

Get Ready to crack CSIR-NET 2021 (Short notes on Nuclear Magnetic Resonance(NMR))



NMR (NUCLEAR MAGNETIC RESONANCE)

Nuclear magnetic resonance spectroscopy is based on the measurement of absorption of electromagnetic radiation in radio-frequency region of roughly 4 to 900 MHz. Nuclei of atoms rather than outer electrons are involved in absorption process.

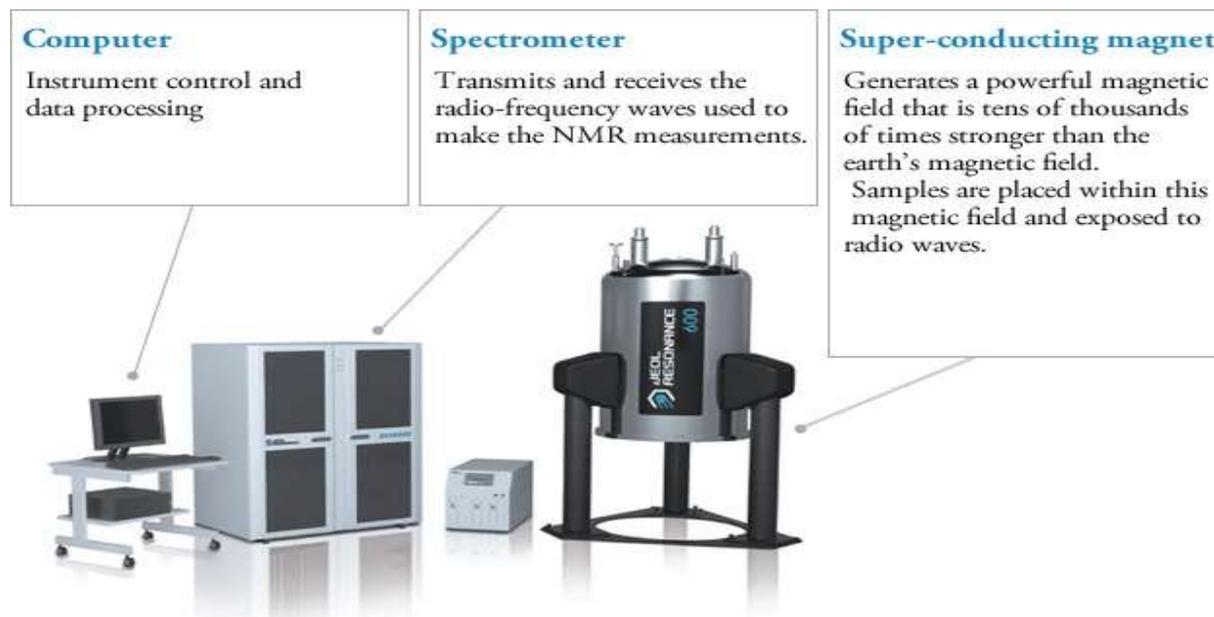


FIG. SHOWING NMR MACHINE SETUP LOOKS LIKE IN LAB

SIGNIFICANCE OF NMR

NMR is the most powerful tool available for organic structure Determination. It is used to study a wide variety of nuclei like:

1. ^1H
2. ^{13}C
3. ^{14}N
4. ^{19}F
5. ^{31}P

Source of Energy in NMR

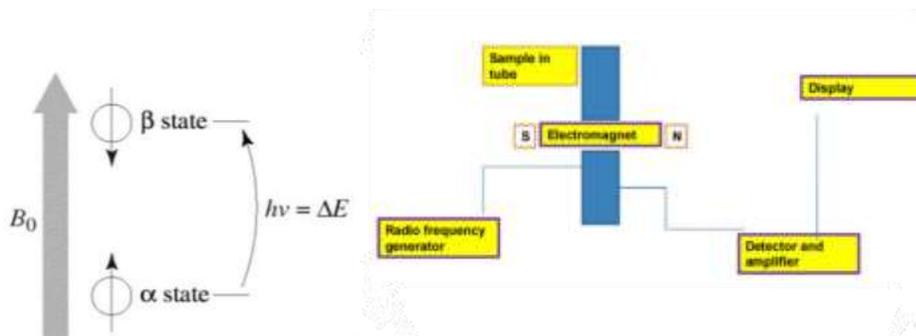
The source of energy in NMR is RADIO WAVES which have long wavelengths having more than 10^7nm , and thus low energy and frequency. When low-energy radioactive waves interact with a molecule, they can change the nuclear spins of some elements, including ^1H and ^{13}C .

