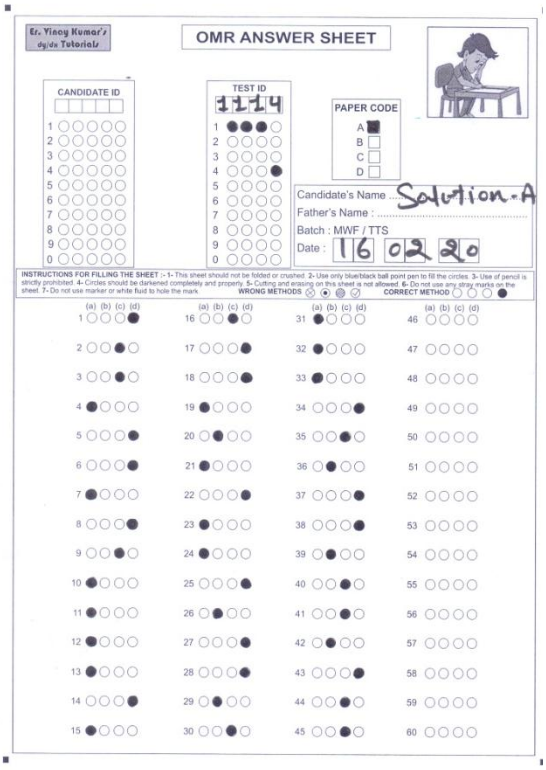
SET-A



Q1. x = Ay + B tan Cz

From the dimensional homogeneity

$[\boldsymbol{x}] = [\boldsymbol{Ay}] = [\boldsymbol{B}] \Rightarrow \left[\frac{x}{A}\right] = [\boldsymbol{y}] = \left[\frac{B}{A}\right]$

$[\boldsymbol{Cz}] = [\boldsymbol{M^0L^0T^0}]$ = Dimension less

x and B; C and z^{-1}; y and $\frac{B}{A}$ have the same dimension but x and A have different dimensions.

Q2.

$c \Rightarrow LT^{-1}$

$G \Rightarrow \frac{F \times r^2}{m^2} \Rightarrow [MLT^{-2}][L^2][M^{-2}] \Rightarrow [M^{-1}L^3T^{-2}]$

$h = \frac{U}{\nu} \Rightarrow \frac{ML^2T^{-2}}{T^{-1}} \Rightarrow [ML^2T^{-1}]$

$m = c^xG^yh^z \Rightarrow [M] = [LT^{-1}]^x[M^{-1}L^3T^{-2}]^y[ML^2T^{-1}]^z$

$[M] = [M^{-y+z}L^{x+3y+2z}T^{-x-2y-z}]$

$-y + z = 1 \ldots\ldots(1)$

$x + 3y + 2z = 0 \;\ldots..(2)$

$-x - 2y - z = 0 \;\ldots..(3)$

eq (2)+(3)⇨

$x + 3y + 2z = 0$

$-x - 2y - z = 0$

$y + z = 0 \;\ldots..(4)$

eq (1)+(4)⇨

$-y + z = 1$

$y + z = 0$

$2z = 1 \Rightarrow z = \frac{1}{2}$

$y + z = 0 \;\ldots..(4)$

$\Rightarrow y = -z \Rightarrow y = -\frac{1}{2}$

$-x - 2y - z = 0 \;\ldots..(3)$

$\Rightarrow -x - 2\left(-\frac{1}{2}\right) - \frac{1}{2} = 0$

$\Rightarrow -x + 1 - \frac{1}{2} = 0 \Rightarrow x = \frac{1}{2}$

$$\left.\begin{array}{l} x = \frac{1}{2} \\ y = -\frac{1}{2} \\ z = \frac{1}{2} \end{array}\right\} \quad m = c^xG^yh^z \Rightarrow \mathbf{m} = \boldsymbol{c^{\frac{1}{2}}G^{-\frac{1}{2}}h^{\frac{1}{2}}}$$

Q3. $\boldsymbol{n_2 = n_1\left(\frac{M_1}{M_2}\right)^1\left(\frac{L_1}{L_2}\right)^1\left(\frac{T_1}{T_2}\right)^{-2}}$

$\boldsymbol{= 100\left(\frac{gm}{kg}\right)^1\left(\frac{cm}{m}\right)^1\left(\frac{sec}{min}\right)^{-2}}$

$\boldsymbol{= 100\left(\frac{gm}{10^3gm}\right)^1\left(\frac{cm}{10^2cm}\right)^1\left(\frac{sec}{60\,sec}\right)^{-2}}$

$\boldsymbol{n_2 = \frac{3600}{10^3} = 3.6}$

Q4. Angle of banking : $\boldsymbol{\tan\theta = \frac{v^2}{rg}}$, i.e. $\boldsymbol{\frac{v^2}{rg}}$ is dimensionless.

