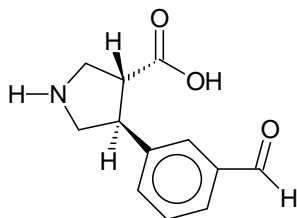


MARK ONE ANSWER FOR EACH QUESTION ON BOTH THE EXAM AND YOUR SCANTRON!

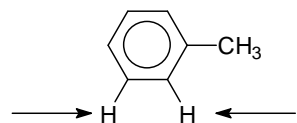
- What is the unit of "wave number"?
A. Hertz B. cm^2 C. m^{-1} D. ppm E. cm^{-1}
- Bromine has two isotopes, ^{79}Br and ^{81}Br . What percentage of bromine is ^{79}Br ?
A. approx. 50% B. approx. 70% C. approx. 30% D. approx. 1.1% E. approx. 0.06%
- What is the "fingerprint" region of an IR spectrum?
A. The region between 400 and $1,500 \text{ cm}^{-1}$.
B. The region between 3,000 and $4,000 \text{ cm}^{-1}$.
C. The region where the carbonyl stretch shows up.
D. A region where the spectra of all and any organic compounds look the same.
E. The region on the spectrum where the operator leaves his/her fingerprint as identification
- You (hopefully) know that tetramethylsilane, "TMS", is the zero standard for proton NMR spectra. What is the standard for ^{13}C NMR spectra?
A. elemental carbon B. carbon dioxide C. also TMS
D. methane E. there is no standard for ^{13}C spectra.
- Why are NMR spectra of isotopes with spin quantum numbers $> \frac{1}{2}$ not commonly recorded?
A. because they are invisible to NMR
B. because they give rise to very broad peaks
C. because only noble gases have spin quantum numbers $> \frac{1}{2}$.
D. because isotopes with spin quantum numbers $> \frac{1}{2}$ are highly radioactive
E. because only actinides have spin quantum numbers $> \frac{1}{2}$

6. How many exchangeable protons does the compound below have?



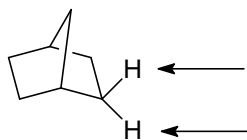
- A. none B. one C. two D. three E. four

7. What is the relationship for the highlighted pair of protons in the compound below?



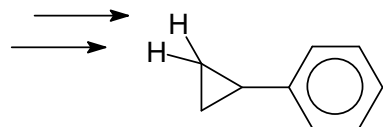
- A. homotopic B. enantiotopic C. diastereotopic D. heterotopic (E is not a valid choice)

8. What is the relationship for the highlighted pair of protons in the compound below?



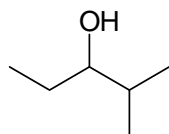
A. homotopic B. enantiotopic C. diastereotopic D. heterotopic (E is not a valid choice)

9. What is the relationship for the highlighted pair of protons in the compound below?



A. homotopic B. enantiotopic C. diastereotopic D. heterotopic (E is not a valid choice)

10. Consider the alcohol below. It can undergo both elimination and alpha cleavage. Which prominent fragments would these processes produce?

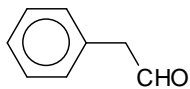


A. $m/z = 30, 42$ and 80 B. $m/z = 29, 43$ and 84 C. $m/z = 18, 23,$ and 55
 D. $m/z = 17, 55$ and 67 E. $m/z = 59, 73$ and 84

