

HOMEWORK ASSIGNMENT # 1
DUE: TUESDAY, 20 JANUARY 2009

1. The relaxation time $\tau = 1/A_{ul}$ for a given atomic transition is 1×10^{-6} s. The transition occurs at a wavelength λ of 2500 Å and involves non-degenerate levels. Compute (in c.g.s. units):
 - a) the dipole matrix element $|\langle \mu \rangle_{ul}|$ in Debye. 1 Debye = 10^{-18} esu-cm
 - b) the natural line width $\Delta\nu$ and the oscillator strength
 - c) the line width $\Delta\nu$ caused by pressure broadening at 300 K and 1 torr pressure. You may assume that $k_{coll} = 1 \times 10^{-10} \text{ cm}^3 \text{ s}^{-1}$. What is the pressure-broadening coefficient γ in MHz/Torr?
 - d) the integrated absorption coefficient and cross section if $n_l = 10^{14} \text{ cm}^{-3}$
2. Obtain a formula for the integrated absorption coefficient for the case in which stimulated emission must be taken into account because the lower and upper state populations are comparable. Assume degeneracy exists. Simplify your answer in the limit that $h\nu_{ul} \ll kT$. This is the limit used by microwave spectroscopists.
3. Show that the half width at half maximum for a spectral line broadened by the Doppler effect is given by the formula

$$\Delta\nu/2 = \frac{v_{ul}}{c} \sqrt{\frac{2kT \ln 2}{m}}$$

What is $\Delta\nu/v_{ul}$ for carbon atoms at 300 K? If this ratio is used for the transition in problem 1, what is the Doppler broadening $\Delta\nu$ for the transition?

4. Derive formulae for the maximum absorption coefficients (at resonance) for homogeneous and inhomogeneous transitions in terms of the integrated absorption coefficient. Use your result to determine the maximum absorption coefficient for the transition in problem 1. What percent of the incident radiation is absorbed in a 1-cm path at resonance?
5. Bernath, Chapter 1, problem 7
6. Bernath, Chapter 1, problem 8
7. Bernath, Chapter 1, problem 10