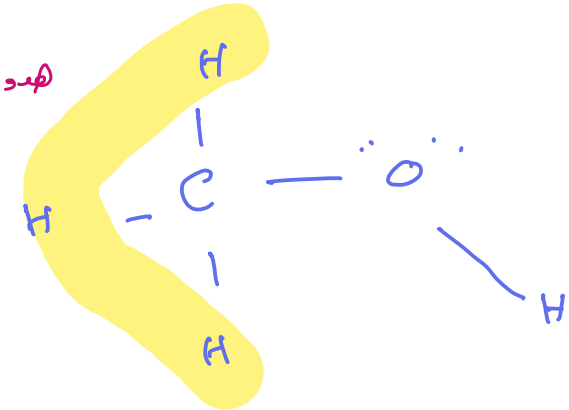
تفريغ تحليل آلي

اسم الموضوع: NMR part 2 Hydrogen

إعداد الصيدلاني/ـة: Sara Jaber

هدول متشابهين



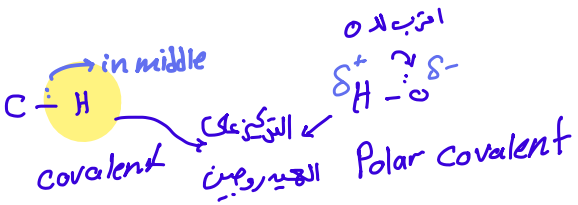
هاي مختلفة بالطاقة

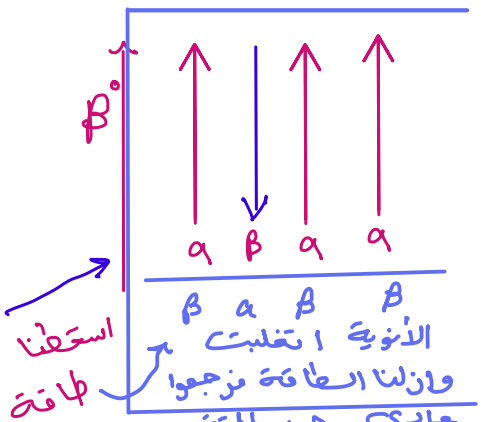
مقدار الطاقة المتحررة
Related with the number of H nucleus

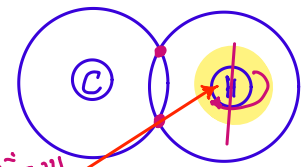
إذا كانوا متساويين ← بعطيني العدد

إذا ما كانوا متساويين ← بعطيني العدد & النوع

مثال





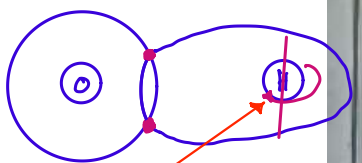


الاشعاع لما يمر يصطدم بالـ e

النواة قريبة لـ e فالـ e يوخذ جزء من الطاقة

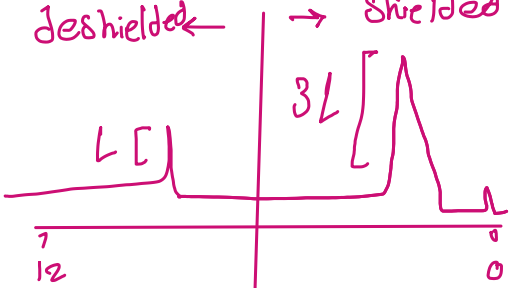
E<100%

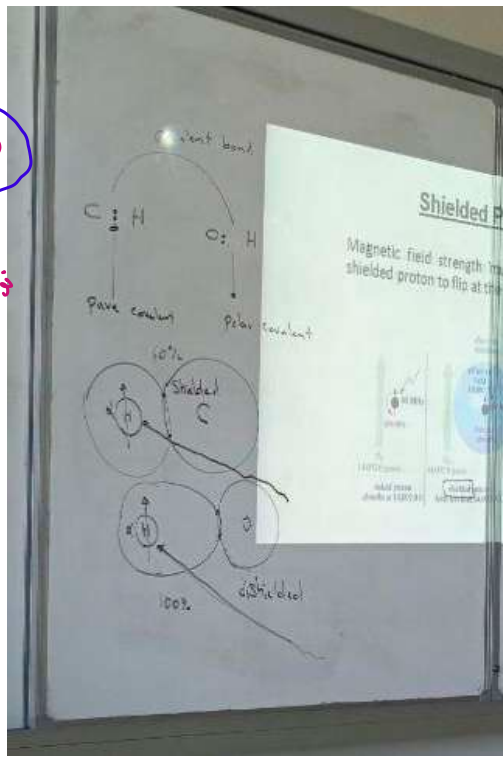
Shielded



E = 100%

ذاة الـ H بعيدة من الـ e





Magnetic Shielding

If all protons absorbed the same amount of energy in a given magnetic field, not much information could be obtained.

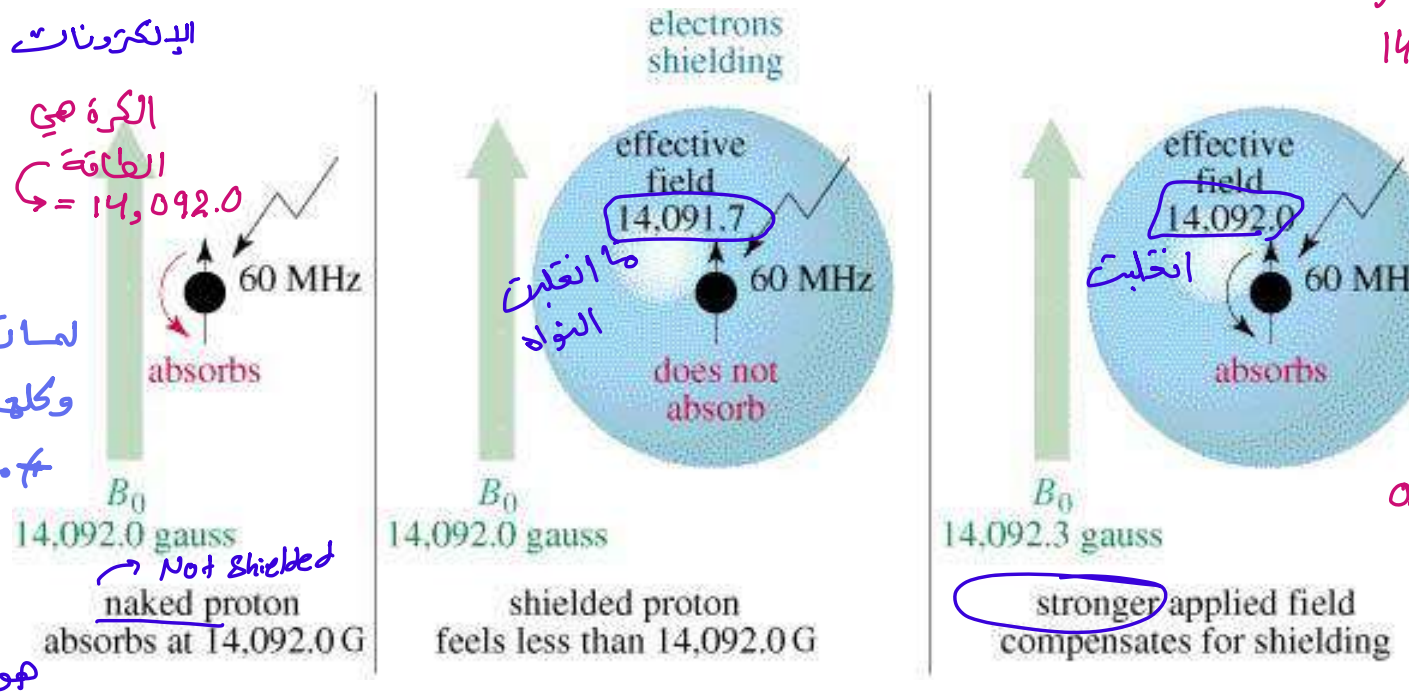
But protons are surrounded by electrons that shield them from the external field.

Shielded

Circulating electrons create an induced magnetic field that opposes the external magnetic field.

Shielded Protons

Magnetic field strength must be increased for a shielded proton to flip at the same frequency.



لما بدي اقلب بروتون بحتاج طاقة شابتة = 14,092.0 G سواءً كان Shielded او non Shielded

* لكن في حالة الـ Sheilded الـ e بتمتص جزء من الطاقة فـ بتتغير شوي بالحسبة

* للتوضيح

هدول كلهم النواه

الإلكترونات

الكرة هي الطاقة = 14,092.0

* Deshielded Proton :
لما تضرب الكرة مباشرة عليهم وكلهم بوقعوا (النواه انقلبت) * ما عندي حواجز *

* Shielded Proton :
هون عندي حاجز فالكرة الاولى راح توقع الحاجز بالاول ووجعة من الأهداف مش كلهم

⊗ اول طاقة اعطيتها كانت = 14,092.06 بصادفها الـ e وامتص منها 14,091.7

14,092.0
14,091.7 -
0.36

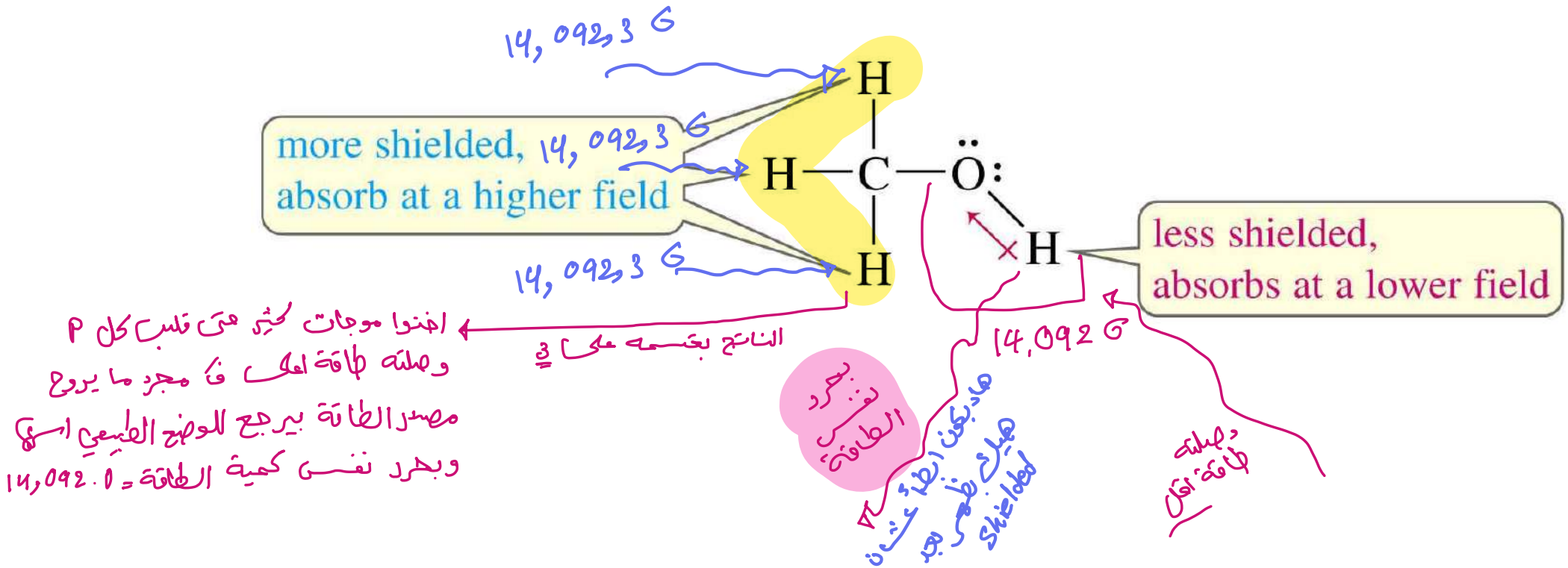
← هاد الي قدر يوصل للنواة من الموجة الأولى وهي غير كافية حتى تقلب النواه

⊗ بعطي الكمية الثانية من الطاقة = 14,092
مع الكي تبقى من الكمية الاولى = 0.3
فالطاقة الواصلة للنواه = 14,092.3

والكرة الثانية راح توقع باقي الاهداف (النواه انقلبت)

Protons in a Molecule

Depending on their chemical environment, protons in a molecule are shielded by different amounts.



اهم سلايد

NMR Signals

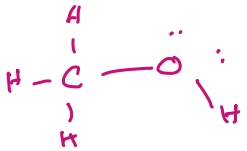
- The ***number*** of signals shows how many different kinds of protons are present.

- The ***location*** of the signals shows how shielded or deshielded the proton is.

withdrawing atoms مرتبط مع الـ

- The ***intensity*** of the signal shows the number of protons of that type.

- Signal ***splitting*** shows the number of protons on adjacent atoms.

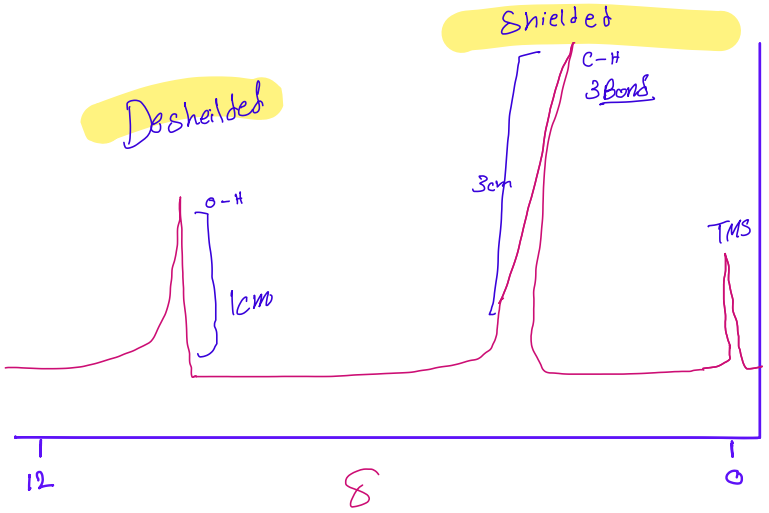


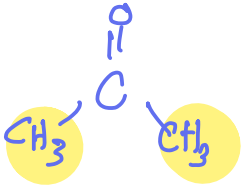
$\beta C:H$ ← sheilded

$\beta O:H$

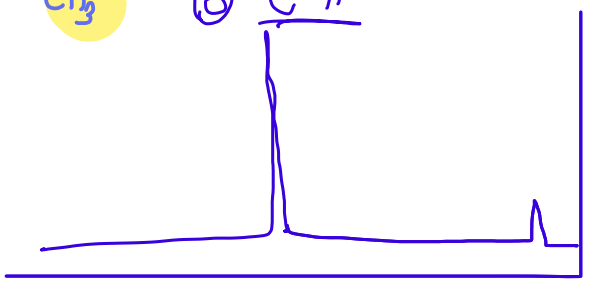
X> H electronegativity

كل ما زاد deshielded

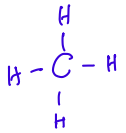


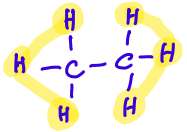


⑧ C-H



CH_4 ④ C-H





ethan

C_2H_6

$CH_3 - CH_3$

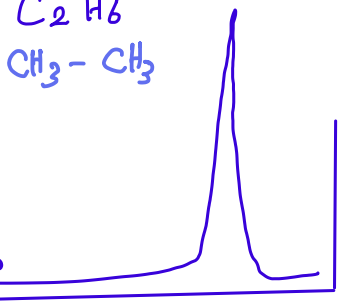
عالية Peak

$\beta C-H$

$\delta C-H$ فوق بعض مش

δ نفس المجموعة

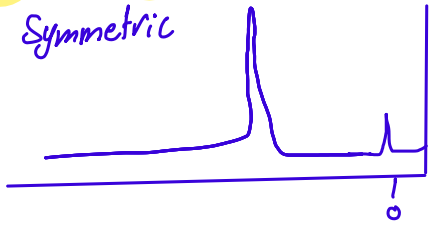
لكن مرتين



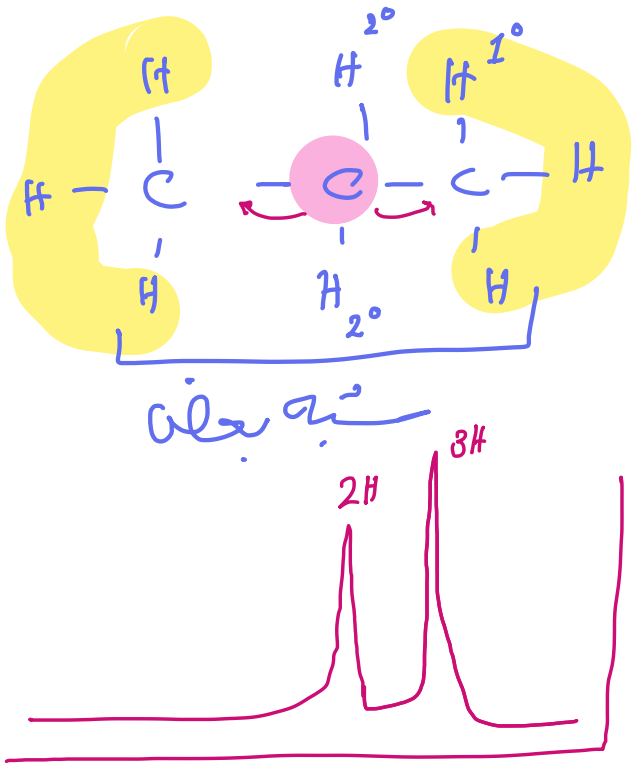
C_2H_2

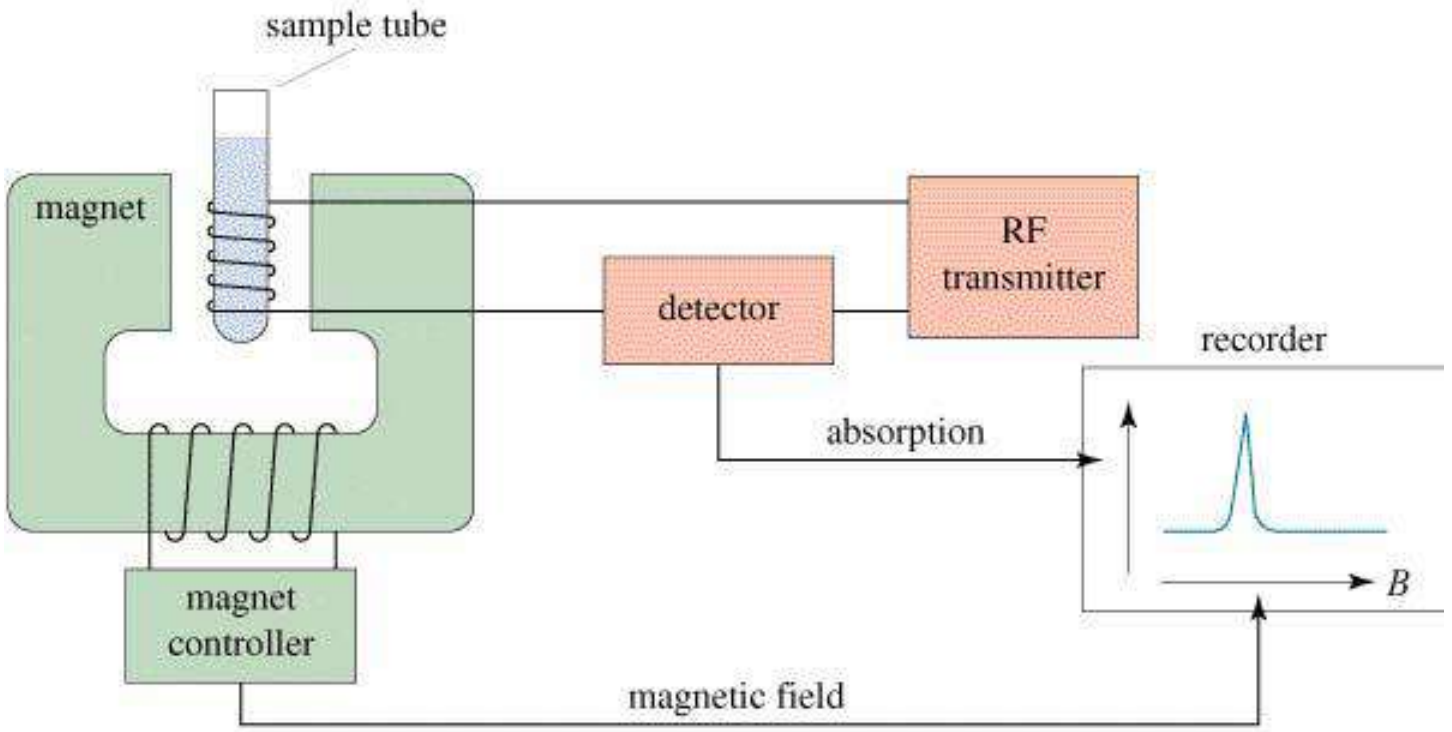
$H-C\equiv C-H$

Symmetric

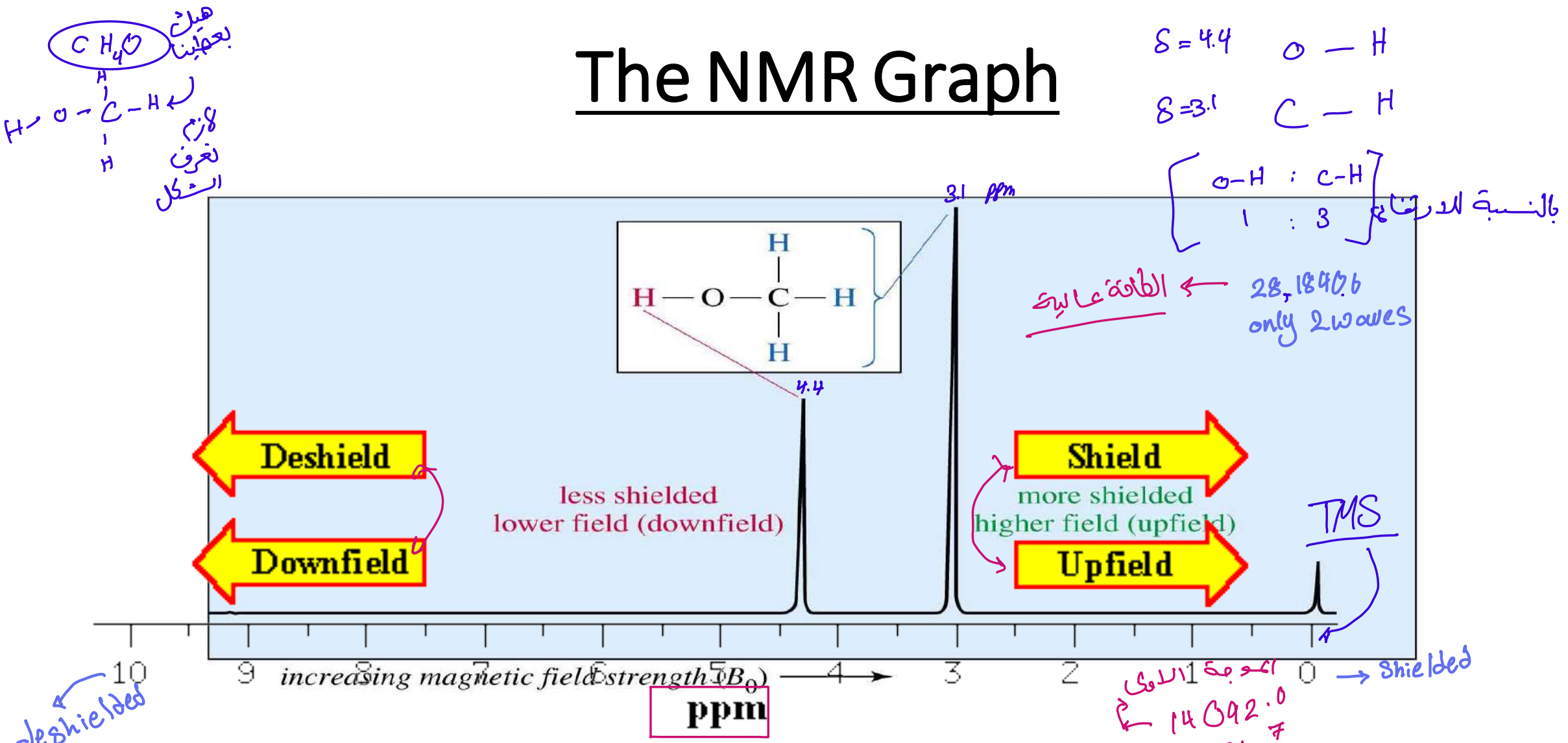


The NMR Spectrometer





The NMR Graph



$C H_4O$ هيك بعطينا

لازم نعرف الشكل

$\delta = 4.4$ O — H

$\delta = 3.1$ C — H

O-H : C-H

1 : 3

بالنسبة للارتفاع

الطاقة عالية ← 28,184.6 only 2 waves

Deshielded

الموجة الأولى ← 14092.0

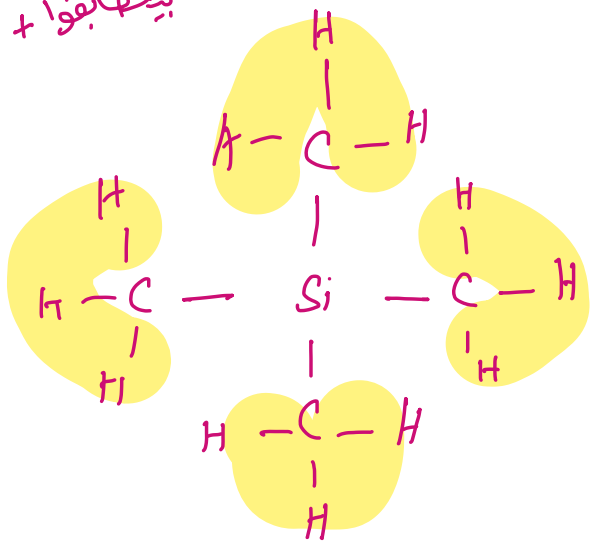
14091.7 ← اضطراب

0.3

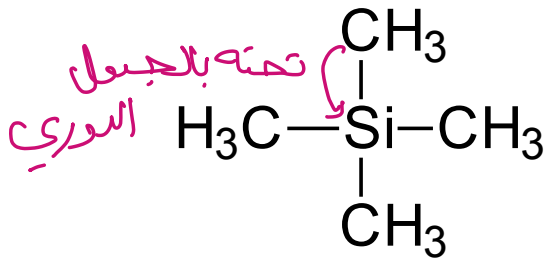
موجتين

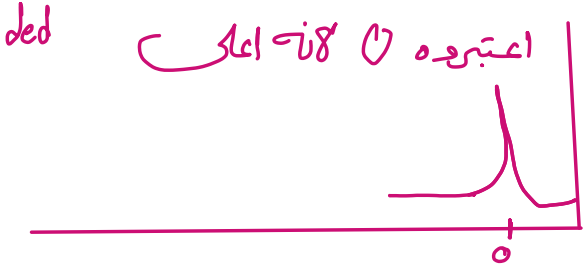
الباقي + موجة ← 14.092.3 ← الطاقة اقل

Shielded



Tetramethylsilane





- TMS is added to the sample.
- Since silicon is less electronegative than carbon, TMS protons are highly shielded. Signal defined as zero.
- Organic protons absorb downfield (to the left) of the TMS signal.

Chemical Shift

الهدف منها يوحد الـ X-axis
لكل الأجهزة بالتالي Chart
بتطلع متطابقة لنفس العينة
باختلاف الجهاز

- Measured in parts per million. ppm in X-axis
- Ratio of shift downfield from TMS (Hz) to total spectrometer frequency (Hz).
- Same value for 60, 100, or 300 MHz machine.
- Called the delta scale (δ).

Chemical Shift calculation

$$\delta = V_H - V_{TMS} / V_{NMR} \times 10^6 \text{ ppm}$$

δ= Chemical shift (ppm)

V_H= Frequency of proton

V_{TMS}= 0

V_{NMR}= 60 MHz or 100MHZ or 300 MHz

1MHz= 10^6 Hz

60 MHz = 14.092 G

$V_{NMR} = 90 \times 10^6$ Hz

$V_H = 300$ Hz

$\delta = \frac{300 - 0}{90 \times 10^6 \text{ ppm}} = 3.3$ ppm

$V_{NMR} = 22.6 \times 10^6$ Hz

$V_H = 480$ Hz

$\delta = \frac{480 \text{ Hz} - 0}{22.6 \times 10^6 \text{ Hz}} = 21.23$ ppm

تفريغ تحليل آلي

اسم الموضوع: NMR part 3
Hydrogen

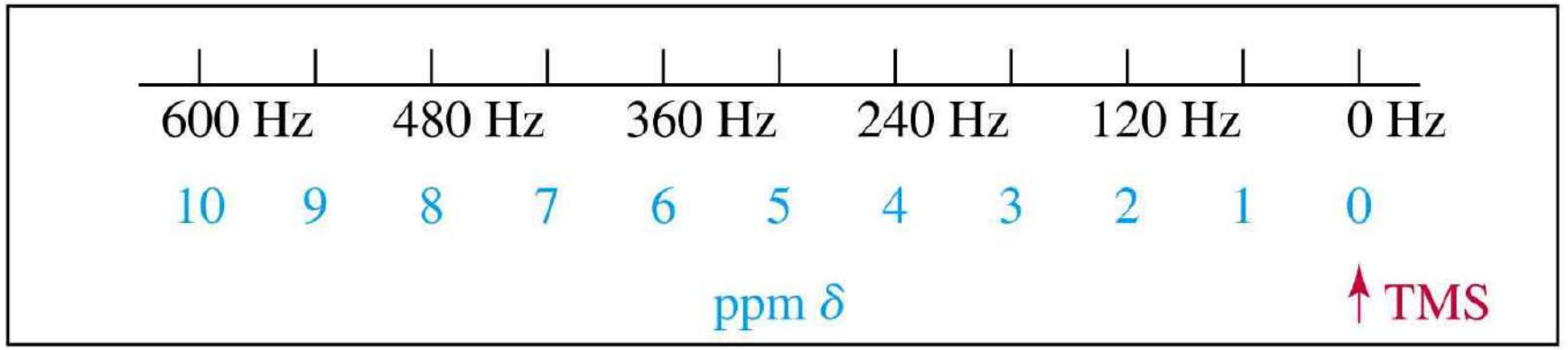
إعداد الصيدلاني/ـة: Sara jaber

Soul Academy

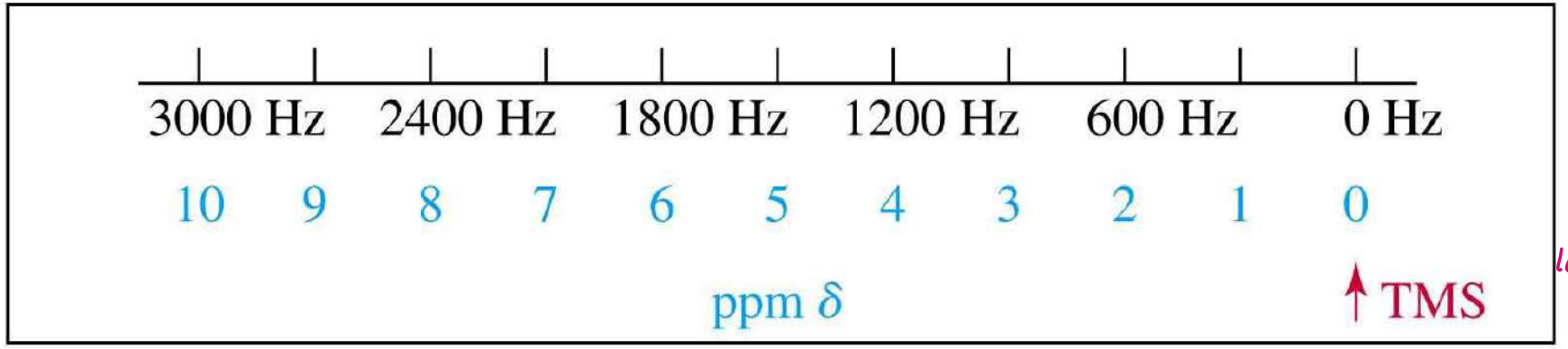
لجان الدفعات

Delta Scale

$$\text{chemical shift, ppm } \delta = \frac{\text{shift downfield from TMS (in Hz)}}{\text{spectrometer frequency (in MHz)}}$$



60 MHz ⟵ للجهاز



300 MHz

كلما δ ↑

C-H , O-H , N-H , F-H

low C-H < N-H < O-H < F-H high

F-H , Cl-H , Br-H , I-H

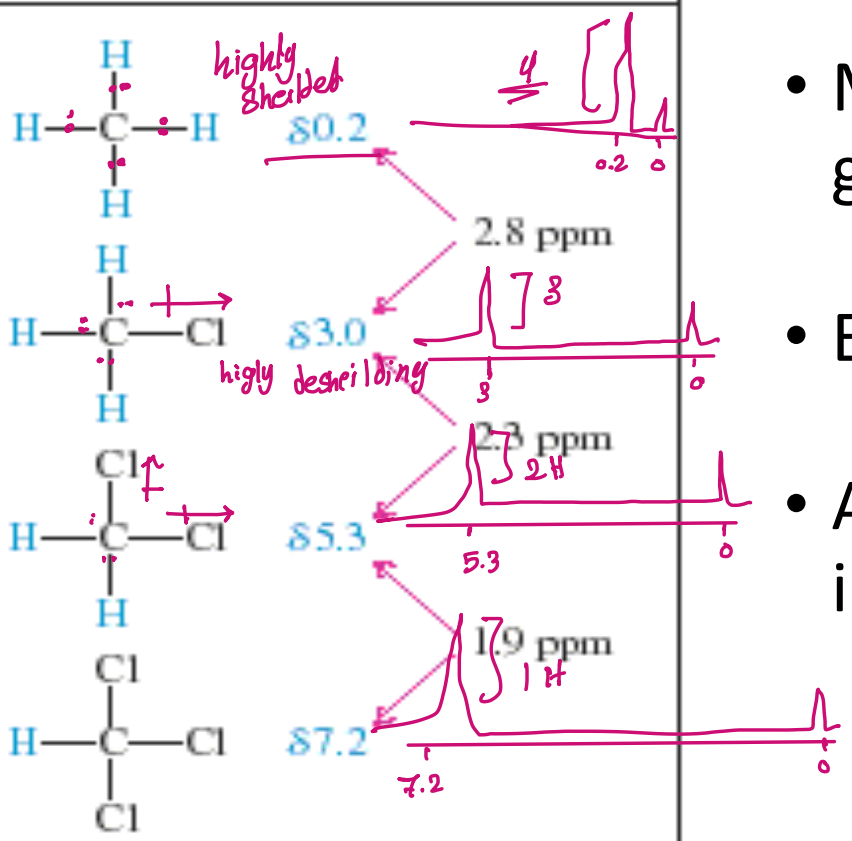
I > Br > Cl > F

Location of Signals

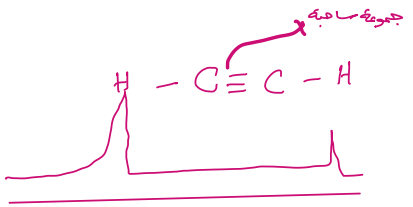
TABLE 13-2 Chemical Shifts of the Chloromethanes

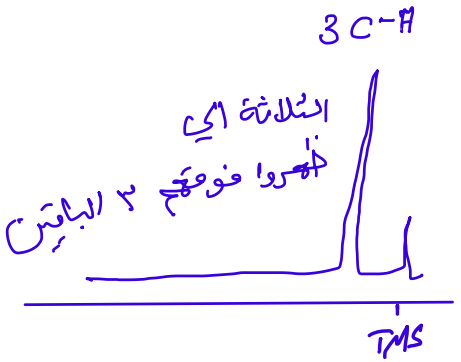
Compound	Chemical Shift	Difference
CH_4	0.2	
CH_3Cl	3.0	2.8 ppm
CH_2Cl_2	5.3	2.3 ppm
$CHCl_3$	7.2	1.9 ppm
CCl_4		

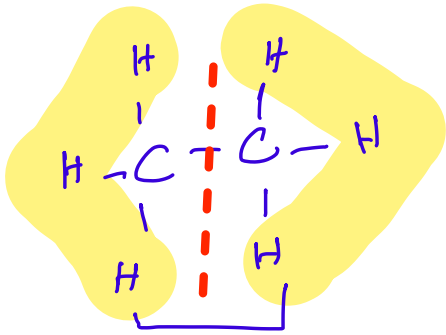
Note: Each chlorine atom added changes the chemical shift of the remaining methyl protons by about 2 to 3 ppm. These changes are nearly additive.