11. What is the smallest number of carbons a ketone can have, which is able to undergo a McLafferty rearrangement?

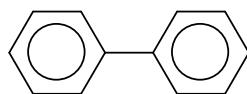
A. two B. three C. four D. five E. six

12. How many signals would you expect to see in a decoupled ^{13}C spectrum of the aldehyde below?



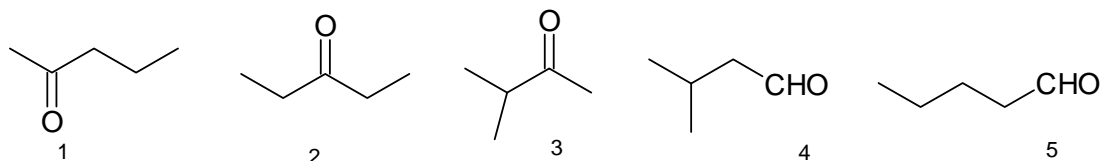
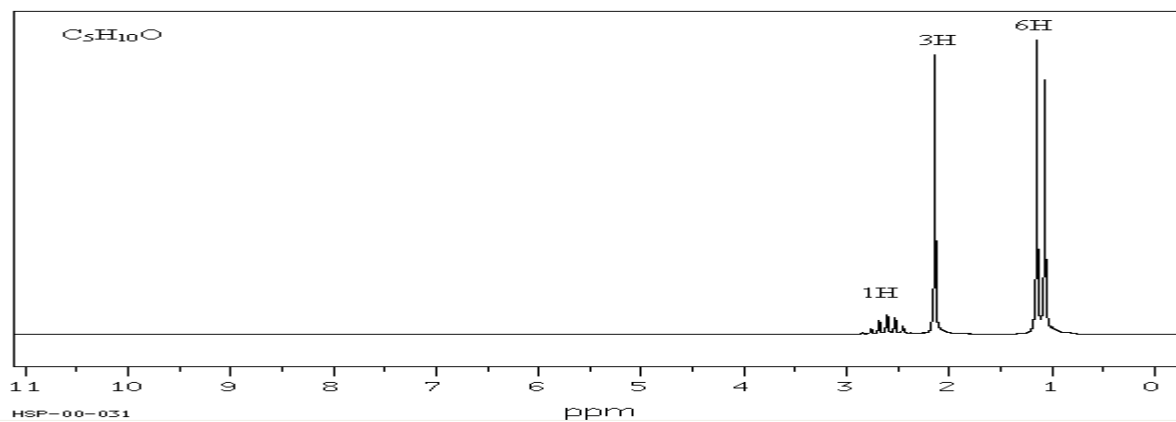
A. two B. three C. four D. five E. six

13. How many signals would you expect to see in a decoupled ^{13}C spectrum of the compound below?



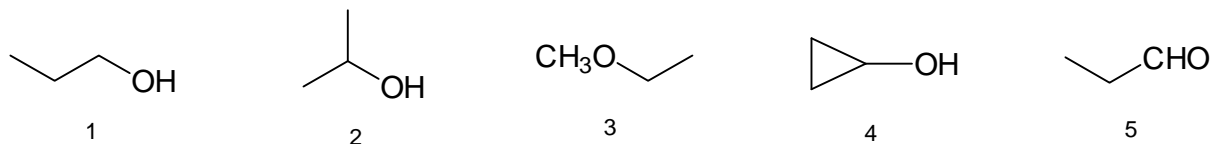
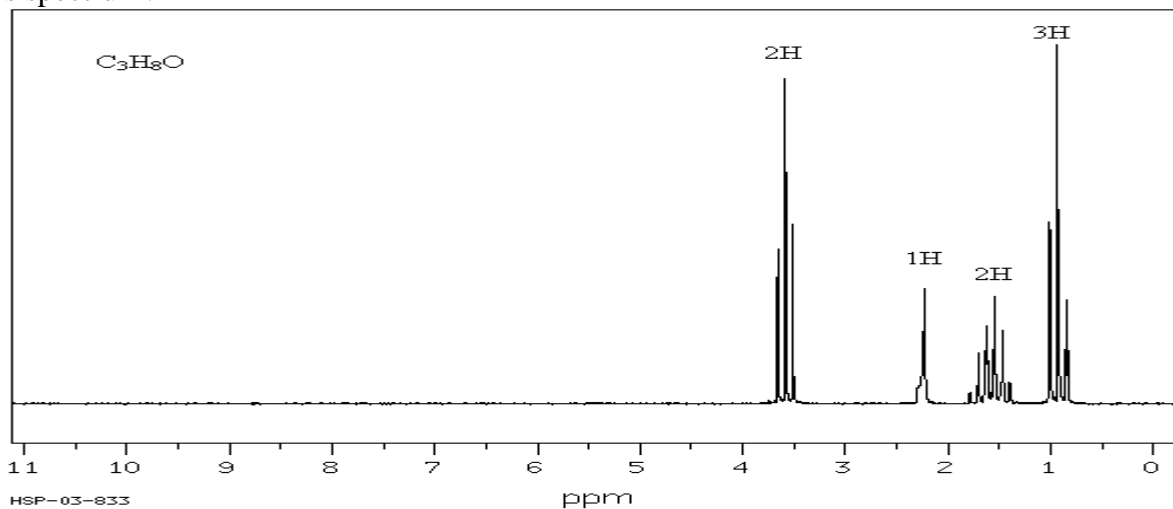
A. two B. three C. four D. five E. six