Q5.

$\lambda_{max} = \frac{n^2(n+1)^2}{(2n+1)R} \Rightarrow \lambda_{\max(L)} = \frac{1^2(1+1)^2}{(2\times1+1)R}$

$\Rightarrow \lambda_{\max(L)} = \frac{4}{3R} \ldots(1)$

$\lambda_{max} = \frac{n^2(n+1)^2}{(2n+1)R} \Rightarrow \lambda_{\max(B)} = \frac{2^2(2+1)^2}{(2\times2+1)R}$

$\Rightarrow \lambda_{\max(B)} = \frac{36}{5R} \ldots..(2)$

$\frac{(1)}{(2)} \Rightarrow \frac{\lambda_{\max(L)}}{\lambda_{\max(B)}} = \frac{\frac{4}{3R}}{\frac{36}{5R}} \Rightarrow \frac{\lambda}{\lambda_{\max(B)}} = \frac{4}{3R} \times \frac{5R}{36} = \frac{5}{27}$

$\Rightarrow \boldsymbol{\lambda_{max(B)} = \frac{27}{5}\lambda}$

Q6.

$N = \frac{n(n-1)}{2} \Rightarrow N = \frac{4(4-1)}{2}$

$\Rightarrow N = \frac{4\times3}{2} \Rightarrow N = 6$

Q8. (a) Emission transition

$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \frac{1}{\lambda_1} = R \times 1 \times \left[\frac{1}{1^2} - \frac{1}{2^2}\right]$

$\Rightarrow \frac{1}{\lambda_1} = R\left[\frac{1}{1} - \frac{1}{4}\right] \Rightarrow \frac{1}{\lambda_1} = R\frac{3}{4} \Rightarrow \lambda_1 = 1.33R$

(b) Absorption transition

(c) Absorption transition

(d) Emission transition

$$\frac{1}{\lambda} = RZ^2\left[\frac{1}{n_1^2} - \frac{1}{n_2^2}\right] \Rightarrow \frac{1}{\lambda_2} = R \times 1 \times \left[\frac{1}{2^2} - \frac{1}{5^2}\right]$$

$$\Rightarrow \frac{1}{\lambda_2} = R\left[\frac{1}{4} - \frac{1}{25}\right] \Rightarrow \frac{1}{\lambda_2} = R\left[\frac{25-4}{100}\right]$$

$$\Rightarrow \frac{1}{\lambda_2} = R\frac{21}{100} \Rightarrow \lambda_2 = \frac{100R}{21}$$

$$\Rightarrow (\lambda_2 = 4.76R) > (\lambda_1 = 1.33R)$$

Q9. Change in the angular momentum

$$\Delta \boldsymbol{L} = \boldsymbol{L_2} - \boldsymbol{L_1} = \frac{\boldsymbol{n_2 h}}{\boldsymbol{2\pi}} - \frac{\boldsymbol{n_1 h}}{\boldsymbol{2\pi}}$$

$$\Rightarrow \Delta \boldsymbol{L} = \frac{\boldsymbol{h}}{\boldsymbol{2\pi}}(\boldsymbol{n_2} - \boldsymbol{n_1})$$

$$= \frac{\mathbf{6.6 \times 10^{-34}}}{\mathbf{2 \times 3.14}}(\mathbf{5-4}) = \mathbf{1.05 \times 10^{-34}}\ \boldsymbol{Js}$$

Q11. ${}_0n^1 + {}_{92}U^{235} \Rightarrow {}_{56}Ba^{144} + {}_{36}Kr^{89} + 3\ {}_0n^1$

Q12. Number of fission per second

$$= \frac{\textit{Power output}}{\textit{Energy released per fission}}$$

$$= \frac{\mathbf{3.2 \times 10^6}}{\mathbf{200 \times 10^6 \times 1.6 \times 10^{-19}}} = \mathbf{1 \times 10^{17}}$$