- More electronegative atoms deshield more and give larger shift values.
- Effect decreases with distance.
- Additional electronegative atoms cause increase in chemical shift.



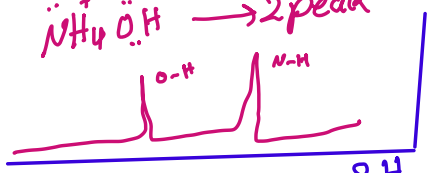




$CCl_4 \longrightarrow$ 0 peaks $\longrightarrow$ ماعندي H

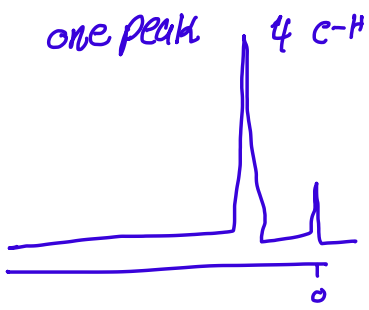
$NH_4 \longrightarrow$ 1 peak بارتفاع 4

$NH_4^+ OH^- \longrightarrow$ 2 peak



1° 2° 1°

C-Cl > C-C-Cl > C-C-C-Cl



Sheilded

$CHCl_3$	CH_2Cl_2	CH_3F	CH_3OH	CH_3Cl	CH_3Br	CH_3I	CH_4	$(CH_3)_4Si$
7.27	5.30	4.26	3.4	3.05	2.68	2.16	0.23	0

وهون 1H — 2H الارتفاع لـ — 3H الارتفاع لـ

high Negativ — أعلى Negative F من واحد جنب O

TMS Tetramethylsilian

highly deshielded

highly Sheilded

أسئلة الامتحان

Negative F > O > Cl

مجموعة ألكيل

CH_3CH_2F أعلى δ

CH_3CH_2OH

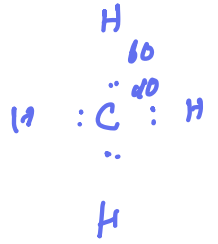
CH_3CH_2Cl أقل δ

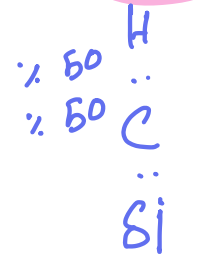
ذرة واحدة هي التي سحبت

Propan

1° 2° 1°

C-C-C



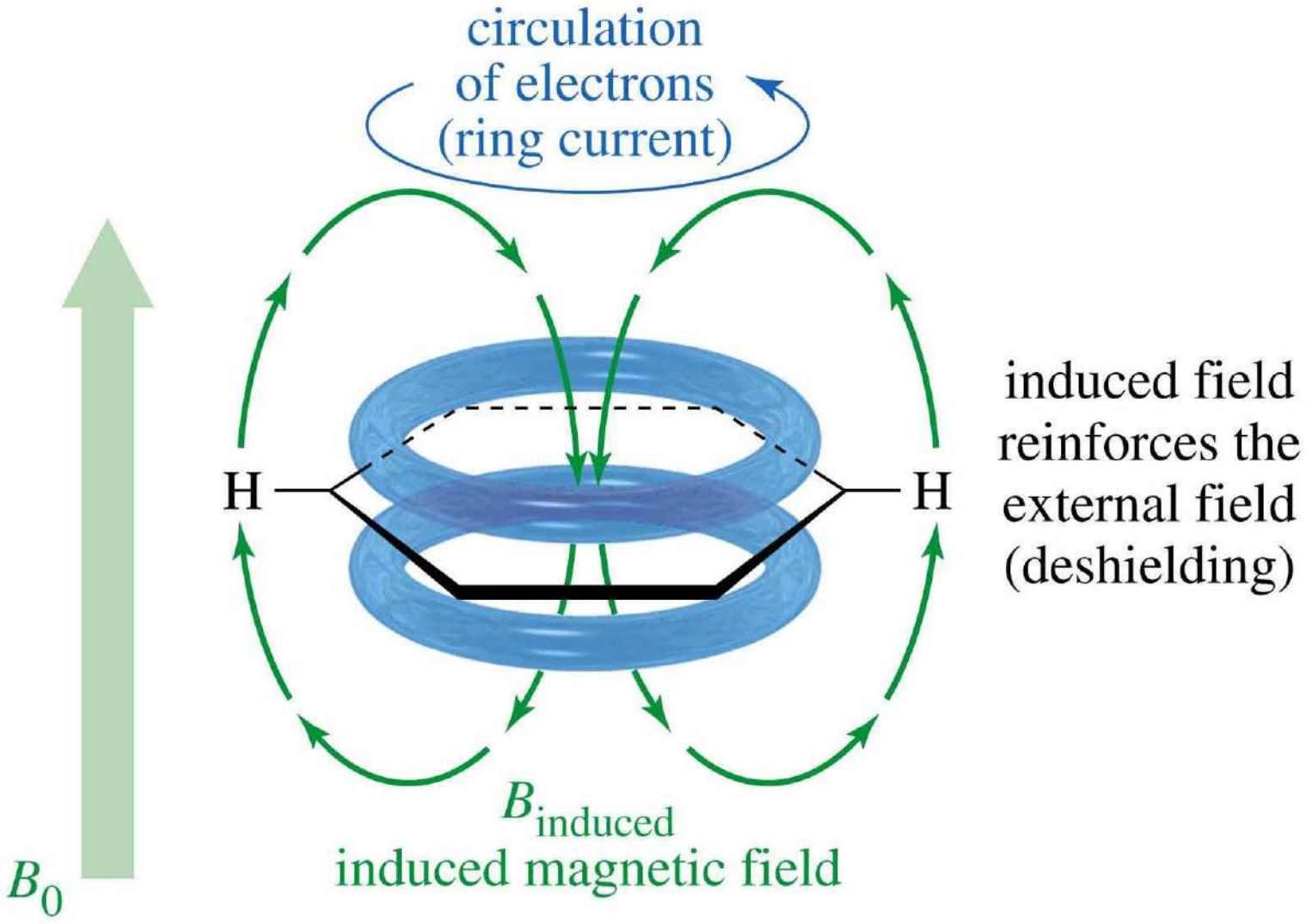


Typical Values

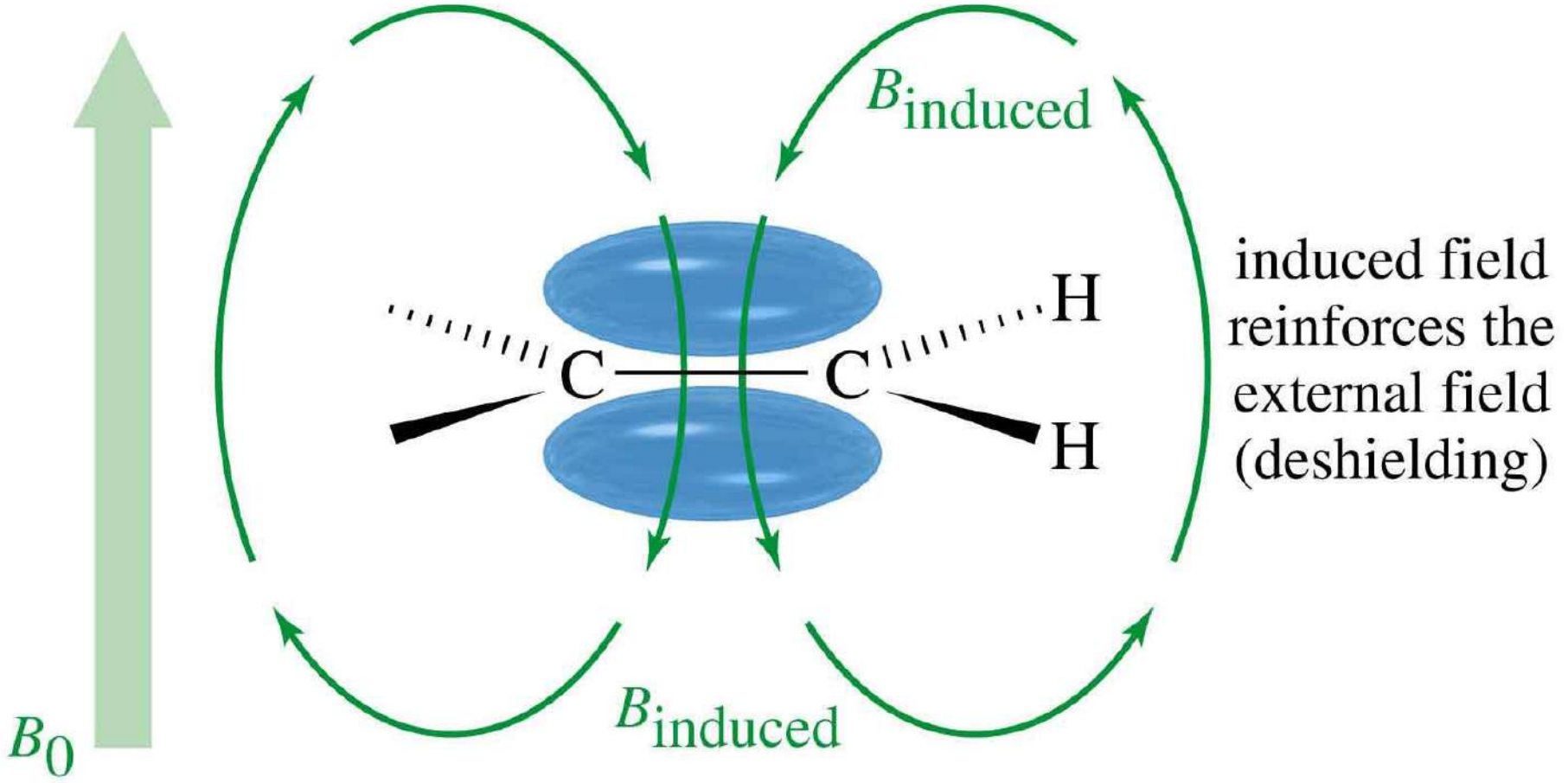
Type of Proton	Approximate δ
alkane (—CH_3)	0.9
alkane (—CH_2—)	1.3
alkane (—CH—)	1.4
O ‖ —C—CH_3	2.1
—C≡C—H	2.5
R—CH_2—X (X = halogen, O)	3–4
C=C(H)—	5–6
C=C—CH_3	1.7
Ph—H	7.2
Ph—CH_3	2.3
R—CHO	9–10
R—COOH	10–12
R—OH (aliphatic)	variable, about 2–5
Ar—OH (aromatic)	variable, about 4–7
R—NH_2	variable, about 1.5–4

Note: These values are approximate, as all chemical shifts are affected by neighboring substituents. The numbers given here assume that alkyl groups are the only other substituents present. A more complete table of chemical shifts appears in Appendix 1.

