SUBJECT - CHEMISTRY
CLASS - B.Sc (Hons) PART-III
PAPER - V
TOPIC - Spin-spin interaction

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Q Explain spin-spin interaction (or Coupling) of nmr Signals with a suitable example.

Ans The splitting of nmr Signal into $2nI+1$ peaks due to interaction of adjacent nucleus spins under high resolution is called spin-spin interaction, where n is the number of equivalent protons on the adjacent group. Though Signal splits but the area under the curve remains the Same. unlike Chemical Shift (δ), it is independent of magnetic field. The relative peak intensities are given by coefficients of terms in the expansion of $(x+1)^n$.

$(x+1)^1 = x+1$ i.e 1:1

$(x+1)^2 = x^2+2x+1$ i.e 1:2:1

$(x+1)^3 = x^3+3x^2+3x+1$ i.e 1:3:3:1

$(x+1)^4 = x^4+4x^3+6x^2+4x+1$ i.e 1:4:6:4:1

$(x+1)^5 = x^5+5x^4+10x^3+10x^2+5x+1$ i.e 1:5:10:10:5:1

It is not operative beyond three bonds and so splitting occurs due to neighbouring H-atoms and no splitting is caused by protons of the Same environment or equivalent protons.

Let us Consider ethanol

(CH_3-CH_2-O-H)

Number of peaks for $= 2nI+1 = 2\times3\times\frac{1}{2}+1 = 4$

Number of peaks for $CH_3 = 2\times2\times\frac{1}{2}+1 = 3$

The nuclear spin of two protons of CH_2 group can have three possible orientations that may affect the resonance frequencies of protons of CH_3 group:

Orientations	I	Peak intensity
↑↑	+1	1
↑↓ ↑↓	0	2
↓↓	-1	1

The nuclear spin of CH_3 protons interacts with I = +1, 0-1 and Thus splits into three peaks in the peak height i.e intensity ratio 1:2:1

The nuclear spin of three protons of CH_3 group can have four possible orientations that may affect the resonance frequencies of protons of CH_2 group

Orientations	I	Peak intensity
↑↑↑	+3/2	1
↓↑↑ ↑↓↑ ↑↑↓	+1/2	3
↑↓↓ ↑↓↑ ↓↓↑	-1/2	3
↓↓↓	-3/2	1

The nuclear spin of CH_2 protons interacts with the nuclear spin of CH_3 protons and thus CH_2 signal splits into four peaks in the intensity ratio 1:3:3:1 The O-H peak does not split due to the presence of O-atom (I=0) between C & H-atoms The ^1H nmr spectrum for ethanol under high and low resolution is shown as: