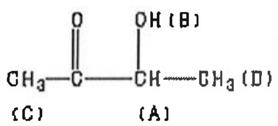
Magnetic Resonance Phenomena 2016

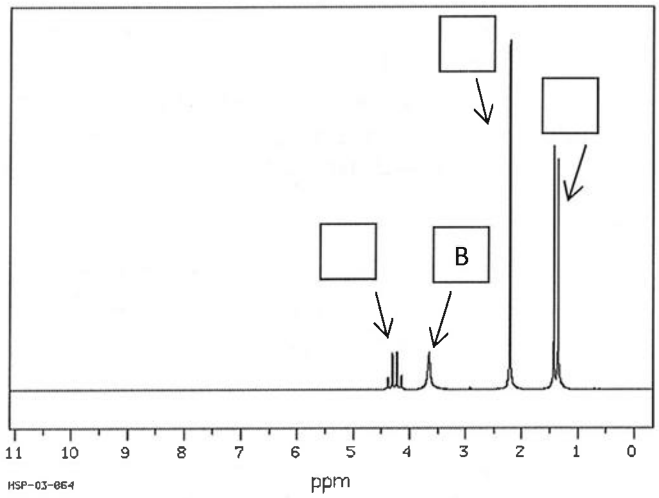
Examen/Tentamen

1. Write the equation of motion for the three components of the nuclear magnetization **M**(M_x,M_y,M_z), in presence of a static, uniform magnetic field **B**(0,0,B_0), and derive the solution. How would the solutions change in a reference frame rotating at the Larmor frequency $\omega_0 = \gamma B_0$? (Neglect relaxation effects).

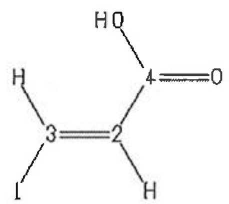
2. Describe the spin-lattice relaxation time T_1, and give an example of a sequence used to measure it. Write the equation of the time-evolution of the magnetization, for the chosen sequence.

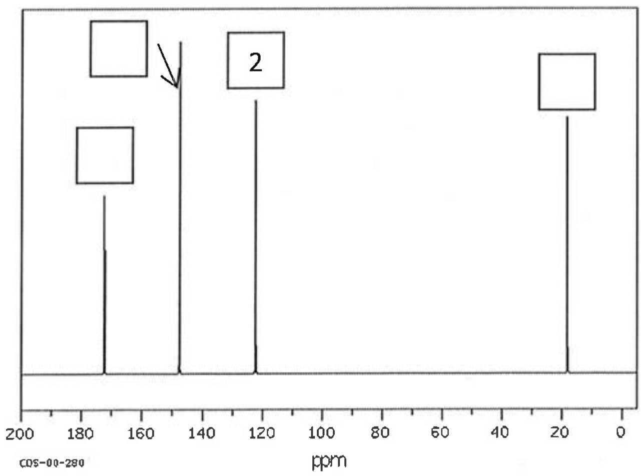
3. Look at the ^{1}**H** NMR spectrum below and assign to each multiplet the correspondent chemically equivalent proton, by filling the empty box. Use the letters reported in the chemical formula. Motivate your choice. Note that the OH group is already assigned.



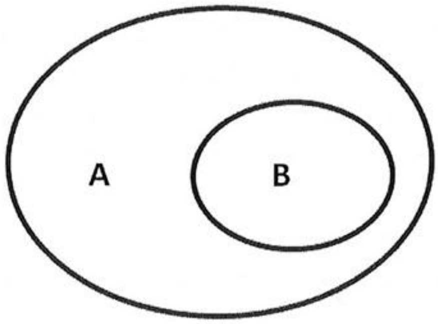


4. Look at the ^{13}**C** NMR spectrum below and assign to each peak the correspondent carbon, by filling the empty box. Use the numbers relative to the C atoms, reported in the chemical formula. Motivate your choice. The second carbon atom is already assigned.