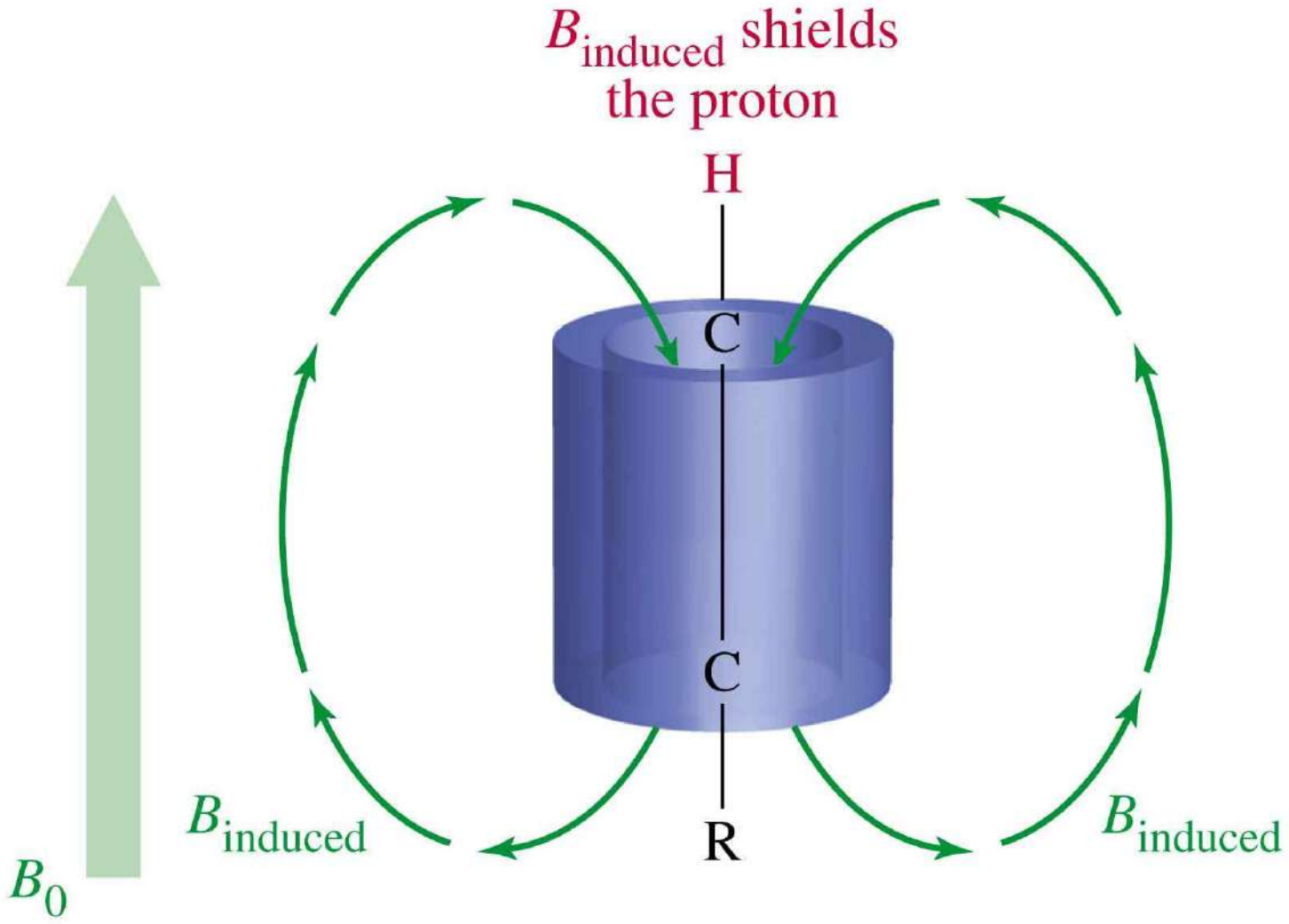
Aromatic Protons, δ7-δ8



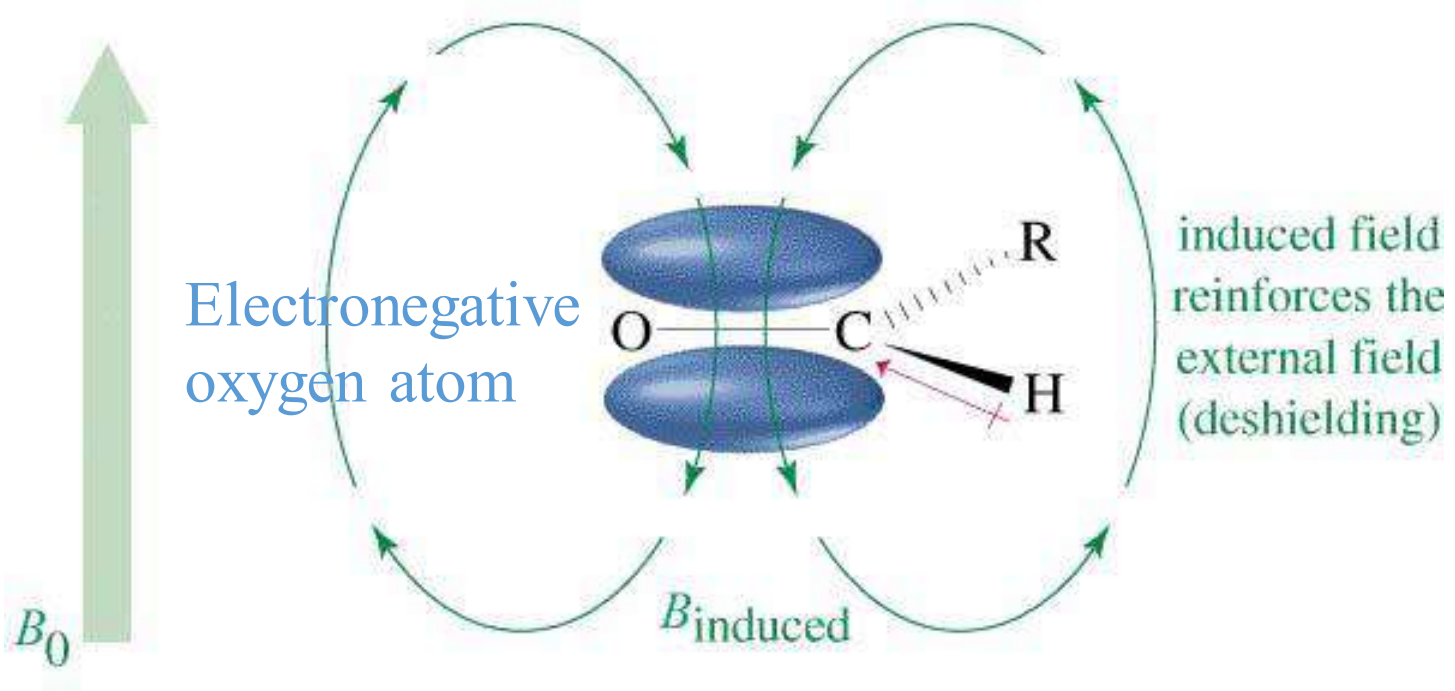
Vinyl Protons, δ5-δ6



Acetylenic Protons, δ2.5

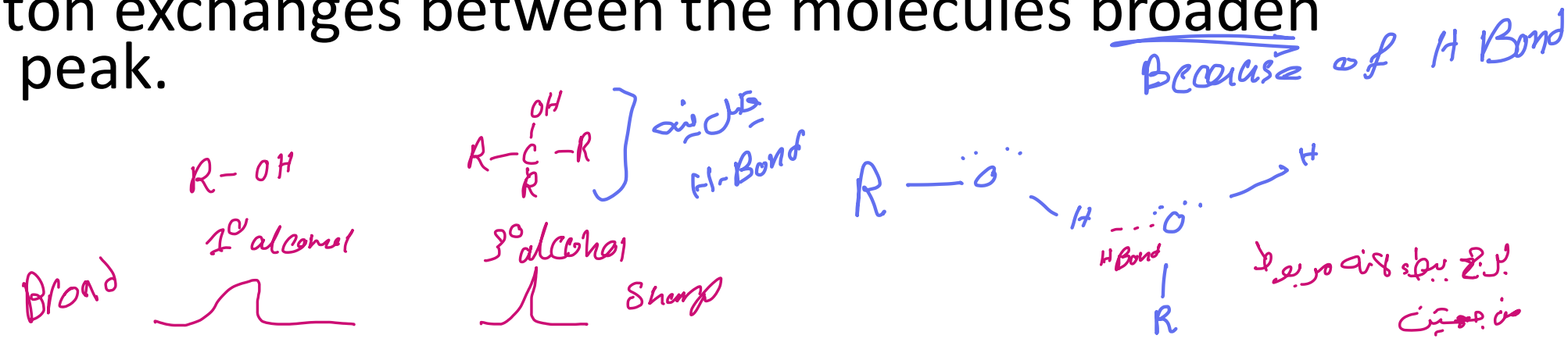


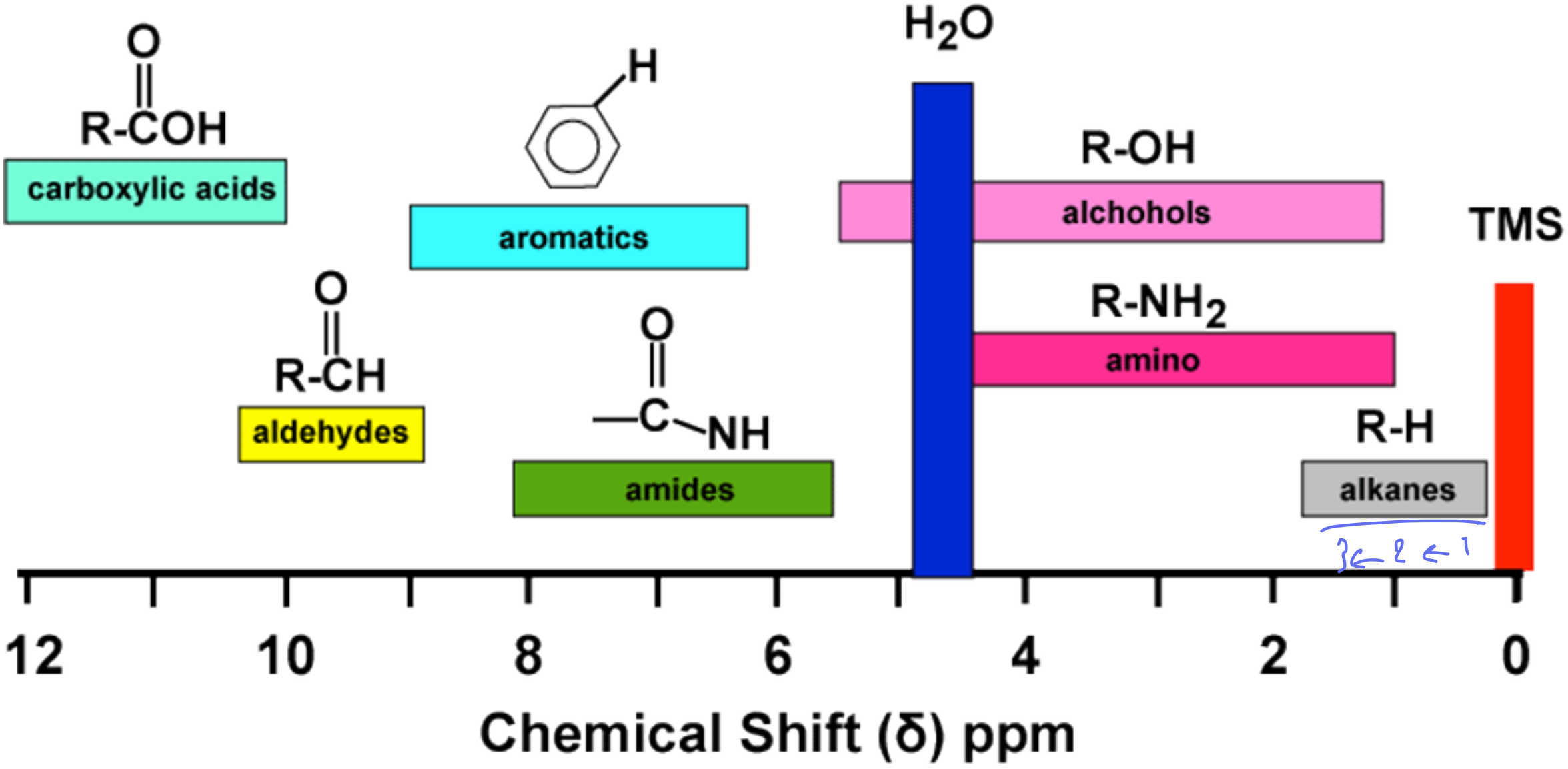
Aldehyde Proton, δ9-δ10



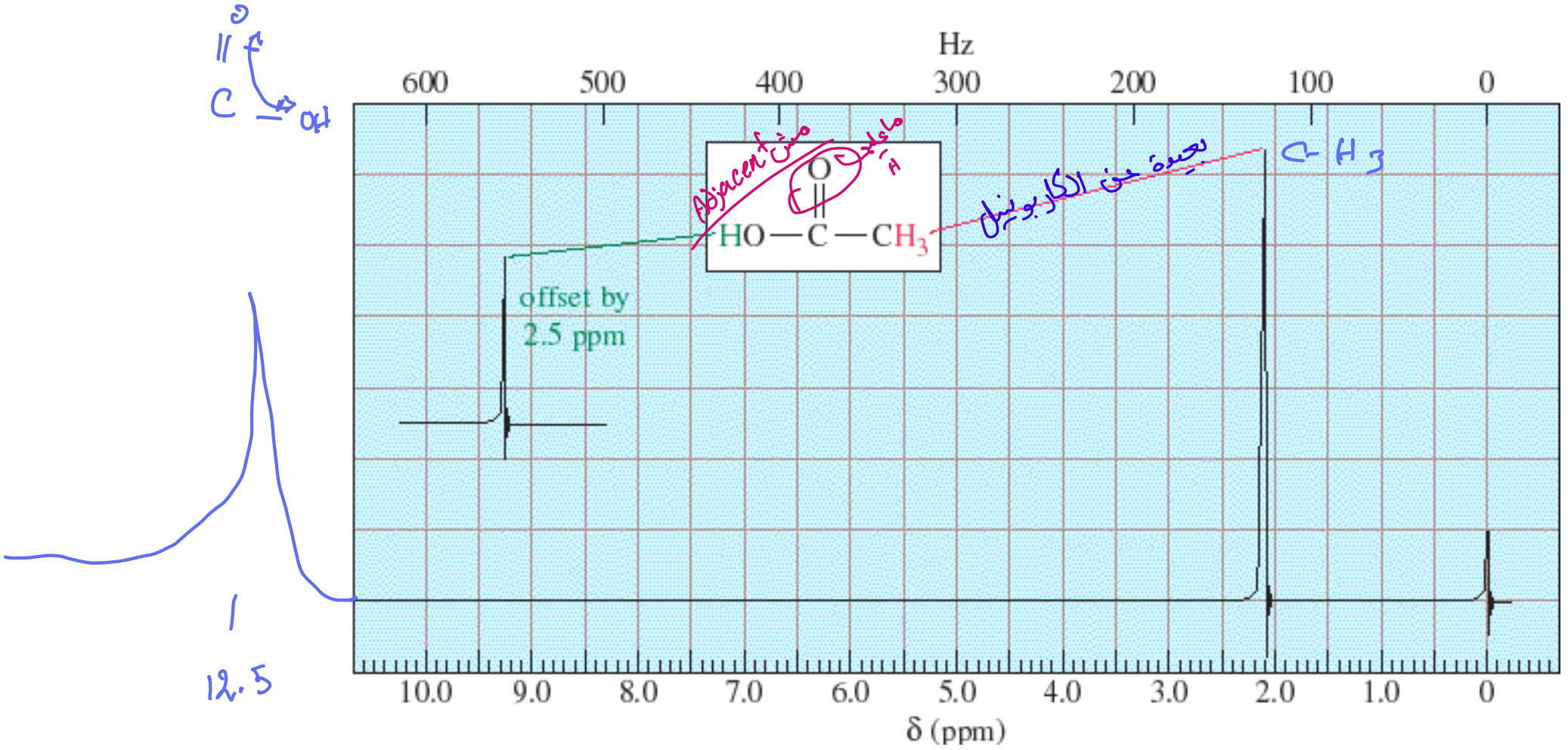
O-H and N-H Signals

- Chemical shift depends on concentration.
- Hydrogen bonding in concentrated solutions deshield the protons, so signal is around δ3.5 for N-H and δ4.5 for O-H.
- Proton exchanges between the molecules broaden the peak.



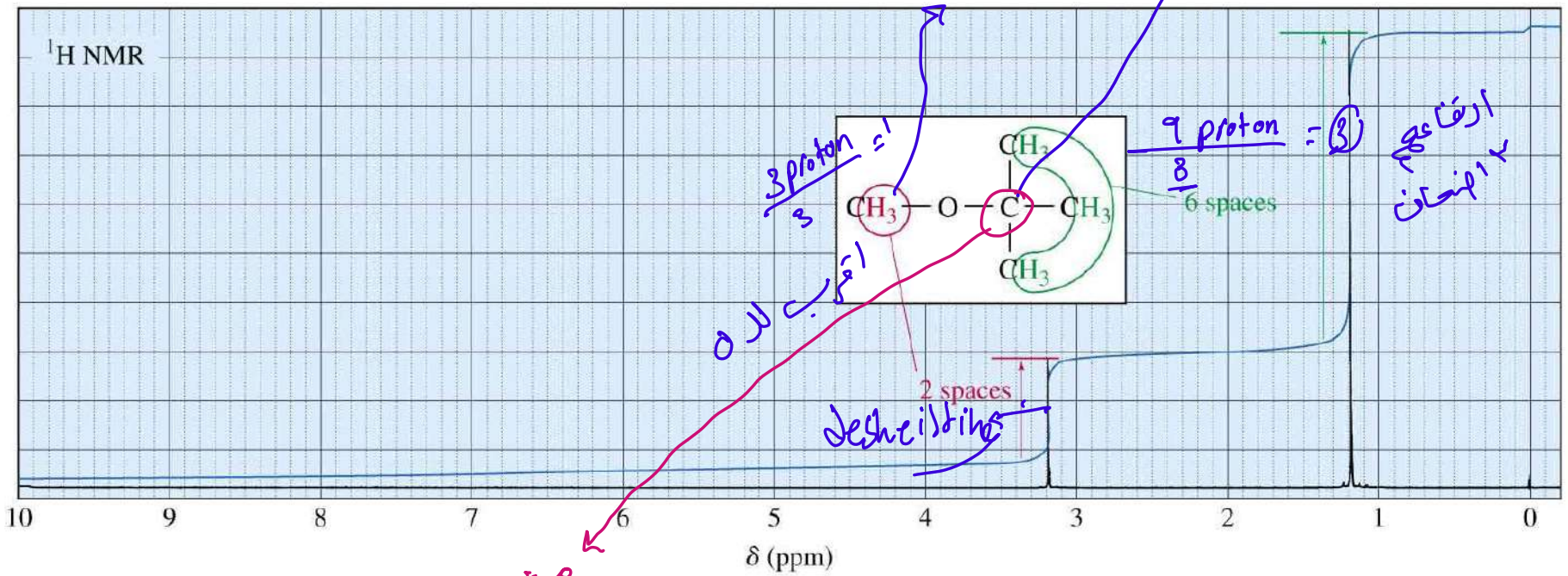

O
R-COH
carboxylic acids
H
aromatics
H_2O
R-OH
alchohols
TMS
O
R-CH
aldehydes
O
C
NH
amides
$R-NH_2$
amino
R-H
alkanes
12
10
8
6
4
2
0
Chemical Shift (δ) ppm

