boxed{C_p=100\,\mu F}$ **[1]**

Product of capacitances = $C_s \times C_P = 1\mu F \times 100\mu F = 100\,(\mu F)^2$

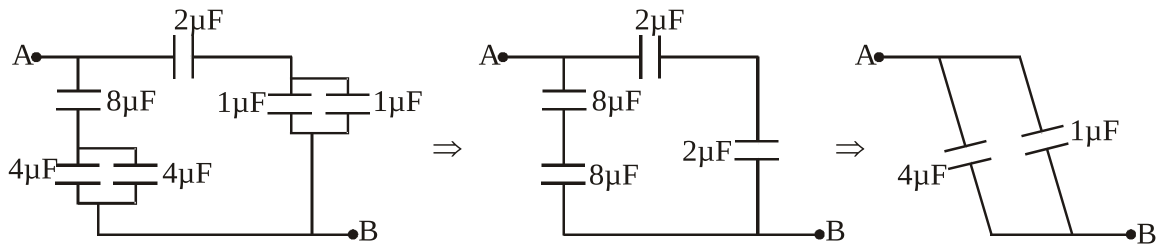
(ii) $C = 4\ \mu F$ (in Air)

Capacitance after completely filled dielectric substance,

$C_m = KC\ \{K = 2\}$

$C_m = 2 \times 4\ \mu F \Rightarrow \boxed{C_m=8\,\mu F}$ **[1]**

(b)



$C_{AB} = 5\mu F$ **[3]**

OR

(a) (i) $C \propto 4$

Capacitance gets doubled

(ii) $C \propto \frac{1}{d}$

Capacitance reduces to half. **[2½]**

(b) $\frac{C}{3} = 1\mu F$ ....Given

(i) Effective capacitance in parallel

$C_p = 3C = 3 \times 3\ \mu F \Rightarrow C_p = 9\mu F$

(ii) $U = \frac{1}{2}CV^2$

$$\frac{U_p}{P_s} = \frac{C_p}{C_s} = \frac{9}{3} = 3:1$$ **[2½]**

33. (a) As the iron rod is inserted, the magnetic field inside the coil magnetizes the iron rod, increasing the magnetic field inside it. Hence, the inductance of the coil increases. Consequently, the inductive reactance of the coil increases. As a result, a larger fraction of the applied ac voltage appears across the inductor, leaving less voltage across the bulb. Therefore, the glow of the light bulb decreases. **[3]**

(b) Impedance of LCR circuit,

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

At resonance, $\omega L = \frac{1}{\omega C}$, Therefore Z = R and LCR circuit behaves as a purely resistive circuit.

(i) If $f > f_r$, then $\omega L > \frac{1}{\omega C}$

Thus, reactance of LCR circuit is inductive. In this case current lags behind the voltage in phase.

(ii) If $f < f_r$, then $\omega L < \frac{1}{\omega C}$

Then, reactance of LCR circuit is capacitive. Therefore, current leads the voltage in phase. **[2]**

OR

(a) **Expression of Motional Electromotive Force :** Let according to diagram, a conducting rod PQ of length ℓ is moving with velocity (v) in plane of paper. A magnetic field B is acting perpendicular to the plane of paper. Free electrons present in conductor are also moving perpendicular to the magnetic field. Lorentz force acting on free electrons is given by :

$$F_m = evB \sin 90°$$

$$\boxed{F_m = evB}$$

The direction of this force is given by Fleming left hand rule and acts towards end 'Q'. Due to this force negatively charged free electrons move towards end 'Q' leaving positive charged ions at 'P'. Resultantly the end 'P' becomes positively charged and the end 'Q' becomes negatively charged, which develops a potential difference (ε) across the ends of the conductor. So, electric field gets induced in the conductor $\left(E = \frac{\varepsilon}{\ell}\right)$. Now, this electric field exerts electric force on electrons

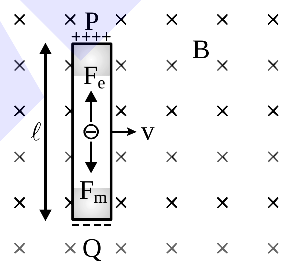
i.e. $F_e = eE$ (towards end P)

In equilibrium state

$$F_e = F_m$$

$$eE = evB$$

$$e \times \frac{\varepsilon}{\ell} = evB$$



Motional emf $\qquad \varepsilon = vB\ell$ **[3]**

(b) Given $\quad \frac{N_S}{N_P} = \frac{400}{100} = 4$

$V_P = 120V$

(i) Transformation ratio = $\frac{N_S}{N_P} = 4$

(ii) $V_S = V_P\left(\frac{N_S}{N_P}\right) = 120 \times 4 = 480V$ **[2]**