Multiple Choice Questions

1. Assuming that no ^{1}H signal can be observed for an aqueous sample, which of the following is most likely not a cause of the problem?
   a. The cable is not connected to the probe after probe tuning
   b. There is a loose cable connection around the probe
   c. The sample is not shimmed well
   d. The probe has a problem

2. Which of the following is most likely not a cause of a VT problem?
   a. Heater is not on
   b. VT air is disconnected
   c. Sample is not in the magnet
   d. The set temperature exceeds the maximum set temperature

3. In which of the following situations does it use a $\frac{1}{4}$ wavelength cable?
   a. ^{15}N decoupler channel
   b. ^{2}H observation
   c. Lock channel
   d. ^{13}C decoupler channel

4. Which of the following delays should be used in a jump-return experiment on a 500 MHz instrument to have maximum intensity at 9 ppm? Assume that the water resonance is at 4.8 ppm.
   a. 467 μs
   b. 119 μs
   c. 1.9 ms
   d. 238 μs

5. What coil configuration is most likely used for a triple-resonance probe?
   a. The inner coil is double-tuned to ^{1}H and ^{13}C
   b. The ^{1}H and lock channel use the inner coil, ^{13}C and ^{15}N use the outer coil
   c. The probe can be used to observe the correlation of ^{1}H, ^{13}C, ^{15}N, and ^{31}P simultaneously
   d. One of the two probe coils is used for ^{1}H, ^{13}C, and ^{15}N, the other for ^{2}H

6. Which of the following is not a property of an RF amplifier?
   a. It has a linear dependence of output power on attenuation
   b. Its output is gated by a transmitter controller
   c. It amplifies the signal from the probe
   d. The output of the amplifier for a heteronuclear channel is higher than that of the ^1H channel in a high resolution NMR instrument

7. A mixer is used to
   a. subtract the frequencies of two input signals
   b. add the frequencies of two input signals
   c. multiply the frequencies of two input signals
   d. produce IF frequency

8. Which of the following frequencies cannot be an intermediate frequency (IF)?
   a. 20 MHz
   b. 10 MHz
   c. 30 MHz
   d. 200 MHz

9. Which of the following has the lowest frequency value?
   a. Carrier
   b. LO
   c. IF
   d. Lock frequency

10. What is the purpose of using LO?
    a. To combine with carrier frequency at transmitter
    b. To make a frequency higher than the spectrometer base frequency
    c. To use a fixed-frequency receiver for all nuclei
    d. To use a fixed-frequency preamplifier for all nuclei

11. Which of the following does not describe IF?
    a. It is the fixed frequency of a receiver
    b. Its frequency value is much lower than that of carrier or LO
    c. Its frequency changes for different carrier frequencies
    d. Either the carrier or LO frequency is made from IF

12. Which of the following statements about the effect of salt concentration on a probe is correct?
    a. High salt concentration affects a conventional probe more severely than a cryogenic probe because it is less sensitive than a cryogenic probe
    b. High salt concentration affects a conventional probe less severely than a cryogenic probe because it is operated at room temperature
    c. High salt concentration affects a cryogenic probe more severely than conventional probe because the salt of sample may precipitate in the cryogenic probe
    d. High salt concentration affects a cryogenic probe more severely than a conventional probe because the high Q value of a cryogenic probe is dramatically decreased due to the dielectric influence of the salt concentration

13. The sensitivity of a cryogenic probe on a 500 MHz spectrometer is close to that of a conventional probe on a spectrometer of
    a. 600 MHz
    b. 750 MHz
    c. 900 MHz
    d. 1,050 MHz

14. Which of the following pulses should be tried first for water suppression by presaturation for a 90%H_2O/10%^2H_2O sample? Assume a 50 watt ^1H amplifier and a carrier on the water resonance.
    a. 3 s pulse with power attenuation of −55 dB from the maximum power
    b. 3 s pulse with power attenuation of −35 dB from the maximum power
    c. 3 s pulse with power attenuation of −45 dB from the maximum power
    d. 5 s pulse with power attenuation of −60 dB from the maximum power

15. Assuming that data are acquired on a 600 MHz with an acquisition time of 64 ms and the data are Fourier transformed without zero-filling and linear prediction, what is the digital resolution of the spectrum?
    a. 7.8 Hz/pt
    b. 0.013 ppm/pt
    c. 3.9 Hz/pt
    d. 0.026 ppm/pt

16. If the size of the above data set is doubled by zero-filling, what is the digital resolution of the spectrum?
    a. 15.6 Hz/pt
    b. 7.8 Hz/pt
    c. 3.9 Hz/pt
    d. 0.026 ppm/pt