Carboxylic Acid Proton, δ10+



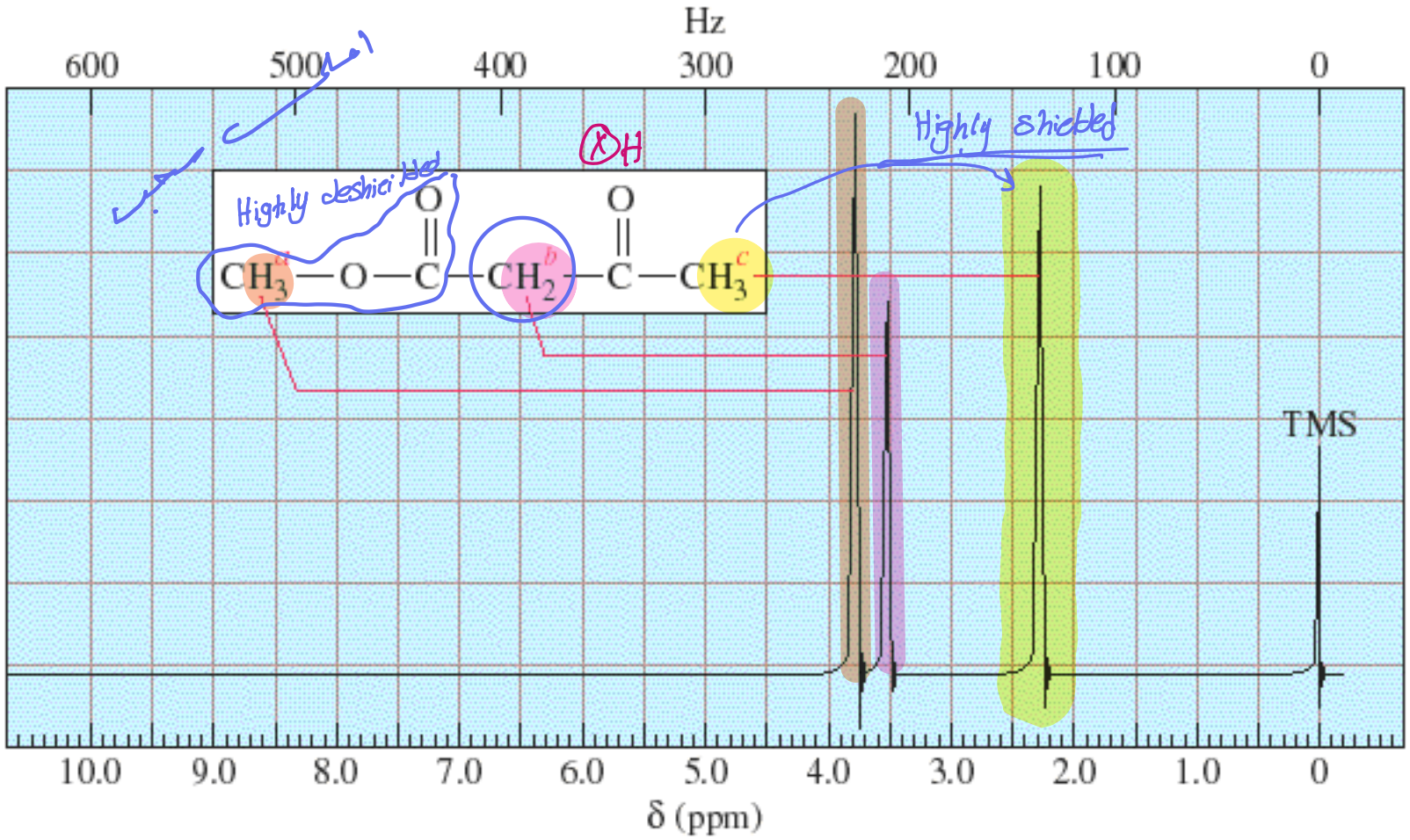
Intensity of Signals

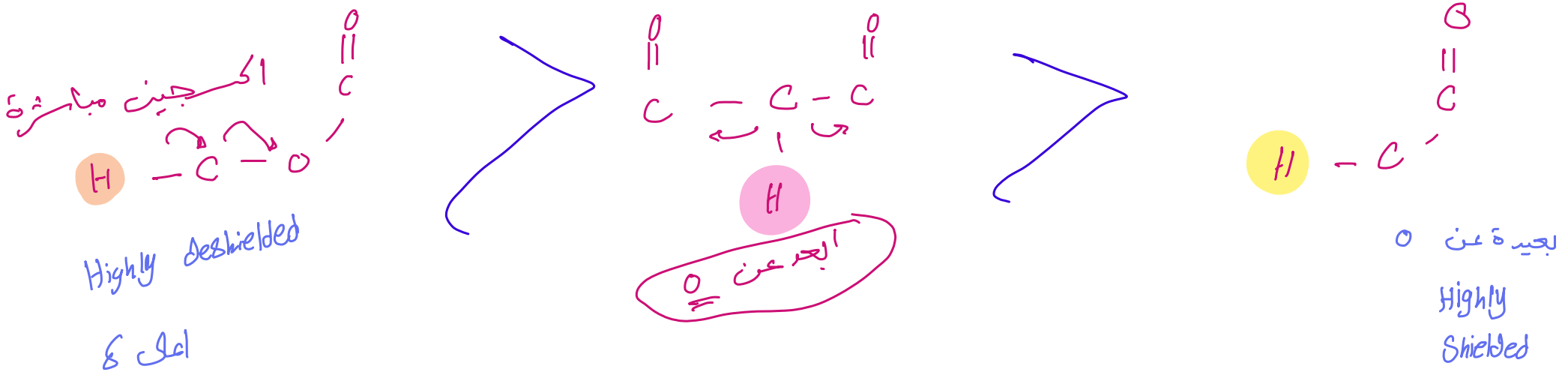
- The area under each peak is proportional to the number of protons.
- Shown by integral trace.



Number of Signals

Equivalent hydrogens have the same chemical shift.




الأكسجين مباشرة
Highly deshielded
أعلى δ
البعد عن O
بعيدة عن O
Highly
Shielded

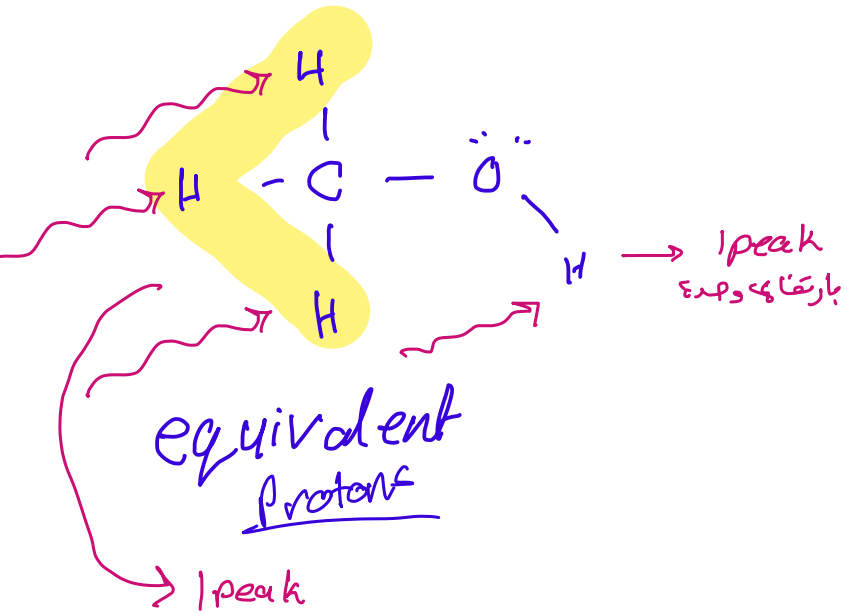
تفريغ تحليل آلي

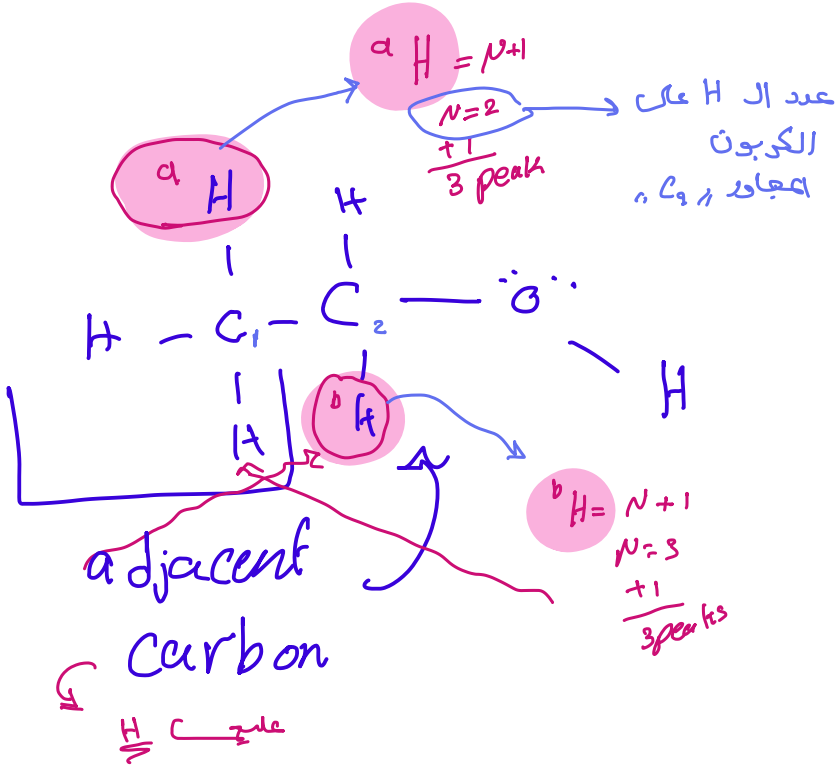
اسم الموضوع: NMR part 4

إعداد الصيدلاني/ـة: Sara Jaber

Seul Academy

لجان الدفعات



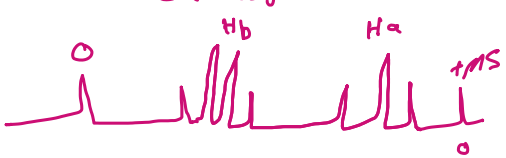


الـ splitting هون بيتداخل ويصطدم مع الـ H المجاورة وبعمل

✨Splitting✨

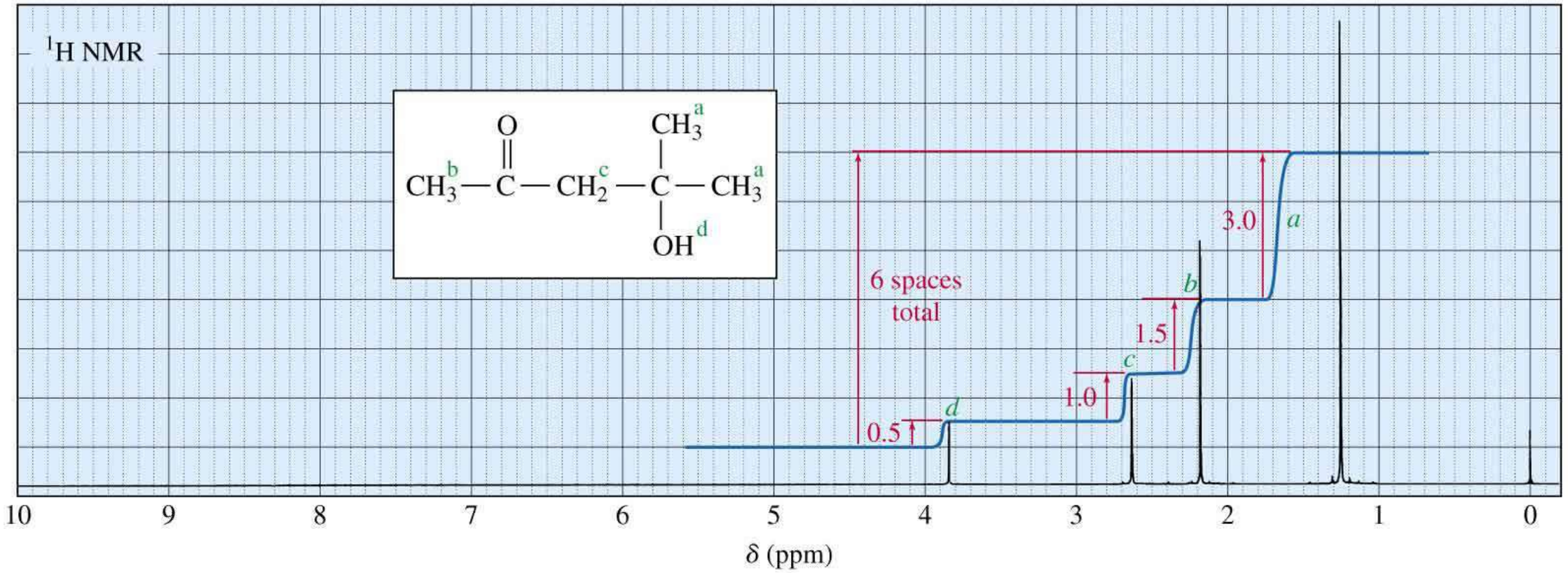
N ⇒ number of Proton on adjacent carbon

N+1 = القاعدة ←



How Many Hydrogens?

When the molecular formula is known, each integral rise can be assigned to a particular number of hydrogens.



The *N* + 1 Rule

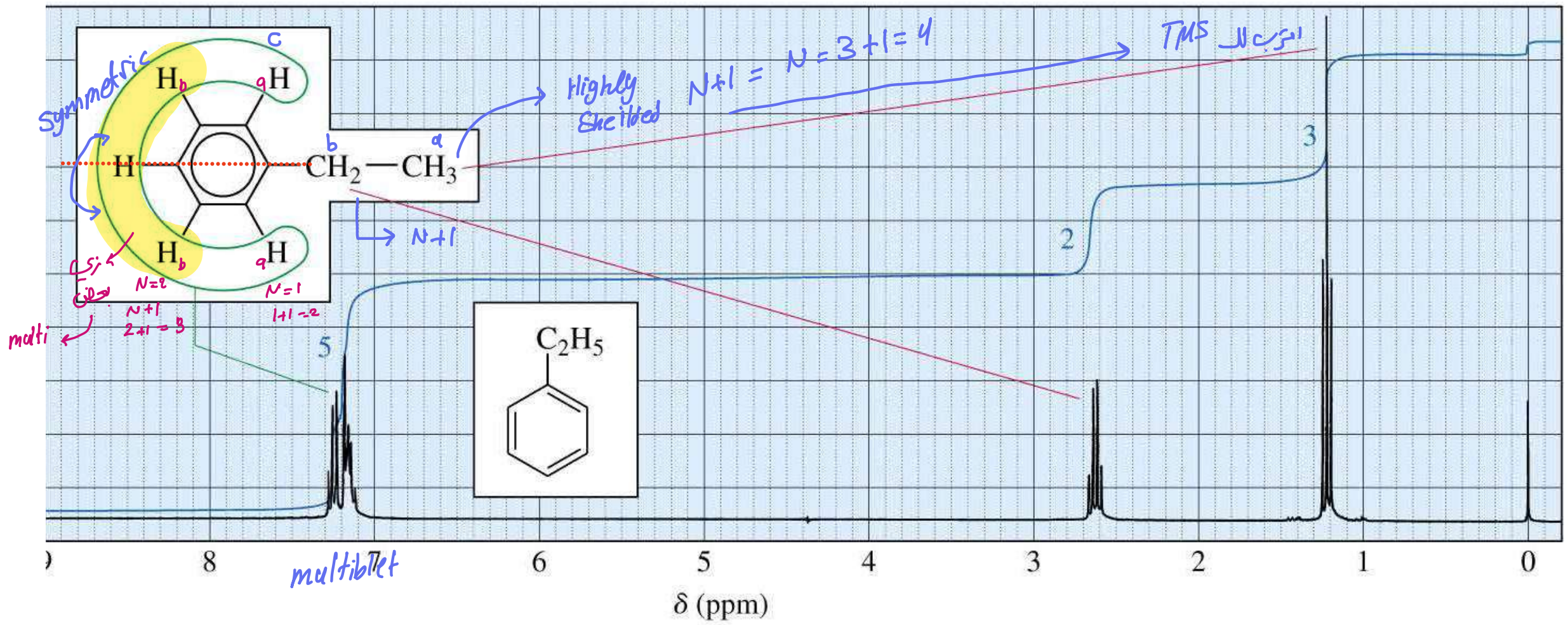
If a signal is split by *N* equivalent protons, it is split into *N* + 1 peaks.

Relative Peak Intensities of Symmetric Multiplets		
Number of Equivalent Protons Causing Splitting	*Number of Peaks (multiplicity)*	*Area Ratios (Pascal's triangle)*
0	1 (singlet)	1
1	2(doublet)	1 1
2	3 (triplet)	1 2 1
3	4 (quartet)	1 3 3 1
4	5 (quintet)	1 4 6 4 1
5	6 (sextet)	1 5 10 10 5 1
6	7 (septet)	1 6 15 20 15 6 1

Range of Magnetic Coupling

- Equivalent protons do not split each other.
- Protons bonded to the same carbon will split each other only if they are not equivalent.
- Protons on adjacent carbons normally will couple.
- Protons separated by four or more bonds will not couple.

