

# CHM 8309A Take-Home Exam

You may use any written material you see fit but may not consult with others.

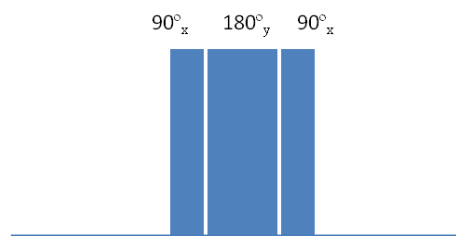
Assigned: Tuesday December 6, 2011

Due: on or before 4:00 pm in D'Iorio Hall room 416A on Friday December 9, 2011

Marks will be deducted for late submissions.

1.  $T_{1\rho}$  is a relaxation time constant for the exponential decay of magnetization along an rf spin locking field in the rotating frame of reference. Describe in detail a simple pulse sequence one could use to measure  $T_{1\rho}$ . Sketch both the pulse sequence and a simple vector diagram illustrating its implementation. (20 points)

2. We have seen in class that the inhomogeneity in the main magnetic field,  $B_0$ , causes magnetization vectors to dephase in the xy plane of the rotating frame of reference because some regions of the sample experience different magnetic fields than others and as a result, each peak has a distribution of frequencies. Inhomogeneities are also present in the magnetic fields in the rotating frame generated by rf pulses,  $B_1$ . Thus, magnetization vectors also dephase in the zx or zy plane during the application of an rf pulse. Spins in one region of the sample will experience a lower magnetic field due to the pulse while spins in another region of the sample will experience a higher magnetic field due to the pulse. This inhomogeneity in  $B_1$  is often due to an imperfect rf coil in the NMR probe. RF inhomogeneity is the reason why the intensity of a resonance using a  $90^\circ$  pulse is greater than that using a  $450^\circ$  pulse. Such rf inhomogeneity during the application of a  $180^\circ_x$  pulse makes it imperfect in that some unwanted magnetization in the y-z plane is also generated since some regions of the sample will experience a pulse less than  $180^\circ$  while other regions will experience a pulse greater than  $180^\circ$ . Imperfect pulses cause losses and errors in complicated pulse sequences in which the pulses are used. It is an area of great interest to compensate for any such errors or losses and attain higher quality data. One of the simplest ways to partially correct the rf inhomogeneity and therefore improve the quality of a  $180^\circ_x$  pulse is to replace it with a composite pulse. The  $90_x-180_y-90_x$  composite pulse below is the simplest of these.



(a) What effect does inhomogeneity of the main magnetic field,  $B_0$ , have on the FID? What effect does it have on the peaks in an NMR spectrum? (5 points)

(b) Demonstrate your knowledge of rf inhomogeneity by using vector diagrams to illustrate why the intensity of a resonance using a  $90^\circ$  pulse is more than that using a  $450^\circ$  pulse. (5 points)

(c) Draw vector diagrams to show the effect of the composite pulse above assuming all three constituent pulses are perfect. (5 points)

(d) Draw vector diagrams to show the effect of the composite pulse above assuming that the  $90^\circ_x$  pulses suffer from rf inhomogeneity. (10 points)

(e) Explain why this composite pulse works well to compensate for small rf inhomogeneities but is not perfect. (5 points)