17. Which parameter can saturate the lock signal if it is set too high?
    a. Lock gain
    b. Lock phase
    c. Lock power
    d. Lock field (or z_0)

18. Which of the following is not true?
    a. Magnets (200–900 MHz) are made of superconducting wires
    b. The magnet solenoid is in a liquid helium vessel
    c. Liquid helium and liquid nitrogen are needed to maintain the magnetic field
    d. Room temperature shims are in a liquid nitrogen vessel

19. By using cryogenic shims, field homogeneity can be as good as
    a. 1 ppm
    b. 10 ppm
    c. 1 ppb
    d. 0.01 ppm

20. The water-flip-back sequence provides superior water suppression. How is the result achieved?
    a. The selective pulse on water saturates some portion of the water magnetization
    b. The selective pulse on water keeps the water magnetization on the xy plane so that the water magnetization is suppressed by the watergate sequence
    c. The selective pulse on water brings the water magnetization to the z axis
    d. The selective pulse on water keeps the water magnetization in the xy plane so that the water magnetization is destroyed by the gradient pulse

21. Which of the following gives a wider decoupling bandwidth for the same amount of RF power?
    a. CW
    b. Waltz16
    c. GARP
    d. BB

22. Which of the following is the better way to set up a water-flip-back experiment after probe tuning, shimming, and locking?
    a. Calibrate VT, ^{1}H 90° pulse, transmitter offset and set the offset at the center of the spectrum
    b. Calibrate ^{1}H 90° pulse, transmitter offset, ^{1}H 90° selective pulse and set the offset at the center of the spectrum
    c. Calibrate ^{1}H 90° pulse, transmitter, and decoupler offsets, ^{1}H 90° selective pulse and set the offset on water
    d. Calibrate ^{1}H 90° pulse, transmitter, offsets, ^{1}H 90° selective pulse and set the offset on water

23. Which of the following data are most likely processed with doubling the size by forward linear prediction, 90°-shifted squared sine-bell function, zero-filling once, and Fourier transformation?
    a. One-dimensional watergate data
    b. ^{1}H dimension of 3D data
    c. ^{15}N dimension of 3D data
    d. Two-dimensional COSY

24. What is the correct way to tune a probe for a triple-resonance experiment?
    a. Tune ^{1}H channel first, then ^{13}C, and ^{15}N last without filters
    b. Tune ^{1}H channel first, then ^{13}C, and ^{15}N last with filters
    c. Tune ^{15}N channel first, then ^{13}C, and ^{1}H last without filters
    d. Tune ^{15}N channel first, then ^{13}C, and ^{1}H last with filters

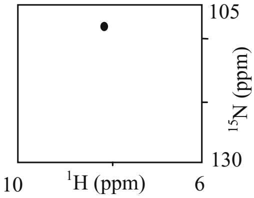
25. An NMR transmitter consists of
    a. Frequency synthesizer, RF signal generator, transmitter controller and receiver
    b. CPU, RF signal generator, transmitter controller, and RF amplifier
    c. Frequency synthesizer, RF signal generator, and transmitter controller
    d. Frequency synthesizer, RF signal generator, transmitter controller, and RF amplifier

26. Which of the following product operators describes the coherence of a two weakly coupled two-spin (I and S) system from an initial coherence of $-I_y$ after INEPT where $\tau \rightarrow \pi(I_x + S_x) \rightarrow \tau$ when $\tau = 1/4J_{\mathrm{IS}}$?
    a. $-I_z S_x$
    b. $I_x S_x$
    c. $-I_x S_z$
    d. I_x

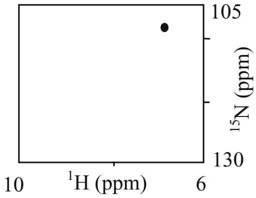
27. Assuming that on a 600 MHz NMR spectrometer the ^{13}C 90° pulse length is 15 μs at 60 dB and a higher decibel value means more power for a pulse, what is most likely the power setting for ^{13}C GARP decoupling over a 50 ppm bandwidth?
    a. 45 dB
    b. 47 dB
    c. 49 dB
    d. 51 dB

28. Which of the following is most likely a Gly NH cross-peak?

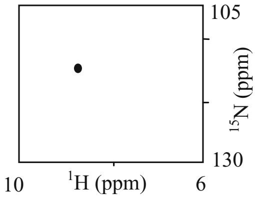
a.



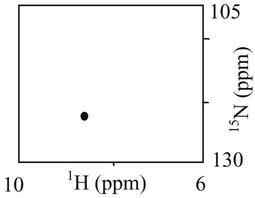
b.



c.



d.



29. Assuming that on a 500 MHz NMR spectrometer the ^{15}N 90° pulse length is 35 μs at 60 dB and a higher decibel value means more power for a pulse, what is most likely the power setting for ^{15}N WALTZ-16 decoupling over a 30 ppm bandwidth?
    a. 40 dB
    b. 42 dB
    c. 45 dB
    d. 49 dB

30. Assuming that on a 500 MHz NMR spectrometer the ^{15}N 90° pulse length is 35 μs at 60 dB and a higher dB value means more power for a pulse, what is most likely the power setting for ^{15}N GARP decoupling over a 30 ppm bandwidth?

a. 35 dB
b. 40 dB
c. 45 dB
d. 49 dB

31. If all four buffers work fine for a protein sample, which one should be used to make the NMR sample?
a. 100 mM Tris-HCl, pH 7, 100 mM KCl
b. 50 mM phosphate, pH 7, 200 mM KCl
c. 100 mM Tris-HCl, pH 7, 20 mM KCl
d. 50 mM phosphate, pH 7, 50 mM KCl

32. On a 600 MHz instrument, if the resonance frequency of DSS is 599.89836472, what is the reference frequency for ^{15}N using liquid NH_3 as reference?
a. 60.8284299
b. 60.8206020
c. 59.1804433
d. 60.8102995

33. On the same spectrometer as in question 32, what is the frequency at 177 ppm of ^{13}C using DSS as ^{13}C reference?
a. 150.8445638
b. 150.8564532
c. 150.8658329
d. 150.8712633

34. On the same spectrometer as in question 32, what is the frequency at 118 ppm of ^{15}N?
a. 60.8356055
b. 60.8174751
c. 59.1871755
d. 60.8206020

35. ^{13}C chemical shift has a much wider range (~300 ppm) than ^{1}H (~10 ppm) because
a. the contribution of the diamagnetic shielding of ^{13}C is much larger than ^{1}H due to the small ^{13}C energy gap
b. the contribution of the paramagnetic shielding of ^{13}C is much larger than ^{1}H due to the small ^{13}C energy gap
c. the electron density of ^{1}H is almost always spherically symmetrical
d. The reason is unknown

36. If a $^{3}J_{H^NH^\alpha}$ coupling constant of a residue has a value of approximately 10 Hz, what could the torsion angle ϕ be?
a. Approximately 0°
b. Approximately $-120°$
c. Approximately $-180°$
d. Approximately 120°

37. What is a better criterion to measure the accuracy of the calculated structure?
    a. RMSD of backbone atoms
    b. Total number of distance violations
    c. Quality factor of residual dipolar couplings
    d. Quality factor of NOE intensity

38. Why is DSS used instead of TMS as the ^{1}H chemical shift reference for a biological sample?
    a. TMS can denature proteins
    b. The chemical shift of TMS is dependent on temperature
    c. DSS has a higher solubility in aqueous solution
    d. DSS is widely used in protein sample preparation

39. At equilibrium state,
    a. there is no $-z$ component of nuclear magnetization
    b. there is a slightly larger $+z$ component than $-z$ component of nuclear magnetization
    c. there are equal $+z$ and $-z$ components of nuclear magnetization
    d. there is a slightly larger $-z$ component than $+z$ component of nuclear magnetization

40. In a magnetic field, nuclear dipoles (nuclear spins with a spin quantum number of $\frac{1}{2}$)
    a. precess around the magnetic field direction randomly
    b. are motionless along the direction of the magnetic field
    c. do not exist
    d. precess around the magnetic field direction at the Larmor frequency

41. A B_1 field used to interact with nuclear dipoles in order to generate an NMR signal has the following property:
    a. The orientation of the B_1 field is fixed in the rotating frame
    b. Components of the B_1 field rotate in the laboratory frame with Larmor frequency
    c. The B_1 field is a linear alternating magnetic field in the laboratory frame
    d. All of the above

42. If your NMR spectrum has a distorted baseline, the problem is most likely because
    a. spectral window (SW) is too low
    b. receiver gain is too high
    c. receiver gain is too low
    d. y-axis scale of display is too high

43. Which of the following quantities is *not* changed at a different magnetic field strength:
    a. Chemical shift (in hertz)
    b. Nuclear spin population in an energy state
    c. J coupling constant
    d. Energy difference between two energy states of nuclei with non-zero spin quantum number

44. Chemical shifts originate from
    a. magnetic momentum
    b. electron shielding

c. free induction decay
d. scalar coupling (*J*-coupling)

45. Chemical shifts of protons have a frequency range of about
a. megahertz
b. 250 MHz
c. kilohertz
d. 10 Hz

46. DSS has a chemical shift value of 0.0 ppm or 0.0 Hz because
a. its absolute chemical shift value is 0.0
b. the chemical shift value of DSS is chosen as the chemical shift reference
c. H_2O has a ^1H chemical shift of 4.76 ppm and the DSS chemical shift is 4.76 ppm lower than H_2O
d. none of the above

47. What is the ^{13}C resonance frequency on a 600 MHz NMR spectrometer?
a. 600 MHz
b. 92 MHz
c. 60 MHz
d. 150 MHz

48. The pulse angle is dependent on
a. transmitter power (pulse power)
b. pulse length
c. receiver gain
d. both (a) and (b)

49. If number of time domain points equals 4k and dwell time equals 100 μsec, then acquisition time equals
a. $100\ \mu\text{sec} \times 4000$
b. $100\ \mu\text{sec} \times 4096$
c. $100\ \mu\text{sec} \times 4000 \times 2$
d. $100\ \mu\text{sec} \times 4096 \times 2$

50. The signal-to-noise ratio (S/N) of an NMR spectrum can be increased by the accumulation of acquisitions. Compared to one recorded with 2 scans, a spectrum with 32 scans has an S/N ratio
a. 16 times higher
b. 4 times higher
c. 8 times higher
d. 32 times higher

51. The wider frequency range covered by an RF pulse (pulse bandwidth) is achieved by the pulse with
a. lower power and longer pulse length
b. higher power and longer pulse length

c. higher power and shorter pulse length
d. none of the above

52. Integration of ^{1}H signal intensities (or peak area) gives information about
a. the absolute number of protons corresponding to the resonance frequencies
b. the ratio of the number of protons corresponding to the resonance frequencies
c. the types of protons corresponding to the resonance frequencies
d. intensities of protons relative to the solvent peak

53. ^{13}C spectra without decoupling show multiplicity of ^{13}C peaks due to the coupling of ^{1}H to ^{13}C. In a 1D ^{1}H spectrum of an unlabeled sample (natural abundance ^{13}C), the coupling of ^{13}C to ^{1}H is neglected because
a. the NMR spectrometer decouples ^{13}C from ^{1}H automatically
b. a large portion of protons are bound to ^{12}C, which is NMR inactive
c. the J_{CH} coupling constant is small compared to the line widths of ^{1}H peaks
d. both (b) and (c)

54. Improper shimming
a. can be eliminated by spinning the sample
b. can broaden the line shape of the NMR signal
c. can shorten T_1 relaxation
d. does not have any effect on NMR spectra

55. The dwell time is defined as
a. the total time needed to acquire an FID
b. the time difference between two adjacent time domain data points
c. the time delay between the last pulse and acquisition
d. the time delay before the first pulse

56. The reason that an exponential function (EM) with line broadening (LB) of 3–5 Hz is used for a ^{13}C FID before Fourier transformation is
a. to increase the resolution of the ^{13}C spectrum
b. to increase sensitivity of the spectrum
c. to improve the baseline of the spectrum
d. to make the FID look nicer

57. The relative sensitivity of ^{15}N to ^{1}H for a 100% ^{15}N enriched sample is
a. 0.1
b. 1.0×10^{-3}
c. 3.7×10^{-5}
d. 1.0×10^{-2}

58. Choose the correct statement(s) about the steady state transients (ss or dummy scans):
a. ss are executed before parameter nt (number of transients or scans)
b. During ss, the experiment is performed except without data acquisition
c. ss are used to ensure a steady state before data acquisition
d. All of the above

59. The natural abundance of ^{13}C is about
    a. four times less than ^{1}H
    b. 0.11% of total carbon
    c. 1.1% of total carbon
    d. 99% of total carbon

60. Deuterated solvent in an NMR sample is used to
    a. stabilize the magnetic field
    b. set the chemical shift reference
    c. obtain good field homogeneity across the sample
    d. both (a) and (c)

61. Digital resolution (Hz/point) can be improved by
    a. decreasing the number of time domain points
    b. zero-filling the FID
    c. decreasing the spectral width
    d. both (a) and (c)

62. Quadrature detection uses
    a. a single detector on the x axis
    b. two detectors that are opposite to each other
    c. two detectors that are perpendicular to each other
    d. four detectors that are on the x, y, $-x$, and $-y$ axes

63. Tuning the probe is to
    a. match the probe impedance to the 50 Ω cable impedance
    b. tune the probe frequency to the carrier frequency
    c. make shimming easier
    d. (a) and (b)

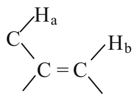
64. $^{3}J_{\mathrm{HH}}$ coupling constants may have a value of
    a. 140 Hz
    b. 35 Hz
    c. 8 Hz
    d. 70 Hz

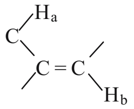
65. $^{1}J_{\mathrm{CH}}$ coupling constants may have a value of
    a. 140 Hz
    b. 35 Hz
    c. 8 Hz
    d. 70 Hz

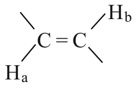
66. $^{3}J_{\mathrm{HH}}$ coupling constants are dependent on
    a. magnetic field strength
    b. relative orientation of the coupled protons
    c. sample concentration
    d. 90° pulse width

67. Assume that a proton is scalar coupled to proton(s) with different chemical environments. If this proton shows a triplet signal, how many proton(s) is it scalar coupled to?
    a. One
    b. Two
    c. Three
    d. Four

68. Which of the following molecules has the largest ${}^3J_{HH}$ coupling constant between H_a and H_b?

a.


b.


c.


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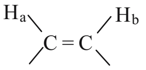
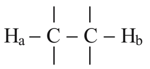
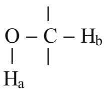
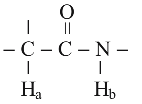
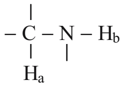


69. In which of the following cases is the J_{HH} coupling constant between H_a and H_b most likely less than 1 Hz:

a.

$H_a-\overset{|}{\underset{|}{C}}-\overset{|}{\underset{|}{C}}-H_b$

b.

$\underset{\underset{H_a}{|}}{O}-\overset{|}{\underset{|}{C}}-H_b$

c.

$-\underset{\underset{H_a}{|}}{\overset{|}{C}}-\overset{\overset{O}{\|}}{C}-\underset{\underset{H_b}{|}}{N}-$

d.

$-\underset{\underset{H_a}{|}}{\overset{|}{C}}-\underset{|}{N}-H_b$

70. If the last ${}^{13}C$ and ${}^{1}H$ 90° pulses are omitted in the INEPT experiment (Figure 1.24), can the ${}^{13}C$ NMR signal be observed?
    a. Yes, because there exists transverse magnetization
    b. No, because the two components of the transverse magnetization will cancel each other out
    c. No, because there is no ${}^{13}C$ transverse magnetization
    d. None of the above

71. How is quadrature detection in the indirect dimension achieved by the States–TPPI method?
    a. For each t_1 increment, one FID is acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each FID. The interferogram is transformed with real Fourier transformation
    b. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each t_1 increment. The interferogram is transformed with complex Fourier transformation

c. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each FID. The interferogram is transformed with complex Fourier transformation

d. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for the second FID of each t_1 increment. The interferogram is transformed with complex Fourier transformation

72. How is quadrature detection in the indirect dimension achieved by the TPPI method?

a. For each t_1 increment, one FID is acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each FID. The interferogram is transformed with real Fourier transformation

b. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each t_1 increment. The interferogram is transformed with complex Fourier transformation

c. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each FID. The interferogram is transformed with complex Fourier transformation

d. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for the second FID of each t_1 increment. The interferogram is transformed with complex Fourier transformation

73. How is quadrature detection in the indirect dimension achieved by the States method?

a. For each t_1 increment, one FID is acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each FID. The interferogram is transformed with real Fourier transformation

b. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each t_1 increment. The interferogram is transformed with complex Fourier transformation

c. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for each FID. The interferogram is transformed with complex Fourier transformation

d. For each t_1 increment, two FIDs are acquired. The phase of the pulse prior to the evolution time is shifted by 90° for the second FID of each t_1 increment. The interferogram is transformed with complex Fourier transformation

74. Assuming that an HMQC experiment is collected on a 600 MHz spectrometer with a spectral window of 60 ppm, $\mathrm{pw}_{90(^{1}\mathrm{H})} = 7\ \mu\mathrm{s}$, $\mathrm{pw}_{90(^{31}\mathrm{C})} = 15\ \mu\mathrm{s}$, and the evolution element $90°(^{13}\mathrm{C})–\frac{1}{2}t_1–180°(^{1}\mathrm{H}) - \frac{1}{2}t_1 - 90°(^{13}\mathrm{C})$ using the States–TPPI method, what is the value of $t_1\,(0)$ chosen for the phase correction of 0° (zero order) and −180° (first order)?

a. 55.5 μs
b. 111.1 μs
c. 78 μs
d. 22.5 μs

75. Assuming that a constant time HMQC experiment is collected on a 600 MHz spectrometer with a spectral window of 60 ppm, $\mathrm{pw}_{90(^{1}\mathrm{H})} = 7\ \mu\mathrm{s}$, $\mathrm{pw}_{90(^{31}\mathrm{C})} = 15\ \mu\mathrm{s}$, and the

evolution element $90°(^{13}\text{C}) - \frac{1}{2}t_1 - T - 180°(^1\text{H}) - \left(T - \frac{1}{2}t_1\right) - 90°(^{13}\text{C})$ using the States–TPPI method, what is the value of $t_1(0)$ chosen for the phase correction of 0° (zero order) and $-180°$ (first order)?

a. 55.5 μs
b. 111.1 μs
c. 78 μs
d. 22.5 μs

76. A larger value of the squared generalized order parameter S^2 describes an internal motion where
    a. the bond vector is more flexible in the molecular frame
    b. the motion is faster
    c. the bond vector is more rigid in the molecular frame
    d. the motion is slower

77. The squared generalized order parameter S^2 is highly sensitive to the angle θ between the equilibrium orientation of the bond vector and the diffusion tensor of the bond vector.
    a. The value of S^2 becomes smaller as the angle θ decreases
    b. The value of S^2 becomes smaller as the angle θ increases
    c. The value of S^2 is constant in the region of $\theta = 0$–$20°$ and then rapidly decreases as θ increases
    d. The value of S^2 is large in the region of $\theta = 70$–$90°$

78. Smaller S^2 with a smaller τ_e characterizes molecular internal dynamics that is
    a. rigid and slow
    b. flexible and fast
    c. rigid and slow
    d. flexible and fast

79. Certain NMR parameters are measured for the study of protein dynamics. Which of the following parameters is *not* measured for the protein dynamics?
    a. $^{15}\text{N}T_1$ relaxation rate
    b. ^1H–^1H NOE
    c. ^1H–^{15}N NOE
    d. $^{15}\text{N}T_2$ relaxation rate

80. NOE connectivities are assigned for structure calculation. How are they usually assigned?
    a. A majority of the NOESY cross-peaks are assigned based on the sequence-specific assignment of chemical shift resonances
    b. A small fraction of the NOESY cross-peaks are assigned for initial structure calculation and more connectivities are added by the iterative NOE analysis
    c. A majority of the NOESY cross-peaks are assigned and the iterative NOE analysis is used to refine the calculated structures
    d. Almost all of the NOE connectivities can be assigned by setting up chemical shift tolerance within values less than 0.2 ppm

81. The nuclear relaxation characterized by T_1 relaxation is *not*
    a. spin–lattice relaxation
    b. longitudinal relaxation
    c. spin–spin relaxation
    d. relaxation along the z axis

82. The purpose of shimming is to
    a. stabilize the static magnetic field
    b. obtain homogeneity of the B_1 field
    c. find the lock frequency
    d. obtain homogeneity of the static magnetic field

83. The TROSY experiment is based on the property of
    a. cross-relaxation caused by dipolar coupling (DD)
    b. cross-correlated relaxation caused by the interference between DD and CSA cross-relaxation (chemical shift anisotropy)
    c. cross-relaxation caused by DD and CSA
    d. auto-correlated relaxation caused by the interference between DD and CSA

84. After a B_1 field is applied along the x axis, the transverse magnetization when relaxing back to the equilibrium state during acquisition
    a. rotates about the x axis of the rotating frame
    b. rotates about the direction of the B_0 field in the laboratory frame
    c. is stationary along the $-y$ axis in the laboratory frame
    d. relaxes only along the z axis

85. During an INEPT subsequence, the magnetization transfers for all three types of CH groups (methine, methylene, and methyl) are optimized by setting the delay τ (half of the INEPT period) to
    a. 11 ms
    b. 2.75 ms
    c. 2.2 ms
    d. 3.6 ms

86. The C^{α} cross-peaks of CBCANH have opposite sign relative to C^{β} cross-peaks because
    a. C^{β} cross-peaks are folded in the spectrum
    b. the magnetization transfer from the C^{α} has opposite sign to that from the C^{β} by setting the delay for the $C^{\alpha,\beta} \rightarrow$ N transfer to 11 ms
    c. the INEPT delay for H $\rightarrow C^{\alpha,\beta}$ transfer is setting to 2.2 ms
    d. none of the above

87. Which of the following sequences can be used for a ROESY spin lock?
    a. 5 kHz off-resonance DIPSI-3
    b. 5 kHz on-resonance MLEV17
    c. 2 kHz off-resonance CW
    d. 6 kHz off-resonance CW

88. Compared to the random coil values, $^{13}C^{\alpha}$ chemical shifts of a α-helix secondary structure are usually
   a. smaller
   b. larger
   c. no significant change
   d. unpredictable

89. Relative to a 2D, a 3D experiment has a better
   a. S/N ratio
   b. resolution
   c. baseline
   d. line shape

90. Which of the following mixing times is most likely used in a homonuclear TOCSY to mainly observe the correlations of H^N to H^{α} and to all aliphatic H^{aliph}?
   a. 30 ms
   b. 5 ms
   c. 60 ms
   d. 100 ms

91. Which of the following mixing times is most likely used in a homonuclear TOCSY to mainly observe the correlation between H^N and H^{α}?
   a. 30 ms
   b. 5 ms
   c. 60 ms
   d. 100 ms

92. Which of the following mixing times is most likely used in a NOESY experiment for a 20 kDa protein sample?
   a. 30 ms
   b. 100 ms
   c. 300 ms
   d. 500 ms

93. Which of the following experiments has been used for measuring ^{1}H–^{15}N residual dipolar coupling?
   a. ^{1}H–^{15}N HSQC
   b. IPAP ^{1}H–^{15}N HSQC
   c. ^{1}H–^{15}N NOE HSQC
   d. PEP ^{1}H–^{15}N HSQC

94. What is a constant time evolution period used for?
   a. Increase the sensitivity of the experiment
   b. Increase the resolution of the experiment
   c. Decouple heteronuclear J coupling
   d. Suppress artifacts

95. Which of the following experiments should be used for studying a complex formed by ^{13}C–^{15}N labeled protein and unlabeled peptide?
    a. Isotope edited experiment
    b. Isotope filtered experiment
    c. 3D HCCH–TOCSY
    d. Saturation transfer experiment

96. It is necessary to perform shimming before an experiment can be run. The shimming is done by:
    a. adjusting the lock power to obtain highest lock level
    b. optimizing lock gain to obtain highest lock level
    c. adjusting the current to room temperature shim coils when monitoring the lock level
    d. adjusting the current to cryogenic shim coils when monitoring the lock level

97. Assuming that a cryogenic probe has a sensitivity 4 times higher than a conventional room temperature probe and both probes give same line widths, the signal intensity of the spectrum obtained using the cryogenic probe compared to that using the room temperature probe with same amount of experimental time is
    a. 16 times higher
    b. 8 times higher
    c. 4 times higher
    d. 2 times higher

98. For a 200 μl ^{15}N labeled protein sample, which of the following probe is the best for a ^{1}H–^{15}N HSQC experiment?
    a. triple-resonance HCX probe (X: ^{15}N–^{31}P)
    b. dual broadband ^{1}H–^{19}F/^{15}N–^{31}P probe
    c. high resolution MAS (magic angle spinning) probe
    d. triple-resonance HCN probe

99. For a sample of 150 μl ^{15}N/^{13}C labeled protein containing 100 mM salt, which of the following probes is best for triple resonance experiments?
    a. 5 mm room temperature HCN probe
    b. 3 mm room temperature HCN probe
    c. 5 mm cryogenic HCN probe using a 5 mm micro tube
    d. 5 mm cryogenic HCN probe using a 3 micro mm tube

100. Which of the following statements about preamplifier, IF amplifier and RF amplifier is wrong?
    a. The outputs of IF and RF amplifiers are adjustable
    b. A preamplifier is located near or inside a probe
    c. They are all frequency tunable amplifiers
    d. RF amplifier has a linear dependence of attenuation

Answers to Multiple Choice Questions

1. c. 2. c. 3. b. 4. b. 5. b. 6. c. 7. c. 8. d. 9. c. 10. c.
11. c. 12. d. 13. d. 14. a. 15. d. 16. b. 17. c. 18. d. 19. a. 20. c.
21. c. 22. d. 23. c. 24. c. 25. d. 26. c. 27. b. 28. a. 29. c. 30. b.
31. d. 32. d. 33. d. 34. b. 35. b. 36. b. 37. c. 38. c. 39. b. 40. d.
41. d. 42. b. 43. c. 44. b. 45. c. 46. b. 47. d. 48. d. 49. b. 50. b.
51. c. 52. b. 53. b. 54. b. 55. b. 56. b. 57. b. 58. d. 59. c. 60. d.
61. b. 62. c. 63. d. 64. c. 65. a. 66. b. 67. b. 68. c. 69. c. 70. c.
71. c. 72. a. 73. d. 74. d. 75. a. 76. c. 77. b. 78. b. 79. b. 80. b.
81. c. 82. d. 83. b. 84. b. 85. c. 86. b. 87. c. 88. b. 89. b. 90. d.
91. a. 92. b. 93. b. 94. b. 95. b. 96. c. 97. c. 98. d. 99. d. 100. c.

