

E/M in Chemistry and/or Medicine
NMR/MRI

- Theory
 - Spin – an intrinsic property of elementary particles
 - NRM applies a large magnetic field to material – two energy states created.
 - A radio frequency (RF) pulse is applied
 - If the RF pulse has the right energy, some spins flip
 - When the RF pulse is removed, these spins relax, giving off radiation
- NMR
 - Use
 - Used on nuclei with total spin
 - Each nucleus shifts a different amount based on the electron density around it
 - The Spectrometer
 - Loops of superconducting wire create uniform magnetic field
 - Magnetic field in solenoids around sample can be altered to homogenize field
 - RLC circuit used to detect radiation given off
- MRI
 - Someone else, take it away... (Probably some theory from Rob first)
 - Use
 - Slice Selection made by choosing a bandwidth of RF frequencies corresponding to a “slice” of the patient
 - 3D images are formed by stacking 2D images on top of each other
 - Blood flow can be monitored since oxygenated blood is diamagnetic
 - Contrast Agents
 - Mostly paramagnetic substances that amplify the signal through an induced magnetic field
 - Shorten both T1 and T2 times
 - Most common is chelated Gadolinium
 - Chelate form reduces toxicity
 - Creates an induced field 1000x stronger than in water

Possible exam questions from the E/m in medicine/chemistry group

Question 1: Why does applying a magnetic field to a population of spins cause a creation of two distinct energy levels?

Answer: If we consider a particle with a spin as a magnet that is either aligned with or against the magnetic field, the incident magnetic field will exert a torque on the magnet, rotating it until it is aligned with the magnetic field. Since in quantum mechanics there are no intermediate states, this causes the spin to flip

Question 2: Why is NMR useful in structure determination in chemistry?

Answer: Nuclei with electrons around them will need a slightly smaller magnetic field for them to flip because of the opposing magnetic field induced in the electrons. Based on how far a signal from a given nucleus shifts, one can glean information on the electronic environment around each nucleus.

Question 3: What is the most commonly used contrast agent and why?

Answer: Paramagnetic substances such as Gadolinium are most commonly used because they increase the signal created by the T1 and T2 tests. They also lower the relaxation times for both types of scans.