① A parallel beam of light of wavelength 6000 Å is incident on a plain transparent film of R.I 1.5. If angle of refraction is 28°. Find the minimum thickness of the film if it appears bright in the reflected light.

rarer - denser - medium

$\lambda = 6000\,Å = 6\times10^{-7}\,m$, $\mu = 1.5$, $r = 28°$

$t_{min} = ?$ bright

for reflected system, $\delta = 2\mu t\cos r + \frac{\lambda}{2}$ → ①

for bright $\delta = n\lambda$ → ②

∴ from ① and ②

$2\mu t\cos r + \frac{\lambda}{2} = n\lambda$ $\left[n\lambda - \frac{\lambda}{2} = (2n-1)\frac{\lambda}{2}\right]$

∴ $2\mu t = (2n-1)\frac{\lambda}{2}$ → ③

for $t = t_{min}$, $n = 1$

$$t_{min} = \frac{\lambda}{4\mu t\cos r}$$

$$t_{min} = \frac{6\times10^{-7}}{4\times1.5\times\cos28^{0}}$$

$t_{min} = 1.132\times10^{-7}\,m$

$t_{min} = 1132\,Å$

② A soap film of RI 1.33 and thickness 1.5×10^{-5} cm is illuminated by light at 30°. Light reflected from it shows a dark band in 2nd order. Calculate wavelength corresponding to the dark band.

rarer - denser - rarer

$\mu = 1.33$, $t = 1.5 \times 10^{-5}$ cm $= 1.5 \times 10^{-7}$ m

$i = 30^\circ$, $n = 2$, dark, $\lambda = ?$

for reflected system, $\delta = 2\mu t \cos r + \frac{\lambda}{2}$ → ①

for dark $\delta = (2n+1)\frac{\lambda}{2}$ → ②

∴ from ① & ②

$2\mu t \cos r + \frac{\lambda}{2} = (2n+1)\frac{\lambda}{2} = (2n)\frac{\lambda}{2} + \frac{\lambda}{2}$

$2\mu t \cos r = n\lambda$

$\lambda = \frac{2\mu t \cos r}{n}$ → ③

$\mu = \frac{\sin i}{\sin r} \Rightarrow \sin r = \frac{\sin i}{\mu} = \frac{\sin 30^\circ}{1.33}$

$\sin r = 0.3759$,

$\cos r = \sqrt{1 - \sin^2 r} = 0.9266$

from ③, $\lambda = \frac{2 \times 1.33 \times 1.5 \times 10^{-7} \times 0.9266}{2}$

$\lambda = 1.848 \times 10^{-7}$ m

$\lambda = 1848$ Å

③ A soap of RI 1·33 is illuminated with light of different wavelengths at angle of 45°. Calculate the smallest thickness of film which will appear dark by reflection. wavelength of light used is 5890 Å.

rarer - denser - rarer

$\mu = 1.33$, $i = 45^\circ$, $t_{min} = ?$, $\lambda = 5.890 \times 10^{-7}$ m

for reflected system, $\delta = 2\mu t \cos r + \frac{\lambda}{2}$ → ①

for dark $\delta = (2n+1)\frac{\lambda}{2}$ → ②

from ① & ②

$$2\mu t \cos r + \frac{\lambda}{2} = (2n)\frac{\lambda}{2} + \frac{\lambda}{2}$$

$$2\mu t \cos r = n\lambda$$

$$\therefore t = \frac{n\lambda}{2\mu \cos r} \rightarrow ③$$

$$\mu = \frac{\sin i}{\sin r} \Rightarrow \sin r = \frac{\sin i}{\mu} = \frac{\sin 45^\circ}{1.33}$$

$$\sin r = 0.5316$$

$$r = 32.11^\circ, \quad \cos r = 0.8469$$

from ③

$$t_{min} = \frac{1 \times 5.890 \times 10^{-7}}{2 \times 1.33 \times 0.8469} = 2.614.2 \times 10^{-7} \text{ m}$$

$$t_{min} = 2614.2 \text{ Å}$$