⇨Number of fission per minute

$= 60 \times 10^{17} = 6 \times 10^{18}$

Q13. Total mass of reactants

= (2.0141) ×2=4.0282 amu

Total mass of products = 4.0024 amu

Mass defect = 4.0282 amu – 4.0024 amu

= 0.0258 amu

∴ Energy released E=931 × 0.0258 = 24 MeV

Q14.

$$n_\alpha = \frac{A - A'}{4} \Rightarrow n_\alpha = \frac{238-222}{4} \Rightarrow n_\alpha = 4$$

$$\Rightarrow Z - Z' = 2n_\alpha + n_{\beta^+} - n_{\beta^-}$$

$$\Rightarrow 90 - 83 = 2 \times 4 + 0 - n\beta^-$$

$$\Rightarrow 7 = 8 - n\beta^- \Rightarrow n\beta^- = 1$$

Q15. Number of half lives in two days for substances 1 and 2 respectively are

$$\boldsymbol{n_1} = \frac{\mathbf{2 \times 24}}{\mathbf{12}} = \mathbf{4} \text{ and } \boldsymbol{n_2} = \frac{\mathbf{2 \times 24}}{\mathbf{1.6}} = \mathbf{3}$$

By using $\boldsymbol{N} = \boldsymbol{N_0}\left(\frac{1}{2}\right)^{\boldsymbol{n}} \Rightarrow \frac{\boldsymbol{N_1}}{\boldsymbol{N_2}} = \frac{(\boldsymbol{N_0})_1}{(\boldsymbol{N_0})_2} \times \frac{\left(\frac{1}{2}\right)^{\boldsymbol{n_1}}}{\left(\frac{1}{2}\right)^{\boldsymbol{n_2}}}$

$$= \frac{\mathbf{2}}{\mathbf{1}} \times \frac{\left(\frac{1}{2}\right)^4}{\left(\frac{1}{2}\right)^3} = \frac{\mathbf{1}}{\mathbf{1}}$$

Q16. $\boldsymbol{\lambda} = \frac{\boldsymbol{h}}{\sqrt{\boldsymbol{2mqV}}} \Rightarrow \boldsymbol{\lambda} \propto \frac{\mathbf{1}}{\sqrt{\boldsymbol{mq}}} \Rightarrow \frac{\boldsymbol{\lambda_p}}{\boldsymbol{\lambda_\alpha}} = \sqrt{\frac{\mathbf{m_\alpha q_\alpha}}{\mathbf{m_p q_p}}}$

$$= \sqrt{\frac{\mathbf{4m_p \times 2q_p}}{\mathbf{m_p \times q_p}}} = \mathbf{2\sqrt{2}}$$

Q17. $\boldsymbol{\lambda} = \frac{\boldsymbol{h}}{\sqrt{\boldsymbol{2mE}}};\ \frac{\grave{\boldsymbol{\lambda}}}{\boldsymbol{\lambda}} = \sqrt{\frac{\boldsymbol{E}}{\boldsymbol{E}}} \Rightarrow \frac{\boldsymbol{E}}{\grave{\boldsymbol{E}}} = \left(\frac{\mathbf{0.5}}{\mathbf{1}}\right)^2$

$$\Rightarrow \mathbf{E} = \frac{\mathbf{E}}{\mathbf{0.25}} = \mathbf{4E}$$

The energy that should be added to decrease wavelength

= E – E = 3E

Q18. $\boldsymbol{V_0} = \frac{(\boldsymbol{E} - \boldsymbol{W_0})}{\boldsymbol{e}} = \frac{(\mathbf{2}\boldsymbol{eV} - \mathbf{0.6}\ \boldsymbol{eV})}{\boldsymbol{e}}$=1.4 V

Q19. The work function has no effect on current. The photoelectric current is proportional to the intensity of light. Since there is no change in the intensity of light, therefore $I_1 = I_2$.

Q20. Stopping potential does not depend on the relative distance between the source and the cell.

Q21. By changing the filament current thermionic emission intensity of X-rays can be changed.

Q22. Peaks on the graph represent characteristic X-ray spectrum. Every peak has a certain wavelength, which depends upon the transition of electron inside the atom of the target. While $\boldsymbol{\lambda_{min}}$ depends upon the accelerating voltage (As $\boldsymbol{\lambda_{min}} \propto \mathbf{1}/\boldsymbol{V}$).