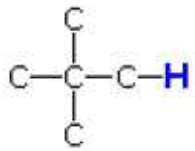
Splitting for Ethyl Groups



only or Bond

No Coupled Hydrogens

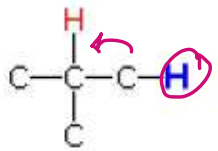
No Adj



N = 0

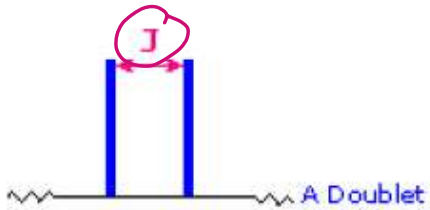
0+1 = 1

One Coupled Hydrogen

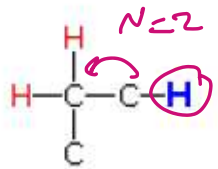


N = 1

1+1 = 2

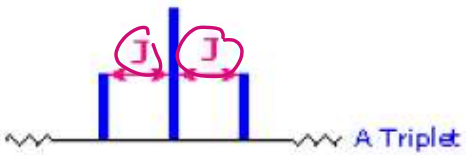


Two Coupled Hydrogens

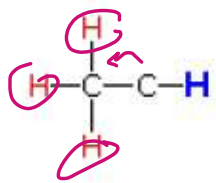


N = 2

2+1 = 3



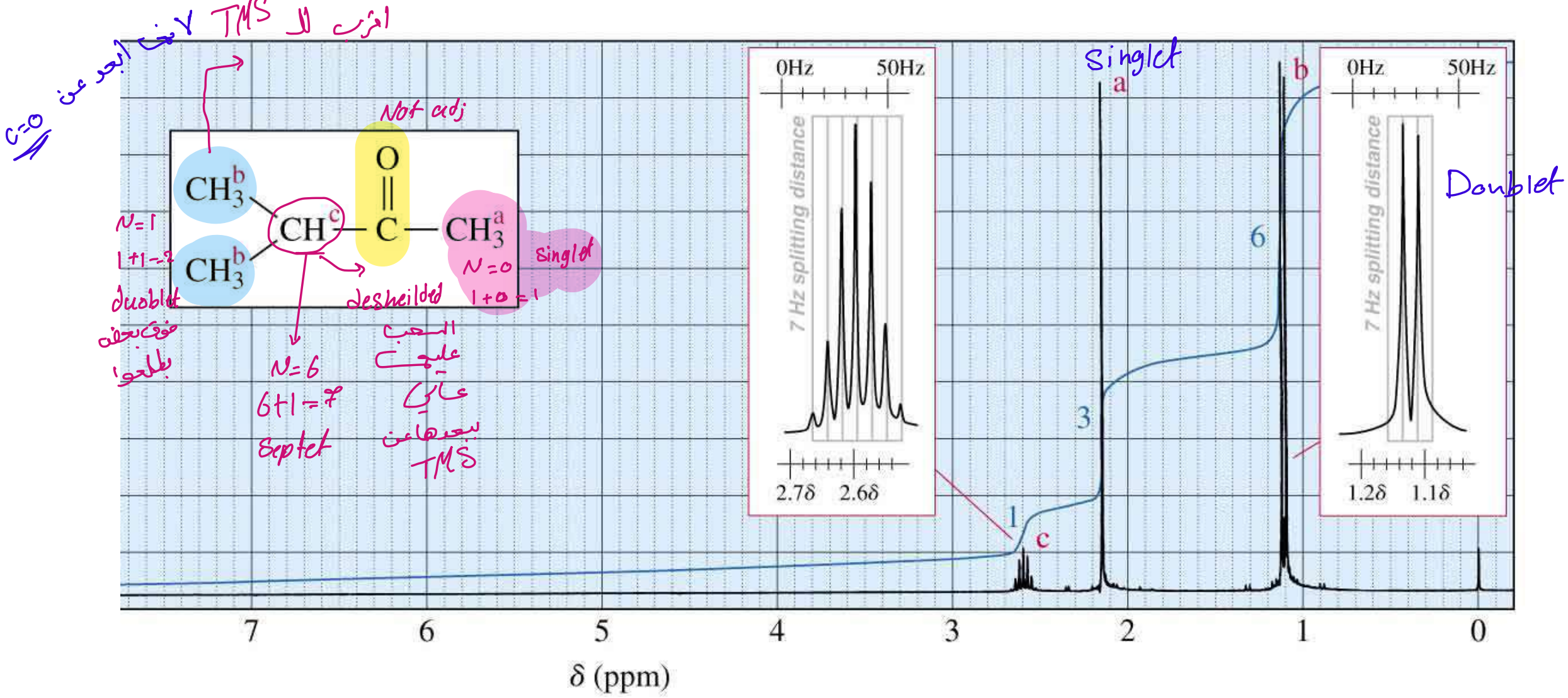
Three Coupled Hydrogens



N = 3

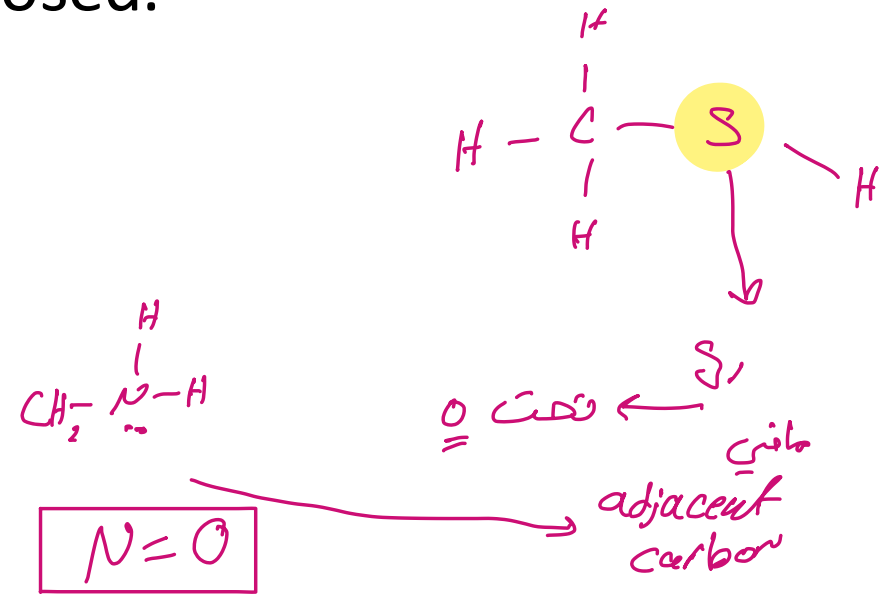
3+1 = 4

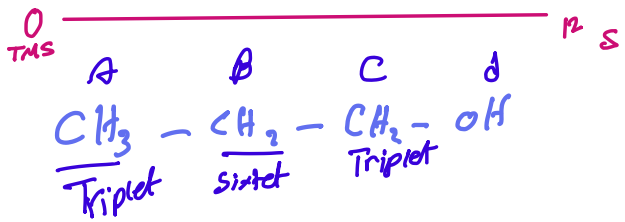
Splitting for Isopropyl Groups



Spin-Spin Splitting

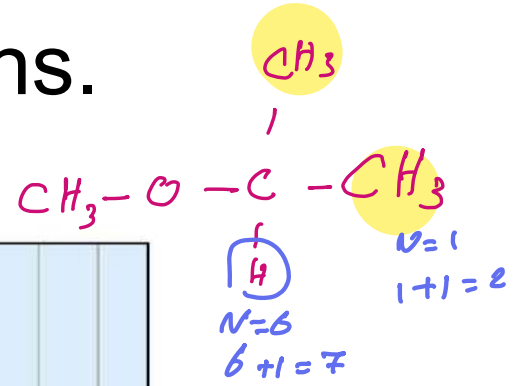
- Nonequivalent protons on adjacent carbons have magnetic fields that may align with or oppose the external field.
- This magnetic coupling causes the proton to absorb slightly downfield when the external field is reinforced and slightly upfield when the external field is opposed.
- All possibilities exist, so signal is split.

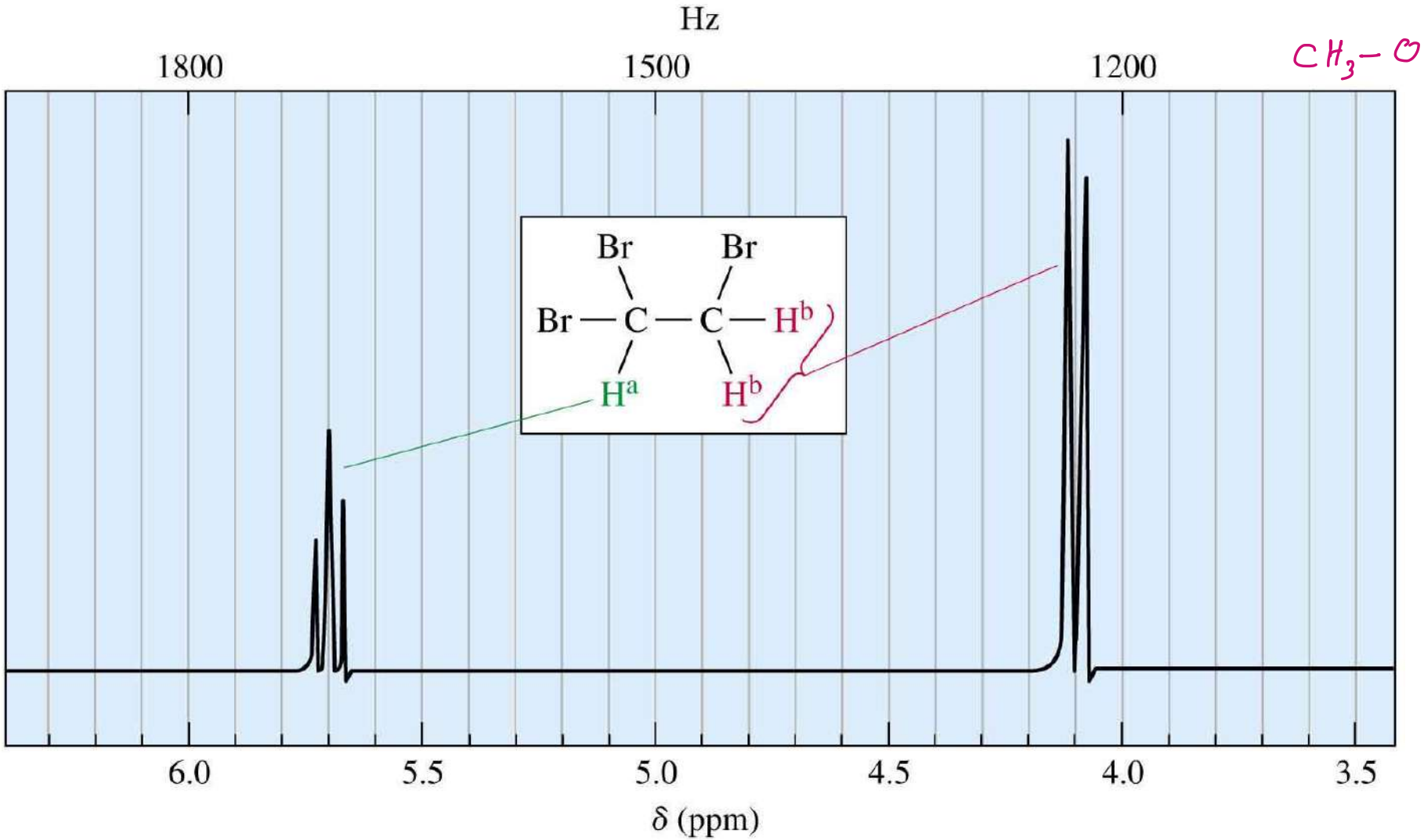




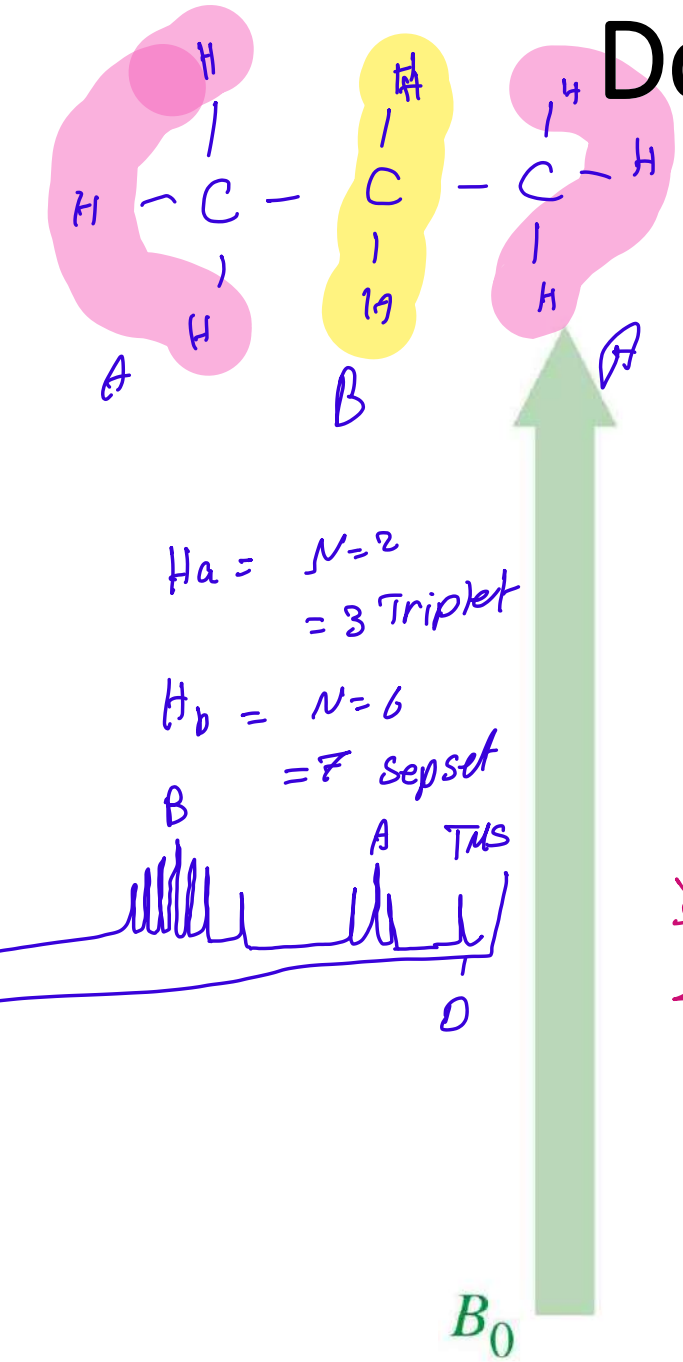
1,1,2-Tribromoethane

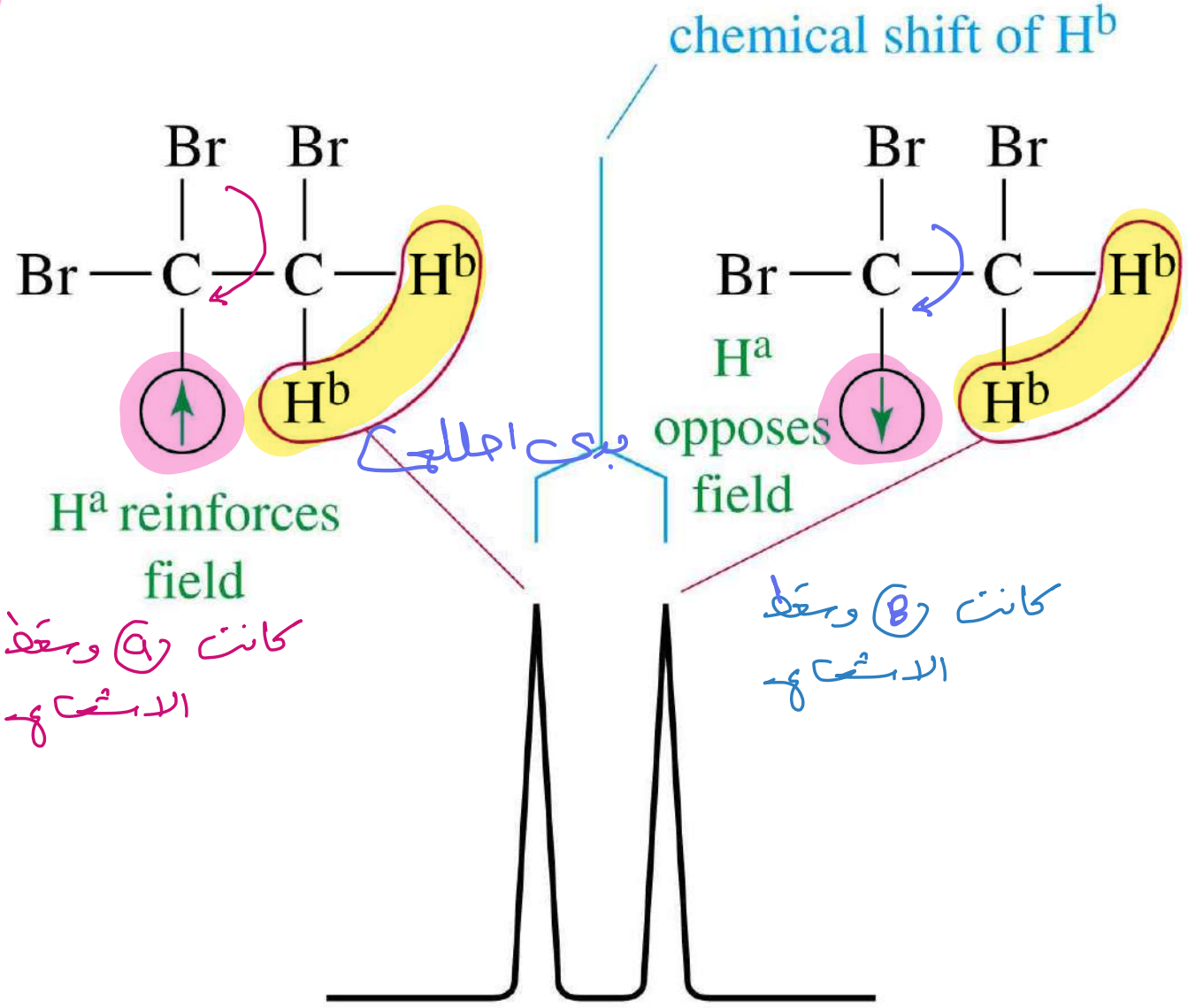
Nonequivalent protons on adjacent carbons.



