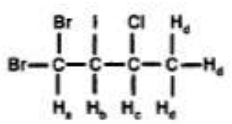# CHM 201
Assignment

1. The excited state of the Na D-line emission near 589 nm has a lifetime of 17 ns. What will be the natural linewidth of this transition? Calculate this linewidth in units of Hz and cm^{-1}.

2. For the same transition discussed in Problem 4, calculate the Doppler linewidth at temperatures of 300 K, 1000 K and 10 K?

3. Comment on the relative values of the natural and Doppler linewidths for this transition in Na, based on your answers in problem 1 and 2.

4. Calculate in Hz, the linewidth of transitions in HCN at 25°C, due to Doppler broadening, in regions of the spectrum corresponding to a) rotational transitions ($10cm^{-1}$); b) vibrational transitions ($1500 \ cm^{-1}$) and c) electronic transitions ($60,000 \ cm^{-1}$).

5. A Nd:YAG laser, with a wavelength of 1064.0 nm, is used to record the rotational Raman spectrum of N_2. Calculate, <u>in units of nm</u>, where the following rotational Raman lines will occur:
   a) first Stokes line, S(0),
   b) second Stokes line S(1) and
   c) first anti-Stokes line S(0) line. The rotational constant, B_0, for N_2 is 2.0 cm^{-1}.

5. Which of the following nuclei, ^4He, ^6Li and ^7Li, are detectable by NMR?

6. What is the energy difference between the two spin of ^1H in a magnetic field of 5.87 T? What is the energy difference between the two spin states of ^{13}C in the same field? Express the energy both in a) Joules and b) in frequency (MHz).

7. At 25°C, what fraction of the ^1H nuclei are the upper and lower states, in a field of 5.87 T and 11.74T?

8. If the spectrometer's magnetic field varied by +0.00001 T, what magnitude of change would be introduced in the resonance frequency of ^1H nuclei at 5.87 T?

9. a) How many peaks would be obtained in the ^1H NMR spectra of the following compounds. Into how many peaks, will each of the NMR signals be split by? Show the splitting pattern.

   a. $CH_3CH_2CH_3$
   b. $C_6H_5CH_2CH_3$
   c. $(CH_3)_2-CH-CH_3$

   d.

10. For the three compounds given in problem 7, what would the ^{13}C spectra look like? Would there be a splitting of the ^{13}C NMR signals? If yes, why, and if no, why not?