Advanced NMR Spectroscopy MCQs

Nuclear Magnetic Resonance Spectroscopy

15 Very Difficult Multiple-Choice Questions

Each question includes all four answer choices arranged clearly beneath it. The complete model answer key is provided at the end of the document.

Prepared from: IA (-7-) Lecture NMR

Questions

Question 1

Which statement most accurately integrates the fundamental principles of NMR spectroscopy presented in the chapter?

A. NMR is primarily an emission technique that monitors electronic transitions induced by microwave radiation without requiring an external magnetic field.

B. NMR is an absorption technique in which the atomic nucleus determines the response; an applied magnetic field is required, and the transitions involve relatively low-energy radiofrequency radiation.

C. NMR measures molecular vibrations using radio waves and is therefore fundamentally equivalent to IR spectroscopy.

D. NMR depends mainly on excitation of valence electrons, while the nucleus only determines signal intensity.

Question 2

Consider the following nuclei:

- ^{1}H: P = 1, N = 0
- ^{13}C: P = 6, N = 7
- ^{12}C: P = 6, N = 6
- ^{2}H: P = 1, N = 1

Which assignment is consistent with the rules in the chapter?

A. ^{1}H and ^{13}C have I = 1/2; ^{2}H has integer spin; ^{12}C has I = 0 and is NMR inactive.

B. ^{1}H and ^{2}H have I = 0; ^{13}C has integer spin; ^{12}C has half-integer spin.

C. ^{12}C is the most useful carbon isotope for NMR because its natural abundance is approximately 98.9%.

D. A nucleus can possess nuclear spin only when both its proton and neutron numbers are odd.

Question 3

For a nucleus with I = 1/2 placed in an external magnetic field B_0, which combination is correct?

A. Three spin states are possible; the beta state is aligned with B_0 and has lower energy.

B. Two spin states are possible; the alpha state is aligned with B_0 and has lower energy, whereas the beta state is opposed and has higher energy.

C. Two spin states are possible, but they remain energetically identical after application of B_0.

D. Four spin states are possible because the number of states is 2I + 2.

Question 4

Using nu = (gamma / 2pi) B_0 and the values used in the chapter for an applied field of approximately 14,092 gauss, which pair of resonance frequencies is most consistent with the worked notes?

A. ^{1}H approximately 15.0 MHz and ^{13}C approximately 60 MHz

B. ^{1}H approximately 60 MHz and ^{13}C approximately 15.0 MHz

C. ^{1}H approximately 60 MHz and ^{13}C approximately 60 MHz because both have I = 1/2

D. ^{1}H approximately 240 MHz and ^{13}C approximately 60 MHz

Question 5

Which description of magnetic shielding is correct?

A. Circulating electrons reinforce B_0, so a shielded proton experiences a stronger effective field and appears farther downfield.

B. Circulating electrons generate an induced field opposing B_0; therefore a more shielded proton requires a stronger applied field to resonate at the same frequency and appears more upfield.

C. Shielding increases the chemical shift because the nucleus becomes more exposed to B_0.

D. Deshielded protons always appear at lower delta values because they require more applied field than shielded protons.

Question 6

Which option correctly matches the information obtained from a typical ^{1}H NMR spectrum?

A. Number of signals -> number of adjacent protons; location -> number of protons; integration -> functional group; splitting -> shielding.

B. Number of signals -> different proton environments; location -> shielding/deshielding; integral area -> relative number of protons; splitting -> neighboring proton environment.

C. Number of signals -> molecular mass; location -> natural isotope abundance; peak height -> number of carbons; splitting -> magnet strength.

D. Signal position and splitting provide the same information, while integration has no structural significance.

Question 7

A proton appears 300 Hz downfield from TMS on a 60 MHz instrument. The same chemical environment is examined using a 300 MHz instrument. Which statement is correct?

A. Its chemical shift is 5 ppm on the 60 MHz instrument and remains 5 ppm on the 300 MHz instrument, although its frequency separation from TMS becomes 1500 Hz.

B. Its chemical shift is 0.5 ppm on both instruments.

C. Its chemical shift changes from 5 ppm to 1 ppm when the instrument frequency increases.

D. Its frequency separation remains exactly 300 Hz because chemical shift is field-independent.

Question 8

Which statement about TMS and the NMR delta scale is correct?

A. TMS is strongly deshielded because silicon is more electronegative than carbon and is assigned delta = 10 ppm.

B. TMS is added as a reference; its protons are highly shielded, its signal is defined as delta = 0, and most ordinary organic proton signals occur downfield from it.

C. TMS is used mainly because its twelve protons generate twelve separate peaks.

D. TMS is positioned at the far downfield end of a normal proton NMR spectrum.

Question 9

Which sequence correctly orders the following proton types approximately from most upfield to most downfield, according to the ranges emphasized in the chapter?

