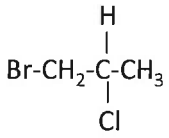
Magnetic Resonance Phenomena Tentamen 2017

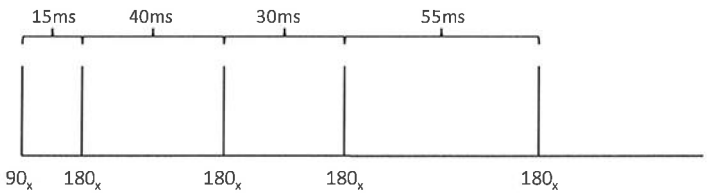
Spectroscopy questions

1. An NMR experiment is to be performed on two samples, one containing hydrogen nuclei and the other sodium nuclei. There are equal numbers of nuclei in each sample. Given the gyromagnetic ratio of hydrogen is 42.58 MHz/Tesla and that of sodium is 11.18 MHz/Tesla, what are the relative signal intensities from the two samples.

2. Sketch the ^{1}**H** NMR spectrum for the molecule below. For each line in the spectrum give the relative intensities. The electronegativity values are in the following order: Cl>Br>C.



3. The diagram below shows a multi-echo pulse sequence with four 180° pulses. At what times (in ms) after the excitation pulse are the echoes created in this sequence?

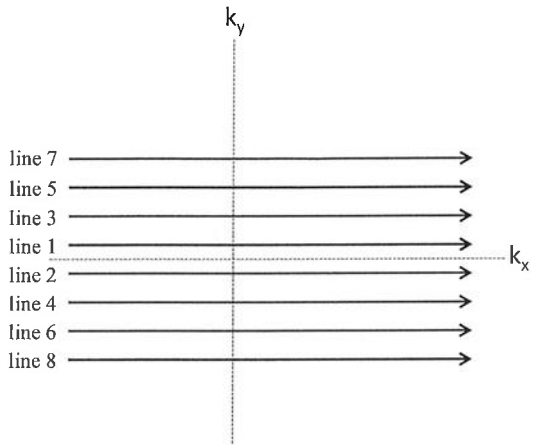


Imaging questions.

4. If an MR image has too low a signal-to-noise for a diagnosis, which of the following changes would increase this signal-to-noise.

(i) Decreasing the thickness of the slice
(ii) Increasing the spatial resolution (number of pixels) in your image
(iii) Scanning the patient at a higher magnetic field
(iv) Increasing the repetition time (TR) of the scan
(v) Increasing the echo time (TE) of the scan

5. The figure shows eight lines of k-space with the respective order of acquisition indicated by the number. Assuming that these eight lines are acquired after a single 90 degree RF pulse, plot the gradient waveforms G_x and G_y which would be used to acquire these 8 lines of k-space. You do not need to consider or draw the slice selection gradients.

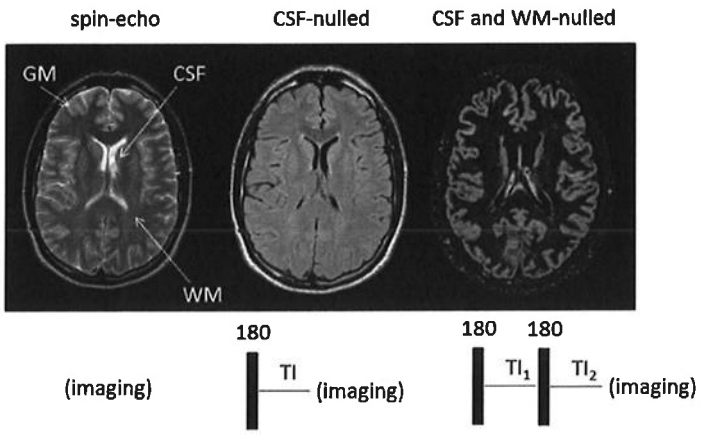


6. An MRI is acquired from the brain of a patient. The major signals come from the white matter, gray matter and a tumour. Three different sequences are run with the following results.

   T_1-weighted sequence: signal (tumour) < signal (white matter) = signal (gray matter)
   T_2-weighted sequence: signal (tumour) = signal (white matter) = signal (gray matter)
   Proton density: signal (tumour) > signal (white matter) > signal (gray matter)

   From this information, what can you tell about the relative values of T_1, T_2 and proton density (ρ) of the tumour, white matter and gray matter?

7. Three images are shown on the next page. The left one shows a scan of the brain obtained with a standard spin-echo imaging sequence. There are signals from the grey matter (GM), white matter (WM) and cerebral spinal fluid (CSF). The central image is obtained using an inversion recovery sequence, in which a 180° pulse is applied, a time delay of TI used to allow T_1 relaxation, and then the image is acquired. The time TI is used to null the signal from CSF. The image on the right uses a double inversion recovery sequence with two time delays TI_1 and TI_2 for T_1 relaxation. This results in an image with zero signal from CSF and WM. Given T_1 values of WM of 900 ms, GM of 800 ms and CSF of 3000 ms, answer the following questions.



   (i) What is the time TI required to null the signal from CSF?
   (ii) For the double inversion recovery sequence, plot the M_z magnetization for WM, GM and CSF as a function of time prior to the imaging sequence being used.
   (iii) What are the times TI_1 and TI_2 required to null the signals from CSF and WM?