14. The proton NMR spectrum below belongs to a compound $\text{C}_5\text{H}_{10}\text{O}$. What structure matches this spectrum?



A. compound 1 B. compound 2 C. compound 3 D. compound 4 E. compound 5

15. The proton NMR spectrum below corresponds to a compound C_3H_8O . What structure matches this spectrum?

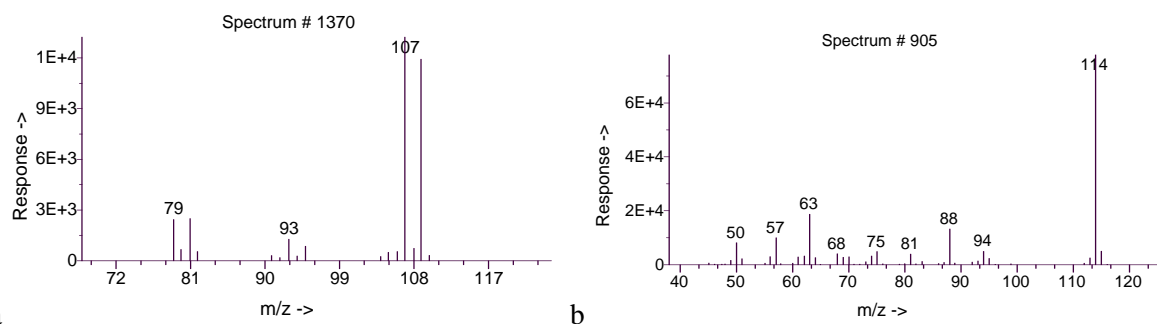


A. compound 1 B. compound 2 C. compound 3 D. compound 4 E. compound 5

16. What happens to the chemical shifts of compounds as the magnetic field strength of the NMR spectrometer doubles, e.g. from 4 Tesla to 8 Tesla?

