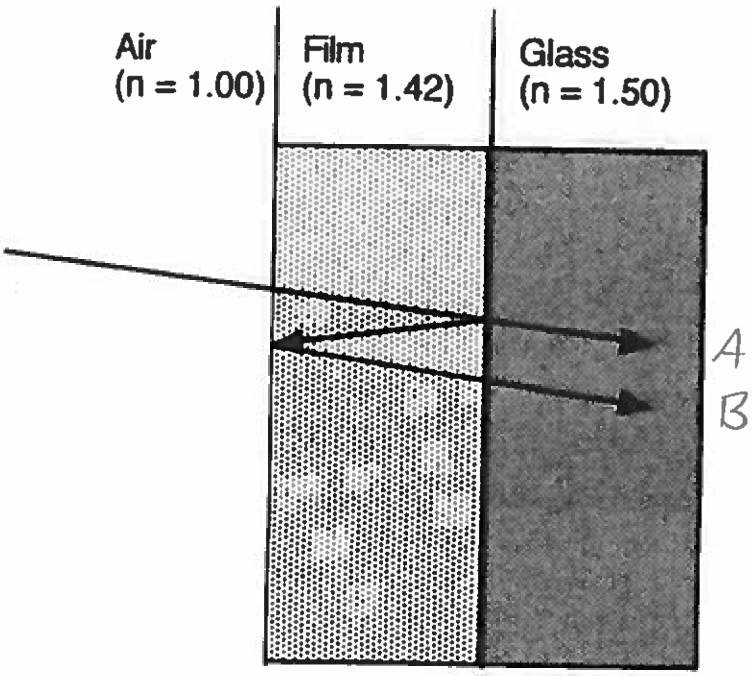
Physics 10164 - Summer 2018 - Exam #4

Partial credit will be given provided you show all work and are solving parts of the problem correctly. Points will be deducted if you don't show your work even if you get the right answer. Clearly indicate your answer with a circle or a box and remember to include correct units and significant figures.

1. (20 pts) A thin coating (n = 1.42) is applied to a glass surface (n = 1.50). What is the minimum thickness of the coating that will allow blue light (wavelength of 422 nm) to transmit brightly through the film and into the glass?



$\phi_A = 0$

$\phi_B = \frac{2nt}{\lambda_0} + \frac{1}{2} + 0$

$\Delta\phi = \frac{2nt}{\lambda_0} + \frac{1}{2} = 0, 1, 2, \ldots$

$\frac{2nt}{\lambda_0} + \frac{1}{2} = 0 \Rightarrow \frac{2nt}{\lambda_0} = -\frac{1}{2}$ ×

$\frac{2nt}{\lambda_0} + \frac{1}{2} = 1 \Rightarrow \frac{2nt}{\lambda_0} = \frac{1}{2} \Rightarrow t = \frac{\lambda_0}{4n} = \boxed{74.3\text{ nm}}$

$\frac{2nt}{\lambda_0} + \frac{1}{2} = 2 \Rightarrow \frac{2nt}{\lambda_0} = \frac{3}{2} \Rightarrow t = \frac{3\lambda_0}{4n}$ (larger)

2. (20 pts) Light of a certain wavelength is incident on a single slit of width 0.155 mm. The light creates a pattern on the wall 12.8 meters away from the slit. The full width of the central maximum of the interference pattern is 8.35 cm. What is the wavelength of the light?

1st min = $\frac{1}{2}$ width $\Rightarrow y = .04175\,m$

$a = .155 \times 10^{-3}\,m$

$L = 12.8$

1st min occurs where

$$\frac{ay}{L} = \lambda, \text{ so } \lambda = \frac{(.155 \times 10^{-3})(.04175)}{12.8}$$

$$= \boxed{506\,nm}$$

#3. (30 pts) When light of wavelength 427 nm is incident on a particular metal, electrons escape the metal with a maximum velocity of 4.9 x 10[5] m/s. When the wavelength of incident light is reduced to some new value, the velocity of the escaping electrons triples. What is the new wavelength?

$$(KE)_{max} = \frac{1}{2}(9.11 \times 10^{-31})(4.9 \times 10^{5})^2$$

$$= 1.094 \times 10^{-19}\ J \text{ or } 0.6835\ eV$$

$$E_\gamma = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34})(3 \times 10^{8})}{427 \times 10^{-9}} = 4.655 \times 10^{-19}\ J$$

$$= 2.9095\ eV$$

$$0.6835 = 2.9095 - \phi$$

$$\phi = 2.23\ eV$$

$$\text{New } KE = 9 * 0.6835 = 6.15$$

if v triples, $KE \propto v^2$, so $KE_{new} = 9 * KE_{original}$

$$6.15 = E_\gamma - 2.23$$

$$E_\gamma = 8.38\ eV \text{ or } 1.34 \times 10^{-18} = \frac{hc}{\lambda}$$

$$\lambda = \frac{hc}{E_\gamma} = \boxed{148\ nm}$$

#4. (30 pts) Cobalt-60 is a common by-product of nuclear fission weapons, and it has a half life of 5.26 years. Assume the mass of Cobalt-60 is 60.0 amu.

a) What is the activity of 125 grams of Co-60, in Curies?

b) How long will it take (in years) for the activity of this initial amount of Co-60 to drop to 2.00% of its original value?

$$T_{1/2} = 5.26 \text{ yr} = 1.66 \times 10^{8} \text{ s}$$

$$\lambda = \frac{.693}{T_{1/2}} = 4.17 \times 10^{-9}$$

$$N = \frac{m_{tot}}{m_{Co}} = \frac{.125 \text{ kg}}{60 \text{ u} \cdot 1.66 \times 10^{-27} \frac{\text{kg}}{\text{u}}} = 1.25 \times 10^{24} \text{ atoms}$$

$$a = \lambda N = 5.21 \times 10^{15} \text{ Bq} \cdot \frac{2.7 \times 10^{-11} \text{ Ci}}{\text{Bq}}$$

$$= \boxed{1.4 \times 10^{5} \text{ Ci}}$$

b)
$$\frac{a}{a_0} = .0200 = e^{-\lambda t}$$

$$-3.912 = -(4.17 \times 10^{-9}) t$$

$$t = 9.38 \times 10^{8} \text{ s} = \boxed{29.7 \text{ yrs}}$$