641.

Problem 45.37 (RHK)

A thin film of acetone $\left(\textit{index of refraction} = 1.25 \right)$ *is coating a thick glass plate* $\left(\textit{index of refraction} = 1.50 \right)$. *Plane light waves of variable wavelengths are incident normal to the film. When one views the reflected wave, it is noted that complete destructive interference occurs at* 600 nm *and constructive interference at* 700 nm. *We have to calculate the thickness of the acetone film.*

Solution:

There is an additional phase change of π in each of the two rays which interfere after reflection from the acetone film, as both reflections are from interfaces of greater index of refraction of the transmitted side than that of the incident side. Let the thickness of the acetone film be *d* nm. The condition of destructive interference of nearly normal incident waves of wavelength 600 nm on reflection from the acetone film on a glass plate will therefore be

$$\frac{4\pi d}{\lambda_{acetone}} = (2m+1)\pi,\ \text{m} = 0,1,2,3...'$$

$$\lambda_{acetone} = \frac{\lambda}{n_{acetone}} = \frac{600}{1.25}\ \text{nm.}$$

Therefore, the set of values of *d* when wave of wavelength 600 nm is used and destructive interference is observed will be

$$d_{600\ \text{nm}} = \{120,\ 360,\ 600,\ 840,\ 1080,\ ..\}\ \text{nm.}$$

It is also given that when light waves of wavelength 700 nm are reflected from the film there is constructive interference. The condition for constructive interference is

$$\frac{4\pi d}{\lambda_{acetone}} = (2m)\pi,\ \text{m} = 0,1,2,3...'$$

$$\lambda_{acetone} = \frac{\lambda}{n_{acetone}} = \frac{700}{1.25}\ \text{nm.}$$

Therefore, the set of values of *d* when wave of wavelength 700 nm is used and constructive interference is observed will be

$$d_{700\ \text{nm}} = \{280,\ 560,\ \ 840,\ 1120,\ ..\}\ \text{nm.}$$

The two conditions will be satisfied for

$$d = d_{600\ \text{nm}}\ \text{I}\ \ d_{700\ \text{nm}} = 840\ \text{nm.}$$

The thickness of the acetone film is 840 nm.