Q23. Because *P*-side is more negative than *N*-side.

Q25. Arsenic has five valence electrons, so it is a donor impurity. Hence *X* becomes *N*-type semiconductor. Indium has only three outer electrons, so it is an acceptor impurity. Hence *Y* becomes *P*-type semiconductor. Also *N* (i.e. *X*) is connected to positive terminal of battery and *P* (i.e., *Y*) is connected to negative terminal of battery so *PN*-junction is reverse biased.

Q28. The output D for the given combination

$$\boldsymbol{D} = \overline{(\boldsymbol{A} + \boldsymbol{B}).\boldsymbol{C}} = \overline{(\boldsymbol{A} + \boldsymbol{B})} + \overline{\boldsymbol{C}}$$

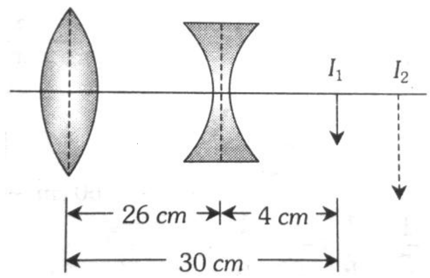
If A = B = C = 0

then $\boldsymbol{D} = \overline{(\mathbf{0} + \mathbf{0})} + \overline{\mathbf{0}} = \overline{\mathbf{0}} + \overline{\mathbf{0}}$ = 1 + 1 = 1

If A = B = 1, C = 0

then $D = \overline{(1+1)} + \overline{0} = \overline{1} + \overline{0} = 0 + 1 = 1$

Q29. Convex lens will form image I_1 at it's focus which acts like a virtual object for concave lens.

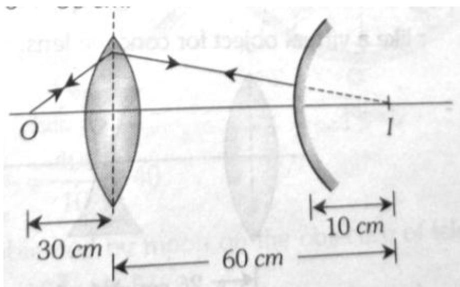


Hence for concave lens u = + 4 cm, f = 20 cm. So by

Lens formula $\frac{1}{-20} = \frac{1}{v} - \frac{1}{4} \Rightarrow \mathbf{v = 5\ cm}$ i.e. distance of final image (I_2) from concave lens v = 5 cm by using $\frac{v}{u} = \frac{I}{O} \Rightarrow \frac{5}{4} = \frac{I_2}{2} \Rightarrow \boldsymbol{I_2 = 2.5}$ **cm**

Q30. For lens u = 30 cm, f = 20 cm, hence by using $\frac{1}{f} = \frac{1}{v} = \frac{1}{u} \Rightarrow \frac{1}{+20} = \frac{1}{v} - \frac{1}{-30} \Rightarrow \mathbf{v = 60\ cm}$

The final image will coincide the object, if light ray falls normally on convex mirror as shown. From figure it is seen clear that separation between lens and mirror is 60 – 10 = 50 cm.



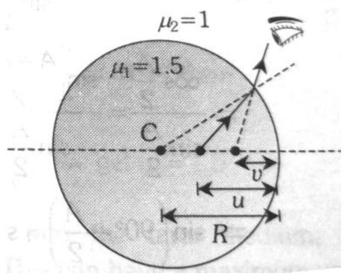
Q31. v = 1 cm, R = 2cm

By using

$\frac{\mu_i}{v} - \frac{\mu_o}{u} = \frac{\mu_i - \mu_o}{R}$

$\frac{1}{-1} - \frac{1.5}{u} = \frac{1-1.5}{-2}$

$\Rightarrow \mathbf{u = -1.2\ cm}$



Q32.

