ECE 476/576

HW #7

9.1

Given: $\lambda_0 = 6328$ Å; $\nu_0 = 4.743\times10^{+14}$ Hz ; $T = 573$ K;

(a) $\Delta\nu_D = \left[\frac{8kT}{Mc^2}\ln 2\right]^{1/2}\nu_0 = 1.81$ GHz

(b) $N_{B.B.} = \frac{8\pi\nu^2\Delta\nu}{c^3}V = 3.793\times10^{+18}$ modes;

(c) $FSR = c/2d = 150$ MHz; $N_L = \frac{1.809}{0.15} = 12$ (or 13) $\times$ 2 for both polarizations

(d) probability $= \frac{N_L}{N_{B.B.}} = 3.173\times10^{-8}$ ($\times$ 2 for two polarizations)

(e) $E_2 = 166{,}658.484\ cm^{-1} \Rightarrow 20.66$ eV; $E_1 = 150{,}855.7 cm^{-1} \Rightarrow 18.70$ eV

(f) $\eta_{Q.E.} = \frac{1.96}{20.66} = 9.47\%$;

(g) $g(\nu_0) = \left(\frac{4\ln 2}{\pi}\right)^{1/2}\frac{1}{\Delta\nu_D} = 5.193\times10^{-10}$ sec ; $\sigma = A_{21}\frac{\lambda^2}{8\pi}g(\nu_0) = 5.43\times10^{-13}\ cm^2$

(using $A_{21} = 6.56\times10^{+6}\ sec^{-1}$)

(h) $[N_2 - (g_2/g_1)N_1]\,\sigma = 0.05\ m^{-1}$; i.e.,5% $m^{-1} \Rightarrow 5\times10^{-4}\ cm^{-1}$

$(N_2 - (g_2/g_1)N_1) = 9.22\times10^{+8}\ cm^{-3}$; $(g_2/g_1) = 3/5$;

$N_2 = 9.22\times10^{+8} + (3/5)N_1 = [9.22\times10^{+8} + 6\times10^9]\ cm^{-3} = 6.92\times10^9\ cm^{-3}$

Note: $N_1 > N_2$! but there is gain. ($N_1 = 10^{10}\ cm^{-3}$ - given)

9.8

$\sigma = A_{21}\frac{\lambda_0^2}{8\pi}g(\nu_0) = 4.05\times10^{-14}\ cm^2$; $\gamma_{th} = \frac{1}{l_g}\ln\frac{1}{R_1R_2R_3R_4} = 5.98\times10^{-2}\ cm^{-1}$

$N_2 - \frac{g_2}{g_1}N_1 = 1.48\times10^{+12}\ cm^{-3}$; $I_s = \frac{h\nu}{\sigma\tau_2}$ since $\tau_1 << \tau_2$ $I_s = 6.8$ watts/cm^2

$\Delta\lambda/\lambda = \Delta\nu/\nu$; $\nu = 375$ THz; $\Delta\lambda = 0.043$ Å

$I_{OUT} = T_4\left\{\frac{\gamma_0 l_g - \alpha_T l_g}{1 - \exp[-\alpha_T l_g]}\right\}$; $\alpha_T l_g = \gamma_{th} l_g$; $\therefore I_{out} = 3.13$ watts/cm^2