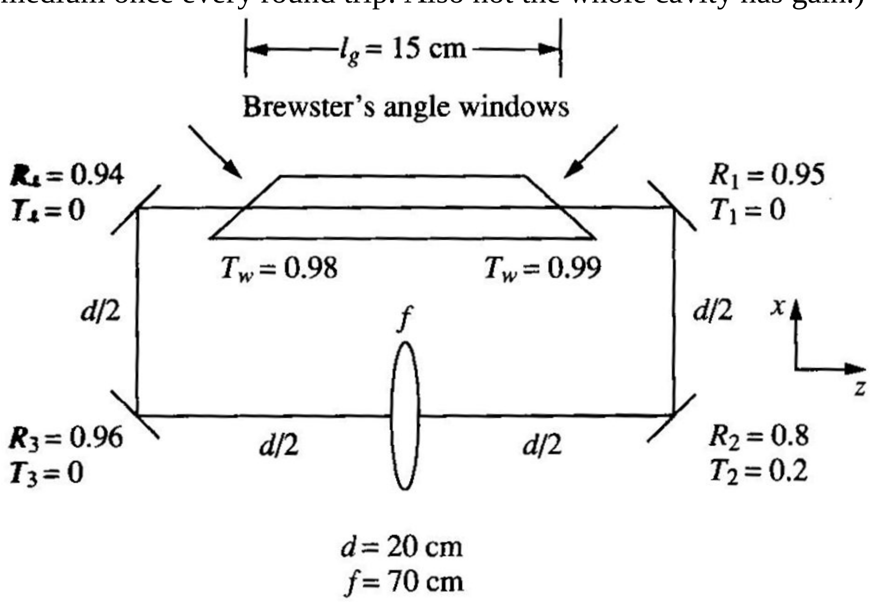
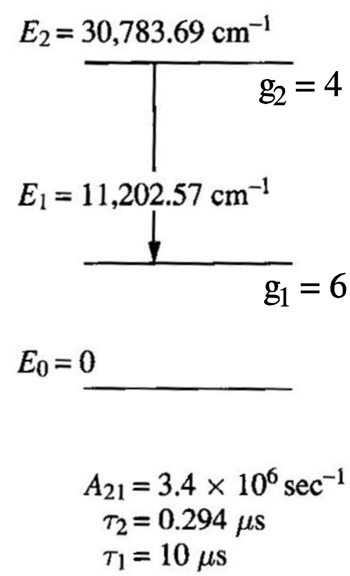
HW 11 due 12/13/2017

1) a) Exercise 14.4-1 (page 557) (1st Ed. Exercise 13.3-1 page 482) (5 points)
b) Exercise 15.1-1 (Note: In a), there is no stimulated emission under thermal equilibrium.) (page 574) (10 points)

2) Consider the following ring laser. Assume that the active medium is an atomic gas (copper) with the energy levels as shown and that the transition is an atomic gas (copper) with the energy levels as shown and that the transition is homogeneously broadened with a Lorentzian line width of 3.5 GHz. (State 1 has a long lifetime and thus the copper vapor laser is not a CW system. However, that fact does not affect what follows.)
a) Find the wavelength in nanometers.
b) What is the line width (FWHM) in angstrom units?
c) What is the stimulated emission cross section (in cm^2) at the line center?
d) What is the minimum required inversion density to reach threshold for CW oscillation?
e) Because of Brewster's angle windows the laser should be linearly polarized. Specify the direction of the optical electric field if the plane of the page is the xz plane and the output is along z.
f) Is the cavity stable? You need to perform the following step in your analysis:
1) Show an equivalent lens diagram starting with M_1 and proceeding counterclockwise around the cavity.
2) Identifying a unit cell with the lens being the first element.
3) Find the ray matrix for the unit cell in terms of d and f.
4) Justify your answer for the stability.
(Note: Yon can assume $\alpha_s = 0$ and refractive index of the active (gain) medium has refractive index =1 in this problem and you cannot use book's formula to find α_r . You need to apply amplitude condition. For example, the amplitude condition is $1 = |r|^2$ where $|r|^2 = R_1R_2e^{(\gamma-\alpha_s)2d}$ for 2 mirrors for Fabry-Perot cavity in Chapter 10 pp. 372-374. Here, we have multiple mirrors and 2 windows similar to HW6 problem 3 and the beam travels through the medium once every round trip. Also not the whole cavity has gain.) (20 points)





Regular problem for graduate students (bonus for undergraduate students)
3) Exercise 14.2-3 (page 547) (1st Ed. Exercise 13.2-3 page 476) (10 points).