$M = -\frac{f_o}{f_e} \Rightarrow -20 = -\frac{f_o}{f_e}$

$\Rightarrow f_o = 20 f_e$ ....(1)

$L = f_o + f_e \Rightarrow 105 = f_o + f_e$ ......(2)

From eq. (1) and (2): $105 = 20f_e + f_e \Rightarrow 105 = 21 f_e$

$\Rightarrow f_e = 5\text{cm}$

$\Rightarrow f_o = 20 f_e \Rightarrow f_o = 20 \times 5 \Rightarrow f_o = 100\text{cm}$

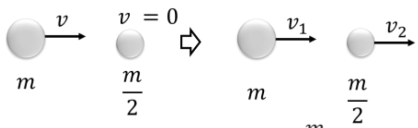
Q33. Total deviation = 0

$\boldsymbol{\delta_1 + \delta_2 + \delta_3 + \delta_4 + \delta_5 = (\mu_1 - 1)A_1 - (\mu_2 - 1)A_2 + (\mu_3 - 1)A_3 - (\mu_4 - 1)A_4 + (\mu_5 - 1)A_5 = 0}$

$\Rightarrow \mathbf{2 \times A_2 (1.6 - 1) = 3\ (1.53 - 1) 9}$

$\Rightarrow \mathbf{A_2 = 3 \left(\frac{0.53 \times 9}{1.2}\right) = 11.9^o}$

Q34.



$p_i = p_f \Rightarrow mv + \frac{m}{2} \times 0 = mv_1 + \frac{m}{2} v_2$

$\Rightarrow 2v_1 + v_2 = 2v$ ....(1)

N. Exp. Law $\Rightarrow$

$\frac{v_2 - v_1}{0 - v} = -\frac{1}{2} \Rightarrow 2v_2 - 2v_1 = v$ ....(2)

Eq. (1)+Eq. (2):

$\Rightarrow 3v_2 = 3v$

$\Rightarrow v_2 = v$

From eq (2): $\Rightarrow 2v_2 - 2v_1 = v$

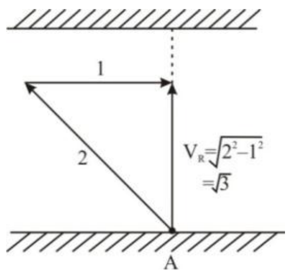
$2v - 2v_1 = v \Rightarrow 2v_1 = v \quad \Rightarrow v_1 = \frac{v}{2}$

de-Broglie wavelength $\Rightarrow \lambda = \frac{h}{mv} \quad \Rightarrow \lambda \propto \frac{1}{mv}$

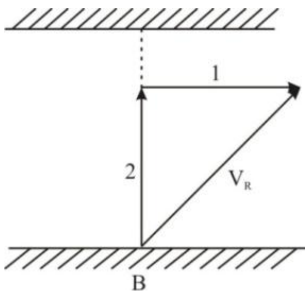
$\Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{m_2}{m_1} \times \frac{v_2}{v_1} \quad \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{\frac{m}{2}}{m} \frac{v}{\frac{v}{2}} \quad \Rightarrow \frac{\lambda_1}{\lambda_2} = \frac{1}{1}$

Q35. Tension = $[MLT^{-2}]$, surface Tension = $[MT^{-2}]$

Q36.



$t_A = \frac{d}{V_R} = \frac{2\sqrt{3}}{\sqrt{3}} = 2\text{hr}$



$t_B = \frac{d}{V} = \frac{2\sqrt{3}}{2} = \sqrt{3}$

= 1.73 hr

Time difference = 2 – 1.73

= 0.27 hr

Q37. $\left(\vec{A}+\vec{B}\right)\cdot\left(\vec{A}-\vec{B}\right)=0$

$\Rightarrow \left(\vec{A}+\vec{B}\right)\perp\left(\vec{A}-\vec{B}\right)\Rightarrow$ this is possible in case of square and rhombus.

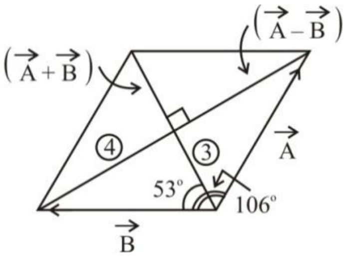
(a) $\left|\vec{A}+\vec{B}\right|=\left|\vec{A}-\vec{B}\right|$ possible in square

(b) $\vec{A}\perp\vec{B}$ possible in square

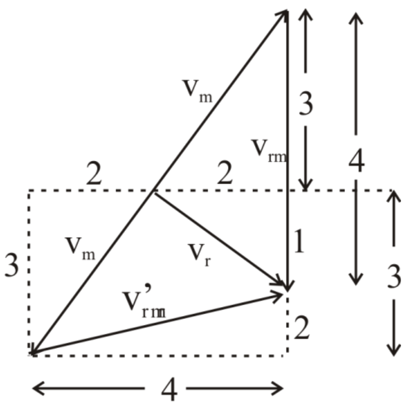
(c) A = B possible in both square & rhombus

(d) A > B not possible

Q38.