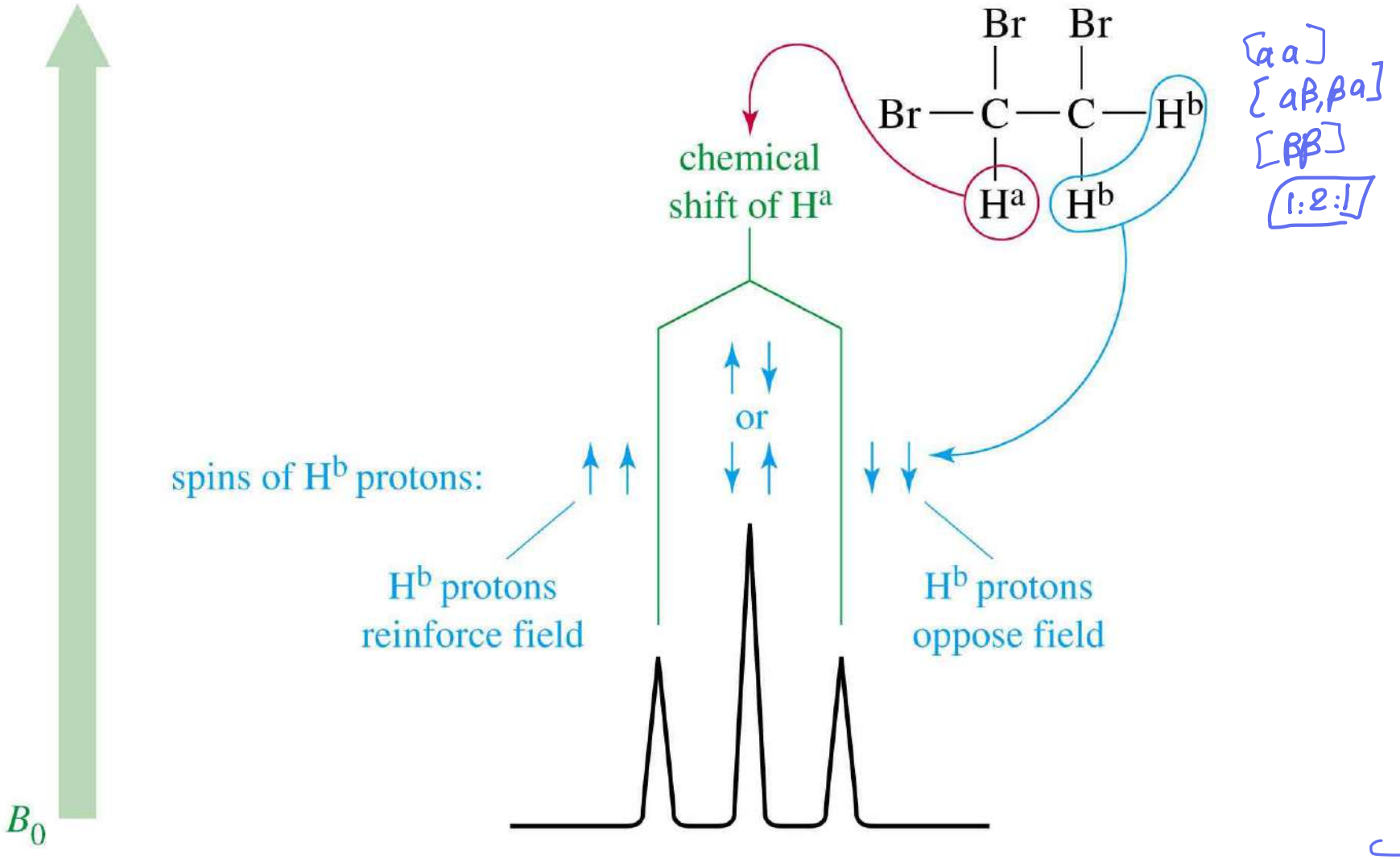


Doublet: 1 Adjacent Proton





Triplet: 2 Adjacent Protons

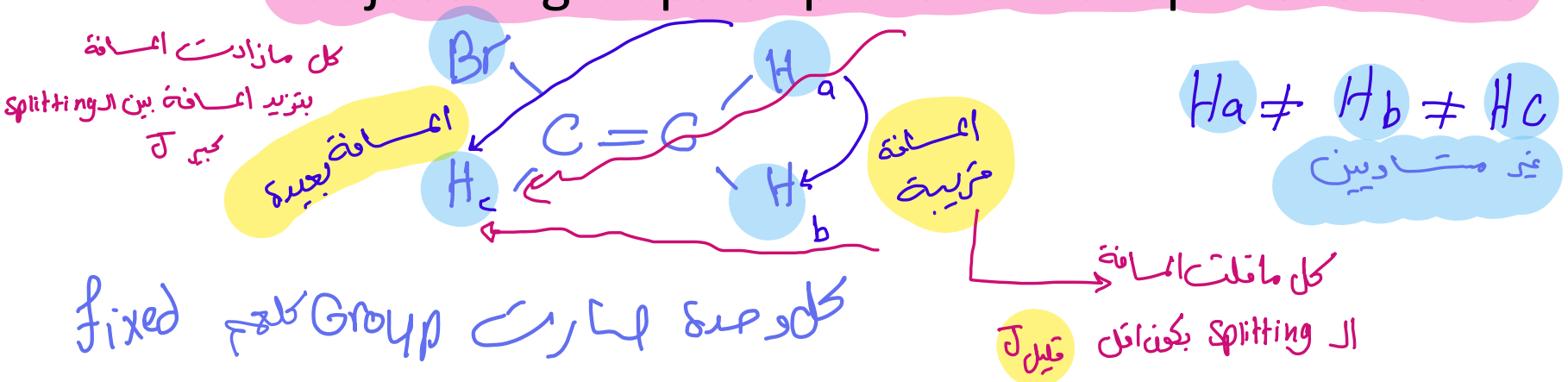


[a a]
[aβ, βa]
[ββ]
1:2:1

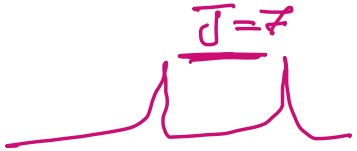
كل المركبات
لحد الآن ...

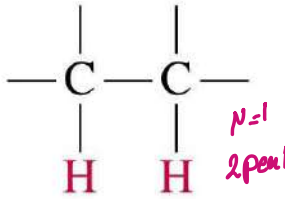
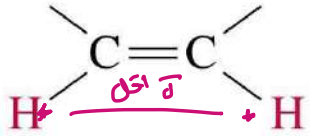
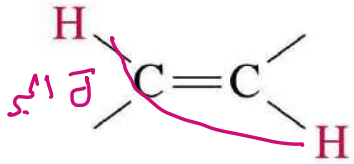
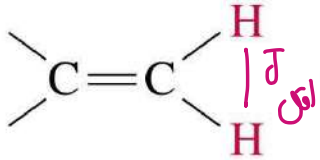
Coupling Constants

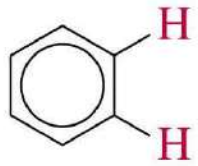
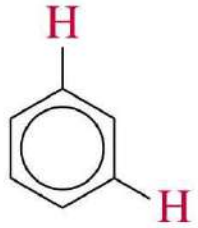
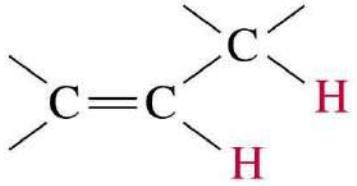
- Distance between the peaks of multiplet
- Measured in Hz
- Not dependent on strength of the external field
- Multiplets with the same coupling constants may come from adjacent groups of protons that split each other.



Values for Coupling Constants

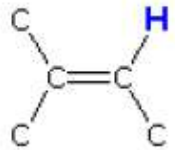


	Approx. J
 (free rotation)	7 Hz[a]
 (cis)	10 Hz
 (trans)	15 Hz
 (geminal)	2 Hz

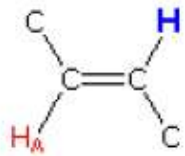
	Approx. J
 (ortho)	8 Hz
 (meta)	2 Hz
 (allylic)	6 Hz

[a]The value of 7 Hz in an alkyl group is averaged for rapid rotation about the carbon–carbon bond. If rotation is hindered by a ring or bulky groups, other splitting constants may be observed.

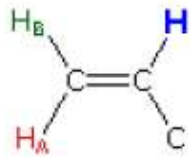
No Coupled Hydrogens



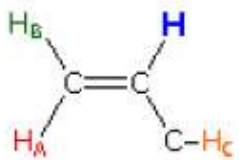
One Coupled Hydrogen

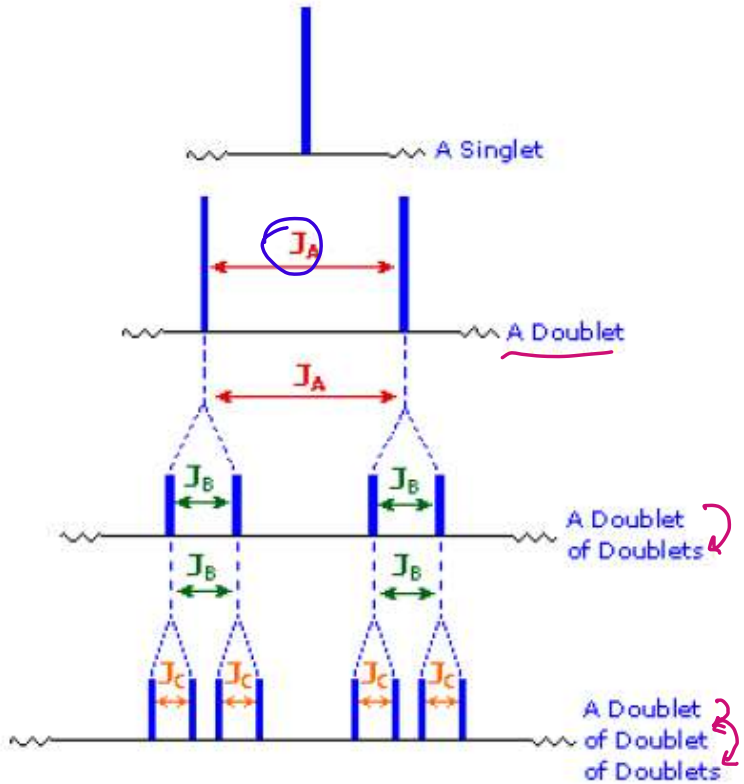


Two Coupled Hydrogens

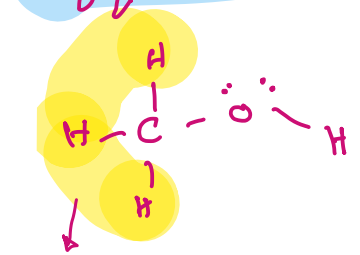


Three Coupled Hydrogens





Equivalent proton



بطبق قاعدة N+1

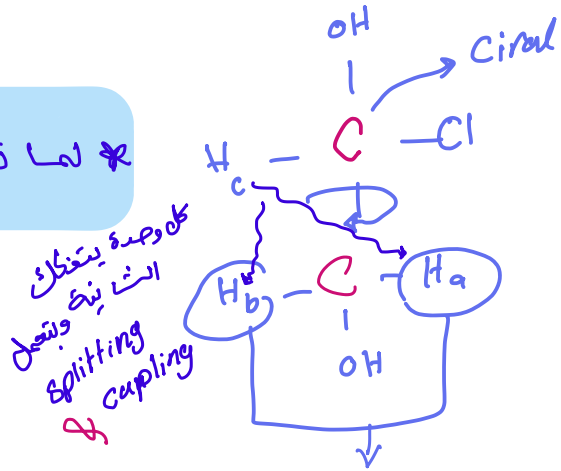
مستويين adjacent ماعني carbon splitting فاعني

Non-Equivalent proton = Coupling Bond (= ≡ ⬡)

Ring

N+1 ما بطبق

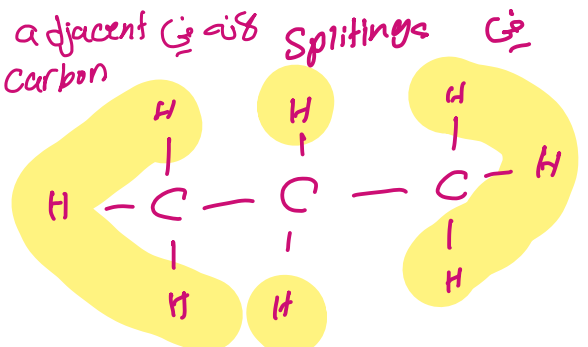
* لما تكون Non equivalent بتكون Ciral



كل وحدة بتعتلك الشبكة وبتعمل splitting & capling

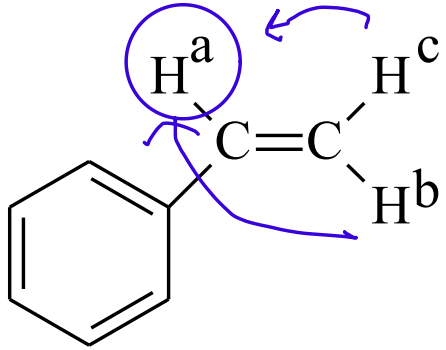
Ha ≠ Hb

مع انهم قاعدين بلغوا لكن بمقدار غير متساوي



Ciral كلهم ٥ معدا اذا كان

Complex Splitting ⇒ Splittin & Coupling

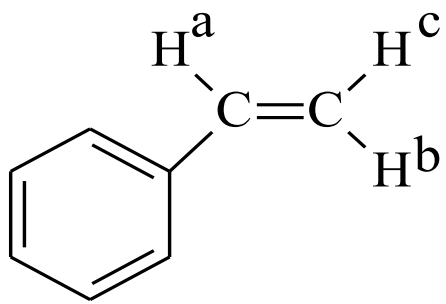


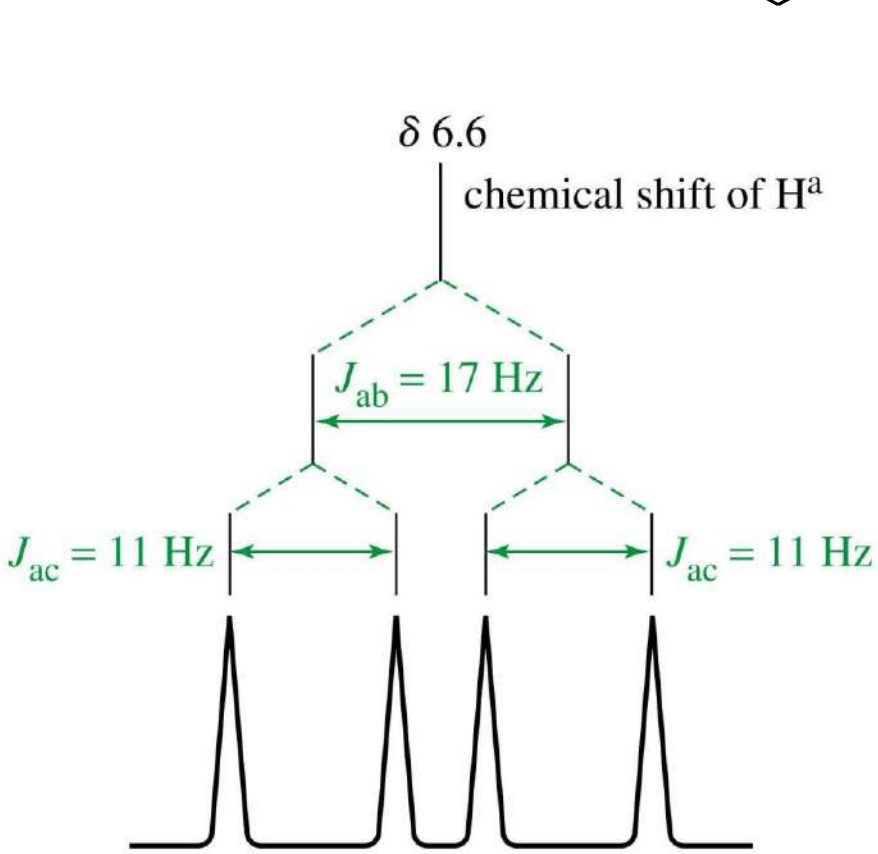
$H_a \neq H_b \neq H_c$

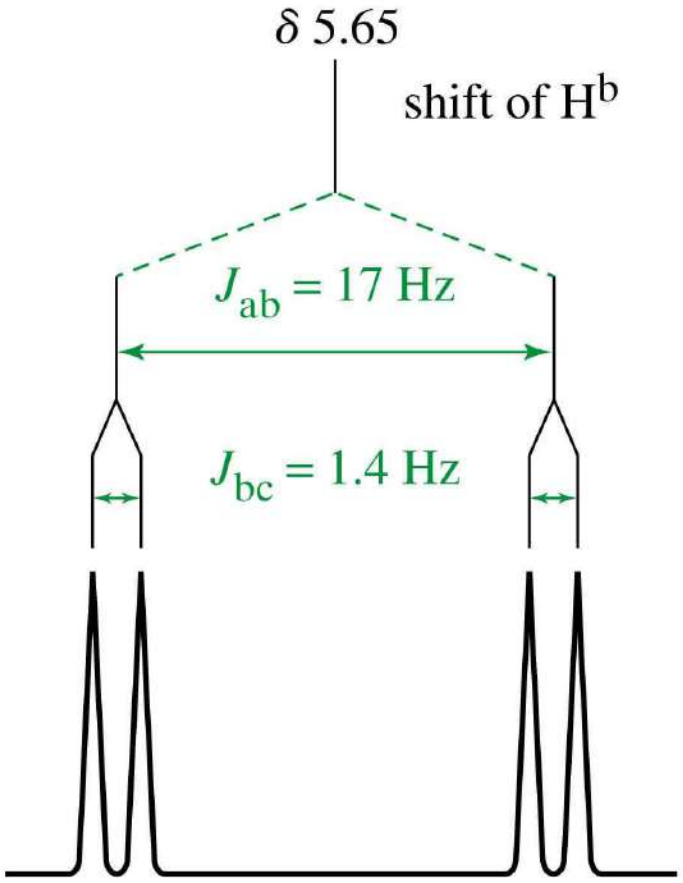
- Signals may be split by adjacent protons, different from each other, with different coupling constants.

