The \((n+1)\) Rule, an empirical rule used to predict the multiplicity and, in conjunction with Pascal's triangle, splitting pattern of peaks in \(^1\text{H}\) and \(^{13}\text{C}\) NMR spectra, states that if a given nucleus is coupled (see spin coupling) to \(n\) number of nuclei that are equivalent (see equivalent ligands), the multiplicity of the peak is \(n+1\).

**eg. 1:**

![Diagram](image1.png)

The three hydrogen nuclei in 1, \(\text{H}_a\), \(\text{H}_b\), and \(\text{H}_c\), are equivalent. Thus, \(^1\text{H}\) NMR spectrum of 1 has only one peak. \(\text{H}_a\), \(\text{H}_b\), and \(\text{H}_c\) are coupled to no hydrogen nuclei. Thus, for \(\text{H}_a\), \(\text{H}_b\), and \(\text{H}_c\), \(n=0\); \((n+1) = (0+1) = 1\). The multiplicity of the peak of \(\text{H}_a\), \(\text{H}_b\), and \(\text{H}_c\) is one. The peak has one line; it is a singlet.

**eg. 2:**

![Diagram](image2.png)

There are two sets of equivalent hydrogen nuclei in 2:

- **Set 1:** \(\text{H}_a\)
- **Set 2:** \(\text{H}_b\), \(\text{H}_c\)

Thus, the \(^1\text{H}\) NMR spectrum of 2 has two peaks, one due to \(\text{H}_a\) and the other to \(\text{H}_b\) and \(\text{H}_c\).

The peak of \(\text{H}_a\): There are two vicinal hydrogens to \(\text{H}_a\): \(\text{H}_b\) and \(\text{H}_c\). \(\text{H}_b\) and \(\text{H}_c\) are equivalent to each other but not to \(\text{H}_a\). Thus, for \(\text{H}_a\), \(n=2\); \((n+1) = (2+1) = 3\). The multiplicity of the peak of \(\text{H}_a\) is three. The peak has three lines; from the Pascal's triangle, it is a triplet.

The peak of \(\text{H}_b\) and \(\text{H}_c\): There is only one vicinal hydrogen to \(\text{H}_b\) and \(\text{H}_c\): \(\text{H}_a\). \(\text{H}_a\) is not equivalent to \(\text{H}_b\) and \(\text{H}_c\). Thus, for \(\text{H}_b\) and \(\text{H}_c\), \(n=1\); \((n+1) = (1+1) = 2\). The multiplicity of the peak of \(\text{H}_b\) and \(\text{H}_c\) is two. The peak has two lines, from the Pascal's triangle, it is a doublet.
To determine the multiplicity of a peak of a nucleus coupled to more than one set of equivalent nuclei, apply the \((n+1)\) Rule independently to each other.

**eg:**

There are three set of equivalent hydrogen nuclei in 3:

Set 1: \(H_a\)
Set 2: \(H_b\)
Set 3: \(H_c\)

<table>
<thead>
<tr>
<th></th>
<th>(H_a)</th>
<th>(H_b)</th>
<th>(H_c)</th>
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<tr>
<td>(H_a)</td>
<td></td>
<td>geminal;</td>
<td>vicinal;</td>
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<td></td>
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<td>coupling occurs</td>
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<tr>
<td>(H_b)</td>
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<td>(H_c)</td>
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<td></td>
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<td>coupling occurs</td>
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</tbody>
</table>

peak of \(H_a\):

\[
(n+1) = (1+1) = 2
\]

multiplicity of the peak of \(H_a\) = \(2 \times 2 = 4\). To determine the splitting pattern of the peak of \(H_a\), use the Pascal’s triangle, based on the observation that, for alkenyl hydrogens, \(J_{cis} > J_{gem}\).
The peak of $H_a$ is a doublet of a doublet.

peak of $H_b$:

\[(n+1) = (1+1) = 2\]

multiplicity of the peak of $H_b = 2 \times 2 = 4$. To determine the splitting pattern of the peak of $H_b$, use the Pascal's triangle, based on the observation that, for alkenyl hydrogens, $J_{\text{trans}} > J_{\text{gem}}$.

The peak of $H_b$ is a doublet of a doublet.

peak of $H_c$:
multiplicity of the peak of $H_c = 2 \times 2 = 4$. To determine the splitting pattern of the peak of $H_c$, use the Pascal’s triangle based on the observation that, for alkenyl hydrogens, $J_{\text{trans}} > J_{\text{cis}}$.

The peak of $H_c$ is a doublet of a doublet.

**Contributors**

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