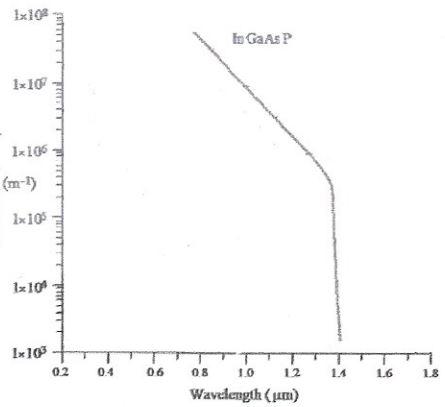
Problem 2.3 (37.5 points) (*Optical communications laser*) You are designing a VCSEL laser based on $In_xGa_{1-x}As_yP_{1-y}$ – InP, for which $In_xGa_{1-x}As_yP_{1-y}$, 52 micrometers thick, is the active layer, while alternating layers of $In_xGa_{1-x}As_yP_{1-y}$ (of the same composition as the active layer) and InP form the dielectric mirrors. The bandgap and index of refraction for $In_xGa_{1-x}As_yP_{1-y}$ (with $y = (1-x)/0.465$) are given by the equations below, while the absorption is given by the curve on the right:

$$\begin{cases} E_g(y)(eV) = 1.35 - 0.72y + 0.12y^2 \\ n(y) = \sqrt{6.287 + \dfrac{2.054}{1 - \left(0.6245 \dfrac{1.35}{\lambda[\mu m] \cdot E_g(y)[eV]}\right)}} \end{cases}$$



(a) What is the composition of the active layer for a design wavelength of 1300 nm?
(b) What is the thickness of the layers forming the dielectric mirrors?
(c) What is the mode number of the peak radiation?
(d) What is the spectral separation between the modes of the cavity at around 1300 nm?
(e) If the gain curve of the active layer has a width of about 30 nm how many modes are emitted by the laser?
(f) If the reflectivity of the back dielectric stack is about ~100% and the reflectivity of the output dielectric stack is ~90 % calculate the threshold gain for this laser.
(g) If the carrier lifetime is $\tau_{sp} \sim 10$ ps, calculate the threshold population inversion.