NUCLEAR SPIN

A nucleus with an odd atomic number or an odd mass number has nuclear spins. The spinning charged nucleus generates a magnetic field.

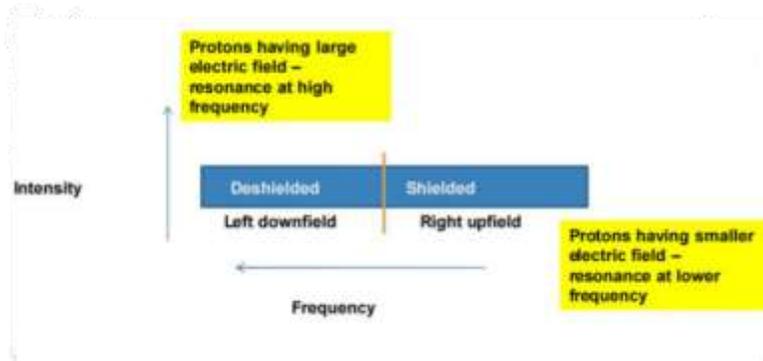
EXTERNAL MAGNETIC FIELD

When placed in external field, spinning protons act like bar magnets. The magnetic field of the spinning nuclei will either with external field or against the field. A proton with right amount of energy can be absorbed and cause the spinning proton to flip.



NMR IMPORTANT POINTS: -

- Protons in different environments absorb at slightly different frequencies, so they are distinguishable by NMR.
- The frequency at which a particular proton absorbs is determined by its electronic environment.
- The size of the magnetic field generated by electrons around a proton determines where it absorbs.
- **NMR spectra show applied field strength increasing from left to right.**
- **Left part is downfield, the right is up field.**
- **Nuclei that absorb on up field side are strongly shielded where nuclei that absorb on downfield side is weakly shielded.**



- **Deshielded nuclei have a much higher energy difference between the a- and b0 spin states and these resonate at a much higher frequency.**

CHEMICAL SHIFT

The relative energy of resonance of a particular nucleus resulting from its local environment is called Chemical Shift.

- Frequency of resonance expressed with reference to standard compound which is defined to be 0ppm.
- Change in the distribution of electron around a nucleus affect:
 1. Local magnetic field
 2. Frequency of nucleus
 3. Chemistry of the molecule of the atom
 4. Reference compound: - Tetra methyl silane (TMS).
- The chemical shift is a field independent value.
- Chemical Shift is the difference in frequency between the sample the standard over the operation frequency
- Numeric value of chemical shift: difference between strength of magnetic field at which the absorbed nucleus resonates and field strength for resonance of a reference.
- Taken as ratio of the field and multiplied by 10^6 so the **shift is in parts per million(ppm)**

$$\text{chemical shift } (\delta) = \frac{\left(\text{frequency of absorbed electromagnetic radiation by sample nucleus in Hz} \right) - \left(\text{frequency of absorbed electromagnetic radiation by TMS standard in Hz} \right)}{\text{Spectrometer frequency in MHz (This accounts for magnet strength)}}$$

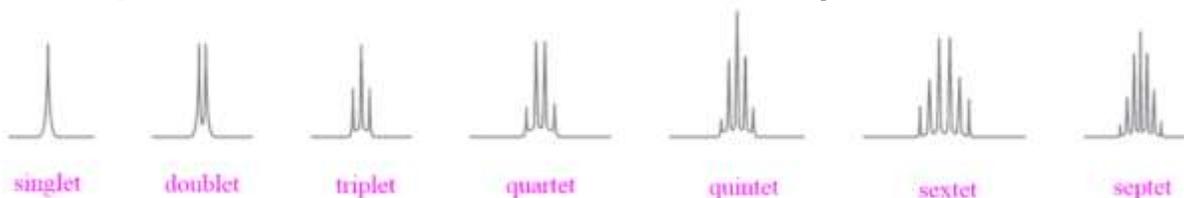
chemical shift (δ) = reported as parts per million (ppm) shift downfield from the TMS standard

Note that the absorbed frequencies are in Hz and the spectrometer frequency is in MHz, meaning there is a millionfold difference in frequencies here, hence the term **"parts per million (PPM)"**.