- Example: H^a of styrene which is split by an adjacent H *trans* to it (J = 17 Hz) and an adjacent H *cis* to it (J = 11 Hz).

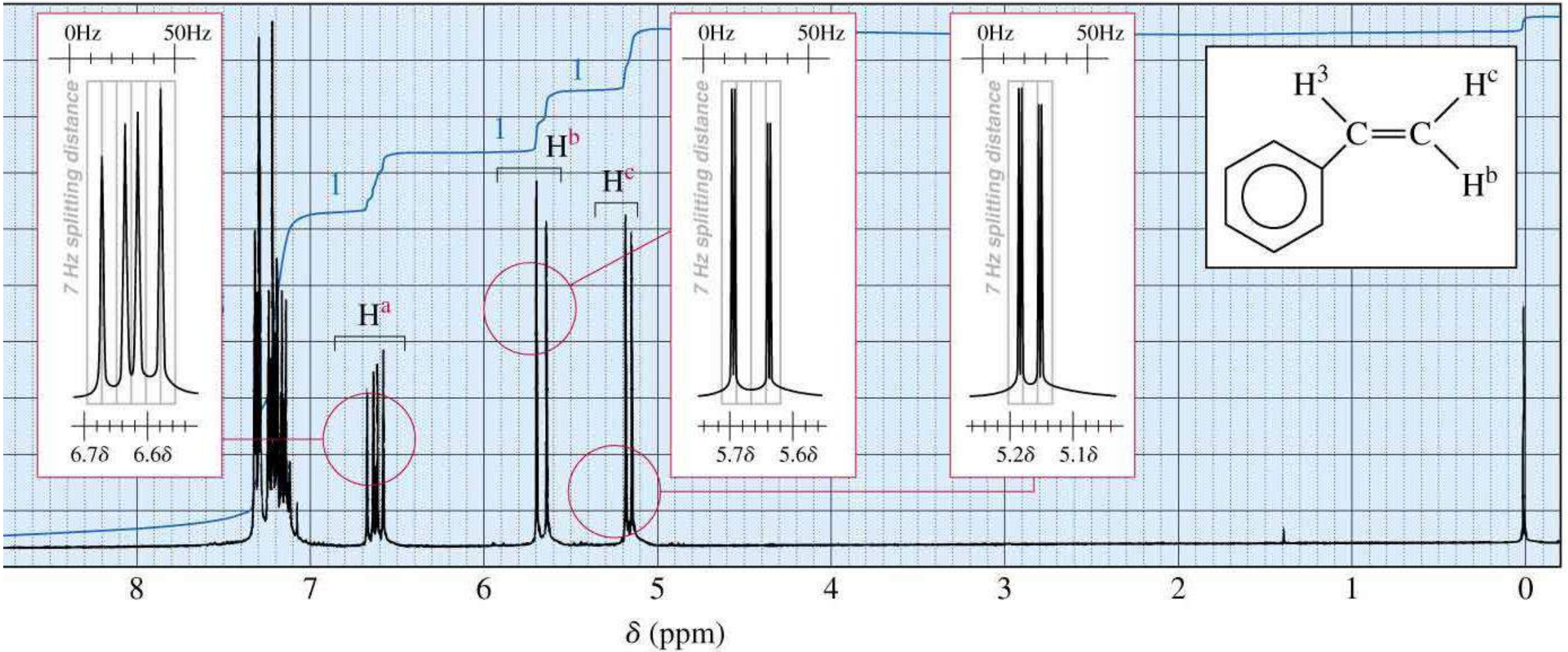
Splitting Tree







Spectrum for Styrene

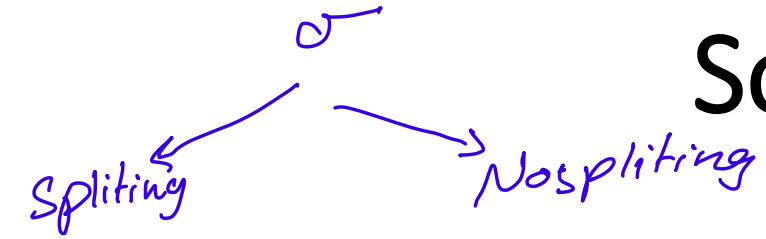


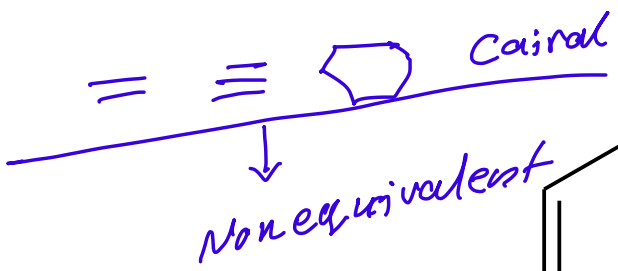
Stereochemical Nonequivalence

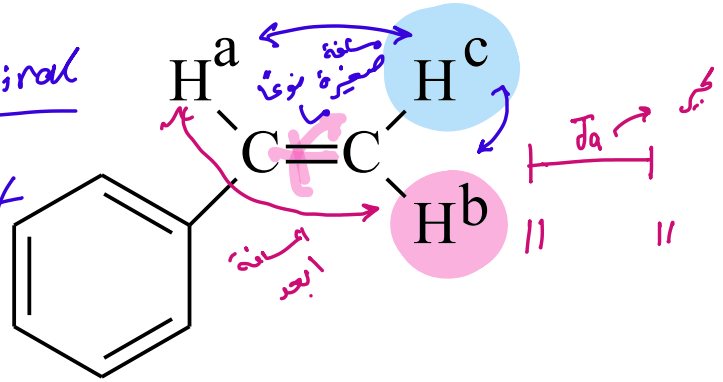
- Usually, two protons on the same C are equivalent and do not split each other.

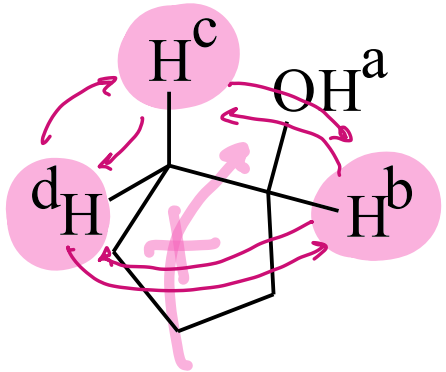
- If the replacement of each of the protons of a -CH_2 group with an imaginary “Z” gives stereoisomers, then the protons are non-equivalent and will split each other.

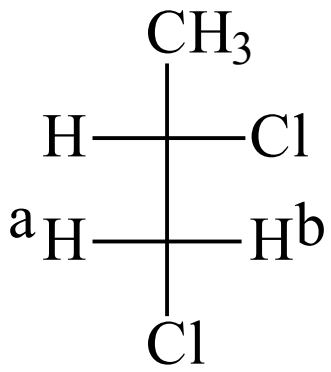
Some Nonequivalent Protons





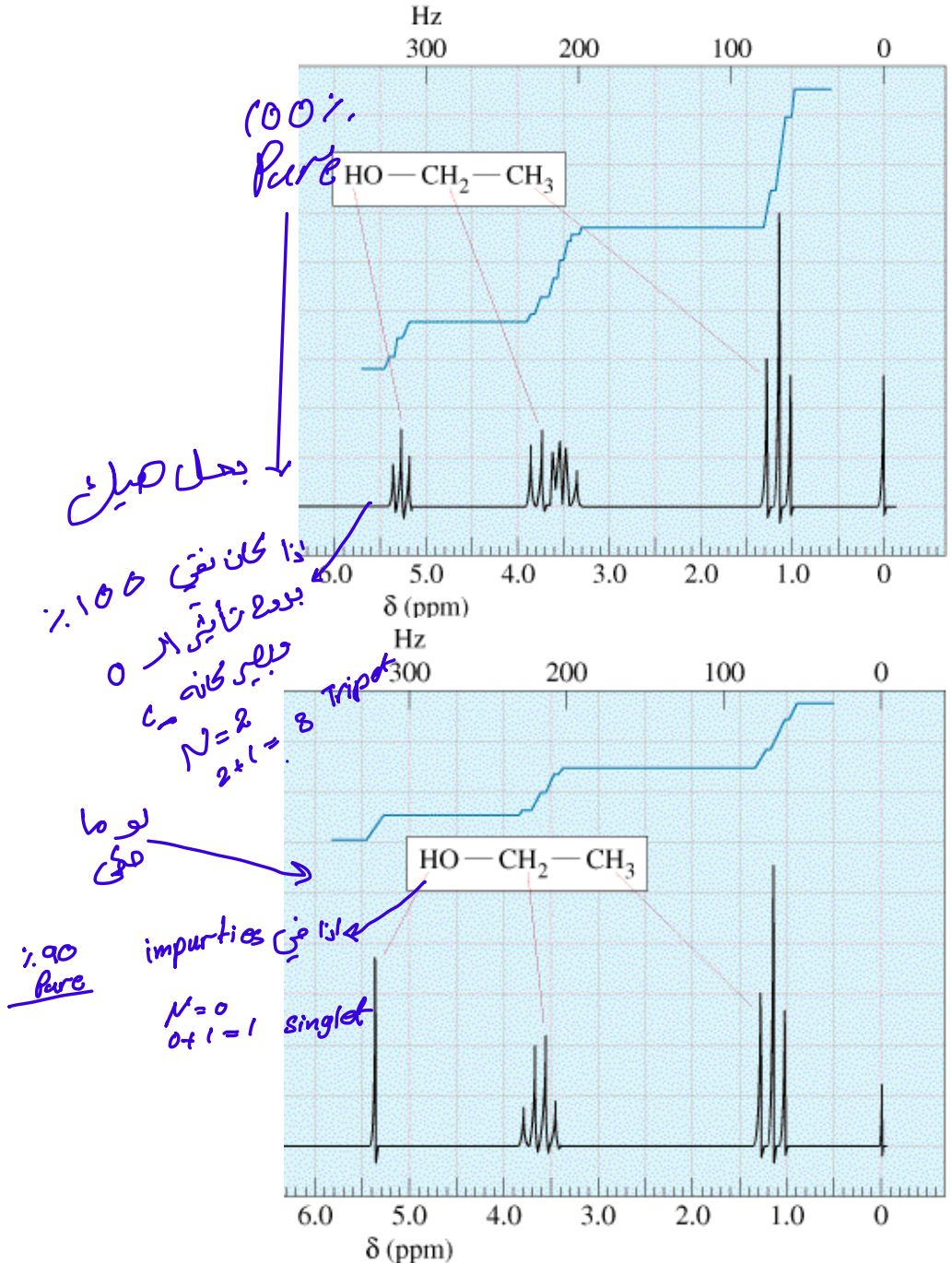






Time Dependence

- Molecules are tumbling relative to the magnetic field, so NMR is an averaged spectrum of all the orientations.
- Axial and equatorial protons on cyclohexane interconvert so rapidly that they give a single signal.
- Proton transfers for OH and NH may occur so quickly that the proton is not split by adjacent protons in the molecule.



Hydroxyl Proton

O — H

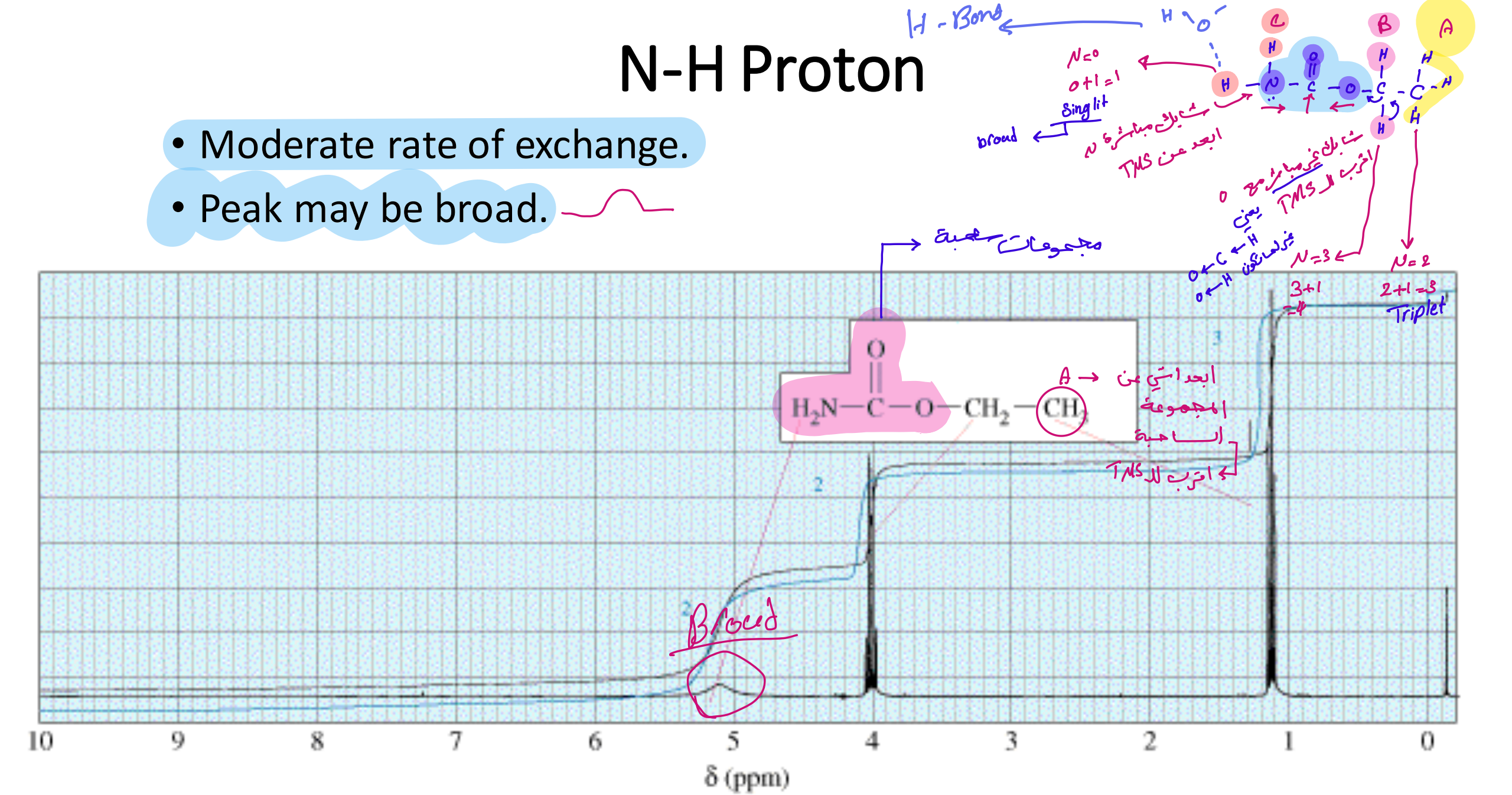
- Ultrapure samples of ethanol show splitting.

CH_3CH_2OH

- Ethanol with a small amount of acidic or basic impurities will not show splitting.

N-H Proton

- Moderate rate of exchange.
- Peak may be broad.

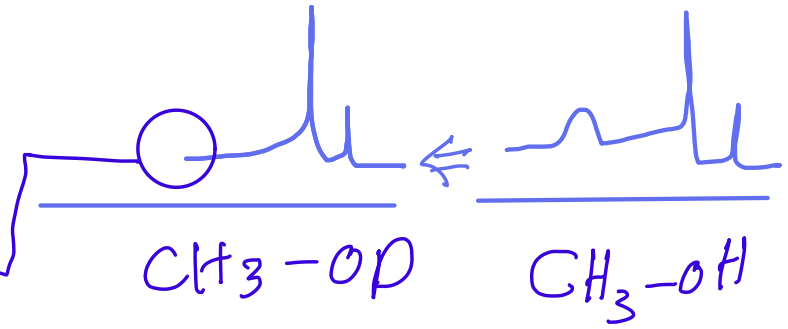


Identifying the O-H or N-H Peak

By using Deuterium oxid D_2O

بيستبدل ال H بال D

والجهاز مابقرأ D, بقرأ بس ال H



Broad اختفت ال ← يعني في (د,ر)

لو ما بقي عليه اشي معناها ما في (د,ر)

Broad واللي سبب ال impurities

- Chemical shift will depend on concentration and solvent.
- To verify that a particular peak is due to O-H or N-H, shake the sample with D_2O
- Deuterium will exchange with the O-H or N-H protons.
- On a second NMR spectrum the peak will be absent, or much less intense.