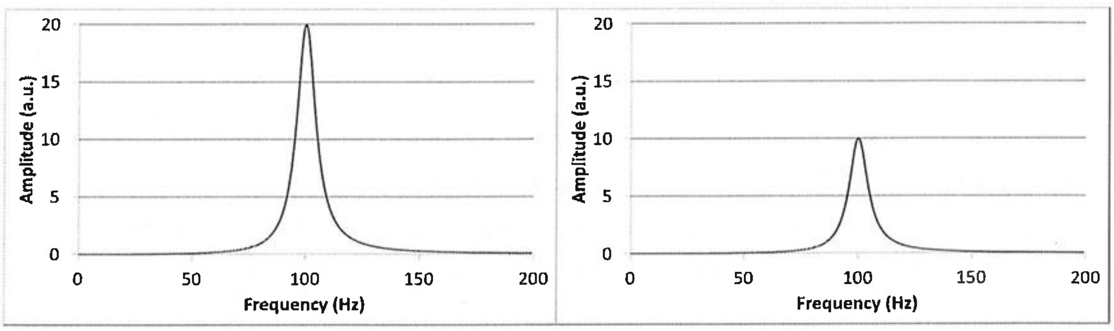
5. Consider the following geometric representation of a body part in an MRI image. Regions A and B in that body part have the following properties:
Region A: T_1 = 1000 ms; T_2 = 100ms; proton density (PD) = 0.8
Region B: T_1 = 1500 ms; T_2 = 150ms; proton density (PD) = 0.8



For each of the following MRI sequences and scan parameters, which region, A or B, appears brighter (more signal) on the image? Explain why, using what you know about the effect of sequence parameters (repetition time = TR, echo time = TE, inversion time = TI, flip angle = FA) on the magnetization with a given set of properties (T_1, T_2, PD).

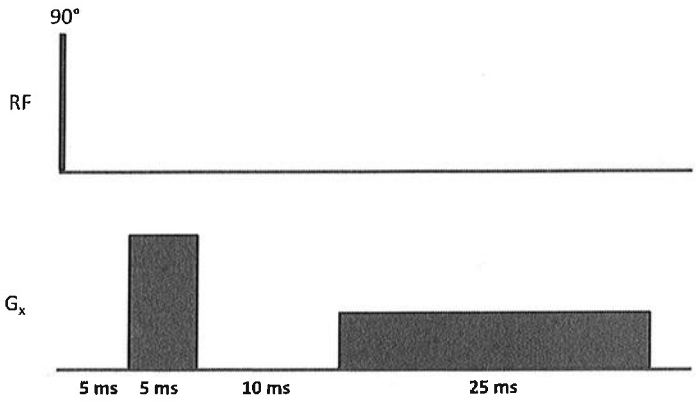
a. T_1-weighted gradient recalled echo (GRE) with TR = 10 ms, TE = 4 ms, FA = 30°;
b. T_2-weighted with TR = 8000 ms, TE = 10 ms, FA = 90°;
c. T_2-weighted with TR = 8000 ms, TE = 120 ms, FA = 90°;
d. T_2-FLAIR with TR = 8000 ms, TI = 700 ms, TE = 120 ms, FA = 90°;
e. T_2-FLAIR with TR = 8000 ms, TI = 1040 ms, TE = 120 ms, FA = 90°;

6. Below are shown two spectra of water. One is obtained from an FID acquired immediately following a 90° pulse, and one after a spin echo sequence with TE = 500 ms. The full width at half maximum (FWHM) of both spectra is 10Hz.



a. What is the T_2 of the water in the sample?
b. What is the T_2^* of the water in the sample?
c. What can you infer from these two values about the level of B_0 homogeneity in which the experiment was performed?

7. Consider the following pulse sequence: the amplitude of the first gradient is 2 g/cm, and that of the second gradient is 1 g/cm.



a. What do we need to modify in this sequence so that it will generate a *gradient echo*?
b. What is the echo time (TE) of the *modified sequence* (where is the echo generated)?
c. Suppose that the maximum gradient strength available in the scanner with the sequence above is 4 g/cm. If you can control the *delays* and the *gradient amplitudes* in this sequence as you wish (given the limitation above), what is the *minimum echo time* you can achieve with the *modified* sequence, while retaining the k_x value obtained at the end of the first gradient in the sequence? Draw a schematic drawing of your suggested sequence.