U'S
PREP

N+1 RULE

- There are different number of peaks (the number of lines) NMR have. This is called the **splitting** of the signal or the **multiplicity**.
- **The simplest signal consists of one line and is called a singlet, followed by the doublet, triplet etc.**
- **A signal with more than seven lines are said to be multiplet.**



Origin of splitting

The splitting is caused by the hydrogens on the same or on the neighboring carbons.

Only nonequivalent protons split the signal of the given proton(s).

One adjacent proton splits an NMR signal into a doublet.

Two adjacent protons split the signal into a triplet.

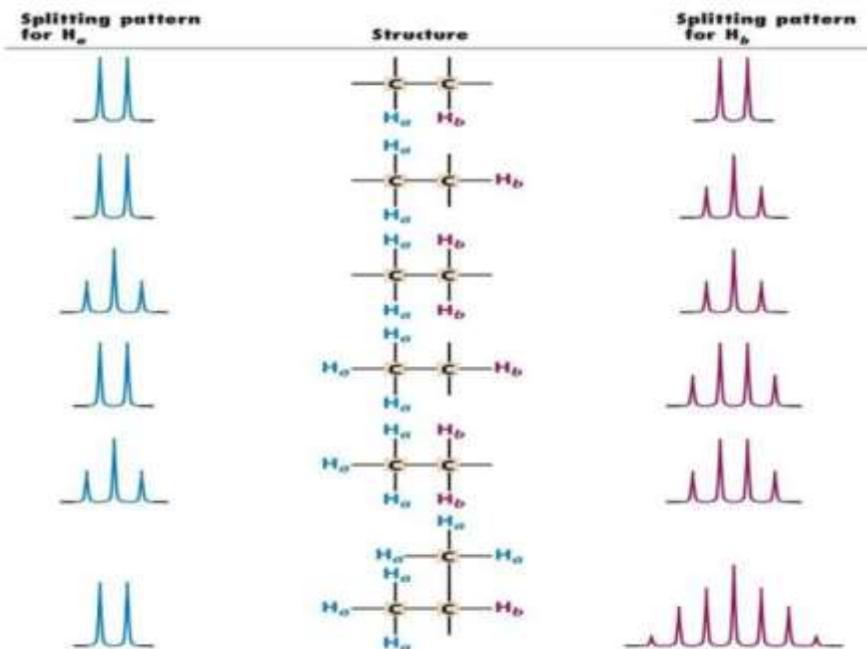


Fig. Showing Splitting patterns commonly seen

ADVANTAGES OF NMR

- 2D and 3D analysis of heterogenous granular structure.
- Near about real time analysis of static and dynamic processes

DISADVANTAGES/LIMITATIONS

- Paramagnetic and ferromagnetic impurities can create artifacts and image distortions.
- Low porosity can lead to long experiment time

APPLICATIONS OF NMR

- 3D STRUCTURE DETERMINATION
- MRI (MAGNETIC RESONANCE IMAGING)
- STRUCTURE DETERMINATION OF ORGANIC COMPOUNDS

CRASH COURSES

Enrol for Ongoing CSIR NET Crash Courses

CSIR NET General Aptitude Course 2021

Complete Study Plan to Boost the CSIR NET Score

What to Expect?

- Live Classes
- Quizzes
- Doubt Sessions
- PYQ Discussion
- Mock Tests
- Chapter-wise Tests
- Revision Tests
- Expert faculty

Course Language

- Bilingual

This Course Includes

-  **80+** Live Classes
-  **1000+** Practice Questions
-  Study Notes & Formula Sheets
-  **10+** Mock Tests

CSIR NET Life Science 2021 Crash Course

Revision Plan to clear the exam

What to Expect?

- Live Classes
- Quizzes
- Doubt Sessions
- PYQ Discussion

Course Language

- English

This Course Includes

-  **200+** Live Classes
-  **3000+** Practice Questions
-  **200+** Study PDFs
-  **10+** Mock Tests

CSIR NET Chemical Science 2021 Crash Course

Complete Revision Plan to ACE the Exam

What to Expect?

- Live Classes
- Quizzes
- Doubt Sessions
- PYQ Discussion
- Mock Tests
- Chapter-wise Tests
- Revision Tests
- Expert faculty

Course Language

- English

This Course Includes

-  **180+** Live Classes
-  **3000+** Practice Questions
-  **200+** Study PDFs
-  **10+** Mock Tests