Q39.



Q40. $\vec{A}\times\vec{B}\Rightarrow 2i-j+k$

$\Rightarrow (-2+1)\,i-(4-1)\,j+(-2+1)\,k$

i - j + 2k

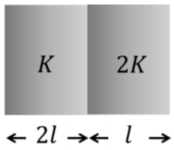
$\Rightarrow -i-3j-k$

unit vector along $\vec{A}\times\vec{B}$

$\Rightarrow \dfrac{-i-3j-k}{\sqrt{1^2+3^2+1^2}}\Rightarrow\dfrac{-i-3j-k}{\sqrt{11}}$

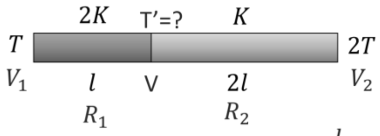
The vector is $2\sqrt{11}\cdot\left(\dfrac{-i-3j-k}{\sqrt{11}}\right)=-2i-6j-2k$

Q41. $K=\dfrac{\sum l}{\sum\frac{l}{K}}\Rightarrow K_{eff}=\dfrac{2l+l}{\frac{2l}{K}+\frac{l}{2K}}$



$\Rightarrow K_{eff}=\dfrac{3l}{\frac{5l}{2K}}\quad\Rightarrow K_{eff}=\dfrac{6}{5}K$

Q42.



$V_1-V=iR_1\ldots.(1)$

$V-V_2=iR_2\ldots(2)$

$\dfrac{(1)}{(2)}\Rightarrow\dfrac{V_1-V}{V-V_2}=\dfrac{R_1}{R_2}$

$\Rightarrow\dfrac{T-T'}{T'-2T}=\dfrac{\frac{l}{2KA}}{\frac{2l}{KA}}\Rightarrow\dfrac{T-T'}{T'-2T}=\dfrac{1}{4}$

$\Rightarrow 4T-4T'=T'-2T$

$\Rightarrow 5T'=6T\quad\Rightarrow \boldsymbol{T'=1.2T}$

Q44. $\dfrac{dT}{dt}=k(T-T_0)$

$\Rightarrow\dfrac{60-40}{10}=k\left(\dfrac{60+40}{2}-T_0\right)\Rightarrow 2=k(50-T_0)\ldots\ldots(1)$

$\dfrac{40-30}{10}=k\left(\dfrac{40+30}{2}-T_0\right)\Rightarrow 1=k(35-T_0)\ldots\ldots(2)$

$\Rightarrow 2=k(50-T_0)\ldots\ldots(1)$

$\Rightarrow 1=k(35-T_0)\ldots\ldots(2)$

$\dfrac{(1)}{(2)}\Rightarrow\dfrac{2}{1}=\dfrac{k(50-T_0)}{k(35-T_0)}$

$\Rightarrow 70-2T_0=50-T_0\quad\Rightarrow T_0=20°C$

Q45.

Wien's displacement law:

$\lambda_0 T=constant\ (0.2892\ cmK)$

$\Rightarrow T\propto\dfrac{1}{\lambda_0}\ldots\ldots(1)$

Stefan Boltzmann law:

$E_e=e\sigma(T^4)\Rightarrow E_e\propto T^4\ldots\ldots(2)$

From eq(1) and (2):

$\Rightarrow E_e\propto\left(\dfrac{1}{\lambda_0}\right)^4$

$\Rightarrow P\propto\left(\dfrac{1}{\lambda_0}\right)^4$

$\Rightarrow\dfrac{P_i}{P_f}=\left(\dfrac{\lambda_{0f}}{\lambda_{0i}}\right)^4\Rightarrow\dfrac{P}{nP}=\left(\dfrac{\frac{1}{2}\lambda_0}{\lambda_0}\right)^4\Rightarrow\dfrac{1}{n}=\left(\dfrac{1}{2}\right)^4\Rightarrow\dfrac{1}{n}=\dfrac{1}{16}$

$\Rightarrow \boldsymbol{n=16}$