Nomenclature and Symbols

ADC	analog-to-digital converter (conversion)
B_0	magnetic field strength
B_1	oscillating RF magnetic field strength
B_{eff}	effective B_1 field strength
C	capacitance
COS	coherence order selection
COSY	correlation spectroscopy
CP	cross-polarization
CSA	chemical shift anisotropy
CT	constant time
CTAB	cetyl (hexadecyl) trimethyl ammonium bromide
DAC	digital-to-analog converter (conversion)
dB	decibel
$\mathrm{dB_m}$	decibel relative to 1 mW
DD	dipole–dipole
DEPT	distortionless enhancement by polarization transfer
DHPC	dihexanoylphosphatidylcholine
DMPC	dimyristoylphosphatidylcholine
DQF	double-quantum filter
DSBSC	double sideband band suppression carrier
DSS	2,2-dimethyl-2-silapentane-5-sulfonic acid
F	noise figure
$F1$, $F2$	frequency domain of multidimensional experiments
f_{d}	decoupling efficiency
Ft, FT	Fourier transformation
g	gradient
G	pulse field gradient strength
GND	ground
HCN	proton/carbon/nitrogen
HCX	proton/carbon/heteronuclei
HMQC	heteronuclear multi-quantum correlation
HSQC	heteronuclear single-quantum coherence
i	current, imaginary unit
I	spin quantum number, spin I, current
IF	intermediate frequency

INEPT	insensitive nuclei enhanced by polarization transfer
IPAP	in-phase anti-phase
j	imaginary unit
J	scalar (indirect, spin–spin) coupling constant (in hertz)
$J(\omega)$	spectral density function at frequency ω
K_A	association constant
K_D	dissociation constant
L	inductance
LC	liquid crystal, inductor-capacitor
LED	longitudinal eddy-current delay
LO	local oscillator
LSB	least significant bit
M	magnetization
M_0	equilibrium bulk (macroscopic) magnetization
MAS	magic-angle spinning
MSB	most significant bit
NMR	nuclear magnetic resonance
NOE	nuclear Overhauser enhancement
NOESY	nuclear Overhauser spectroscopy
p	coherence order
P	nuclear angular momentum, power levels of the signals (in watt)
PAS	principal axis system
PEP	preservation of equivalent pathway
PSD	phase sensitive detector
pw_{90}	90° pulse length
Q	nuclear quadrupole moment, quality factor, adiabatic factor, Q factor of probe circuits
R	resistance
R_1	spin–lattice (longitudinal) relaxation rate
R_2	spin–spin (transverse) relaxation rate
RDC	residual dipolar coupling
RF	radio frequency
rMD	restrained molecular dynamics
rmsd	root-mean-square deviation
ROESY	rotating frame Overhauser spectroscopy
RT	real time
S	Saupe order matrix, spin S, generalized order parameter
S^2	squared generalized order parameter
SAR	structure–activity relationship
SC	superconducting
SDS	sodium dodecyl sulfate
se	sensitivity enhancement
SL	spin lock
SQ	single quantum
SSB	single sideband
ST	sweep-tune
T_1	spin–lattice (longitudinal) relaxation time

t_1, t_2	time domain of multidimensional experiments
$T_{1\rho}$	T_1 of spin locked magnetization in rotating frame
T_2	spin–spin (transverse) relaxation time
T_2^*	effective T_2
$T_{2\rho}$	T_2 of spin locked magnetization in rotating frame
TMS	tetramethylsilane
TOCSY	total correlation spectroscopy
T/R	transmitter/receiver
TROSY	transverse relaxation optimized spectroscopy
V	voltage
V_{pp}	peak-to-peak voltage
V_{rms}	root-mean-square amplitude of a signal (in Volt)
VT	variable temperature
w_0, w_1, w_2	transition probabilities for zero-, single-, and double-quantum transitions
X	heteronucleus
Z	impedance, generalized resistor
δ	chemical shift (in ppm)
γ_{I}	gyromagnetic ratio of nucleus I
η	nuclear Overhauser enhancement, filling factor of probe coil, asymmetric parameter of principal axis system, viscosity
λ	wavelength, decoupling scaling factor
μ_0	permeability of vacuum
μ	magnetic dipole moment, nuclear angular moment
ν_{D}	dipolar coupling constant
ρ	density operator
σ	chemical shift tensor, conductivity of sample, cross-relaxation rate
σ_{dia}	diamagnetic shielding
σ_{para}	paramagnetic shielding
τ_{c}	correlation time
τ_{e}	effective correlation time
τ_{m}	global correlation time
τ_{s}	internal correlation time
Ω	frequency offset, free precession frequency
ω	angular frequency
ω_0	Larmor frequency (in rad sec^{-1}), carrier frequency
ω_1	frequency of B_1 field (in rad sec^{-1}), Larmor frequency in the rotating frame
ω_{L}	local oscillator frequency (in rad sec^{-1}), carrier frequency
ω_{R}	intermediate frequency (in rad sec^{-1})
Ξ	frequency ratio of chemical shift reference

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