A. Alkyl CH_3 -> acetylenic H -> R-CH_2-X -> vinyl H -> aromatic H -> aldehydic H -> carboxylic-acid H

B. Carboxylic-acid H -> aldehydic H -> aromatic H -> vinyl H -> acetylenic H -> alkyl CH_3

C. Acetylenic H -> alkyl CH_3 -> aromatic H -> R-CH_2-X -> aldehydic H -> vinyl H

D. Alkyl CH_3 -> aromatic H -> acetylenic H -> aldehydic H -> vinyl H -> carboxylic-acid H

Question 10

Which explanation correctly compares aromatic, vinyl, and acetylenic protons?

A. Aromatic and vinyl protons are relatively deshielded because the induced pi-electron field can reinforce the external field at the proton, whereas an acetylenic proton lies in a region where the induced field provides relative shielding.

B. Acetylenic protons occur farther downfield than aldehydic protons because a triple bond always causes stronger deshielding than a carbonyl group.

C. Aromatic protons are highly shielded by ring current and normally appear around delta 1-2.

D. Vinyl protons are more shielded than ordinary alkane protons because pi electrons completely cancel the applied magnetic field.

Question 11

Which statement concerning O-H and N-H protons is correct?

A. Their chemical shifts are completely independent of concentration and solvent, and they always obey normal N+1 splitting.

B. Hydrogen bonding in concentrated solution can deshield these protons; exchange can broaden their peaks, and treatment with D_2O can cause the O-H or N-H signal to disappear or become much less intense.

C. Addition of D_2O converts every C-H proton into C-D, causing the entire ^1H NMR spectrum to disappear.

D. Hydrogen bonding shifts O-H protons strongly upfield because it increases electron density around hydrogen.

Question 12

A signal is split by four equivalent neighboring protons. According to the simple N+1 rule and Pascal-type intensity relationships used in the chapter, which result is expected?

A. Quartet with relative intensities 1:3:3:1

B. Quintet with relative intensities 1:4:6:4:1

C. Sextet with relative intensities 1:5:10:10:5:1

D. Triplet with relative intensities 1:2:1

Question 13

Which set of statements about spin-spin coupling and coupling constants J is entirely correct?

A. Equivalent protons normally split each other; J is measured in ppm and increases directly with magnet strength.

B. Protons on adjacent carbons normally couple; protons separated by four or more bonds generally do not couple under the simple rules presented; J is measured in Hz and is independent of external field strength.

C. The typical trans-vinylic coupling is smaller than the cis-vinylic coupling, and geminal coupling is approximately 15 Hz.

D. Typical values given are approximately 2 Hz for alkyl coupling, 15 Hz for cis-vinylic coupling, and 10 Hz for trans-vinylic coupling.

Question 14

Which option correctly combines the characteristic splitting patterns emphasized for common groups?

A. An ethyl group normally gives CH_3 as a quartet and CH_2 as a triplet; an isopropyl methine gives a doublet.

B. An ethyl group normally gives CH_3 as a triplet and CH_2 as a quartet; in an isopropyl group the six equivalent methyl protons appear as a doublet and the methine proton may appear as a septet.

C. Both ethyl and isopropyl groups give only singlets because equivalent protons never cause splitting of neighboring groups.

D. An isopropyl methine proton is split into six peaks because it is adjacent to six equivalent protons.

Question 15

Which statement most accurately integrates the advanced ^{13}C NMR concepts and the later handwritten/annotated material?

A. Because ^{13}C is highly abundant, ^{13}C-^{13}C coupling dominates most spectra; broadband proton decoupling further increases the complexity.

B. ^{13}C-^{13}C splitting is usually negligible because ^{13}C has low natural abundance. In proton-decoupled spectra each chemically different carbon gives a single unsplit signal, whereas off-resonance decoupling retains splitting only by directly attached protons and follows the N+1 rule. Carbon chemical shifts are strongly influenced by hybridization and electronegative substituents.

C. Off-resonance decoupling removes all C-H coupling, so CH_3, CH_2, CH, and quaternary carbons all appear identically as singlets.

D. ^{13}C chemical shift depends almost exclusively on the number of hydrogens attached and is essentially unaffected by hybridization or electronegativity.

Model Answers

Answer key for Questions 1-15

Q1	**B**	**Q6**	**B**	**Q11**	**B**
Q2	**A**	**Q7**	**A**	**Q12**	**B**
Q3	**B**	**Q8**	**B**	**Q13**	**B**
Q4	**B**	**Q9**	**A**	**Q14**	**B**
Q5	**B**	**Q10**	**A**	**Q15**	**B**

Answers: 1-B, 2-A, 3-B, 4-B, 5-B, 6-B, 7-A, 8-B, 9-A, 10-A, 11-B, 12-B, 13-B, 14-B, 15-B.