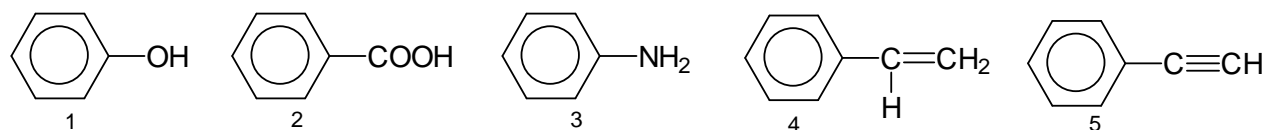
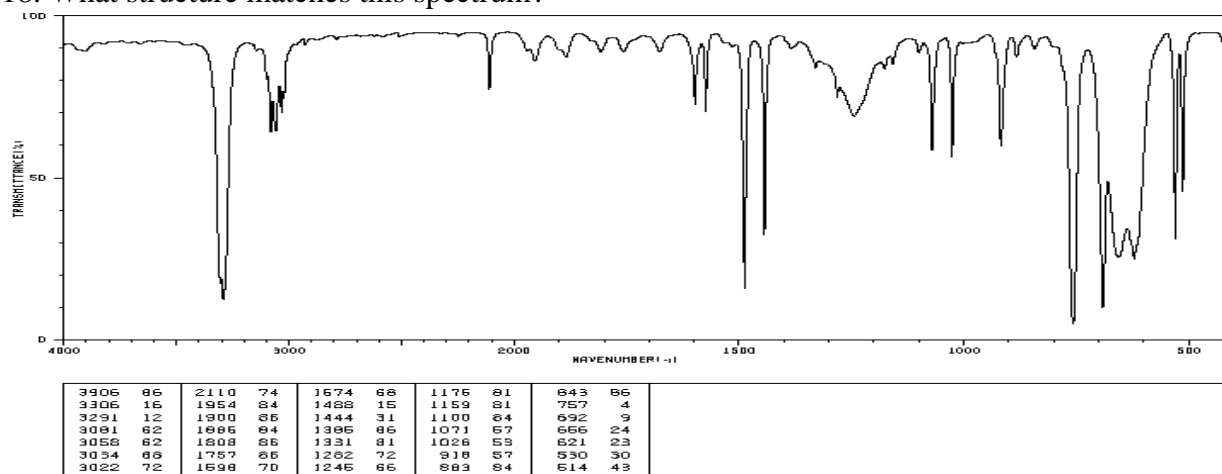
A. Nothing, they stay the same B. They double C. They quadruple
D. They decrease E. They change in unpredictable ways

17. Consider the mass spectra below and select the best statement. The heaviest m/z values correspond to M^+ .



- a
- b
- A. The left spectrum (a) indicates the presence of a phenyl group
 B. Both spectra indicate presence of an odd number of nitrogen atoms
 C. The right spectrum (b) indicates the presence of a benzyl group
 D. The left spectrum (a) indicates the presence of a bromine atom
 E. The right spectrum (b) indicates the presence of a chlorine atom

18. What structure matches this spectrum?

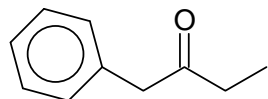


- A. compound 1 B. compound 2 C. compound 3 D. compound 4 E. compound 5

19. The mass spectrum of a compound displays M^+ at $m/z = 101$, with a minor $M+1$ peak. What formula matches this spectrum?

- A. $C_5H_8O_2$ B. C_5H_7Cl C. C_2H_3Br D. $C_5H_{12}N_2$ E. $C_6H_{15}N$

20. The ketone below is prone to alpha cleavage. Which fragments would you expect to result from this process?



- A. $m/z = 77$ and $m/z = 89$ B. $m/z = 57$ and $m/z = 119$ C. $m/z = 29$ and $m/z = 119$
 D. $m/z = 57$ and $m/z = 82$ E. $m/z = 29$ and $m/z = 82$

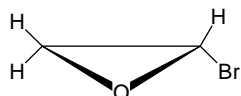
21. In the mass spectrometer, benzyl cations rearrange to a very stable cation with $m/z = 91$. What is the name of this cation?

- A. allyl cation B. cyclopentenyl cation C. cyclohexatrienyl cation
D. cycloheptadienyl cation E. cycloheptatrienyl cation

22. How is the energy of electromagnetic radiation related to the frequency and the wavelength?

- A. **As the energy increases**, the frequency increases and the wavelength decreases
B. **As the energy increases**, the frequency decreases and the wavelength increases
C. **As the energy increases**, both frequency and the wavelength increase
D. **As the energy increases**, both frequency and the wavelength decrease
C. **As the energy increases**, the frequency decreases and the wavelength stays the same

23. How many coupling constants would we need to know to draw a tree diagram for the spin-spin splitting of the compound below?

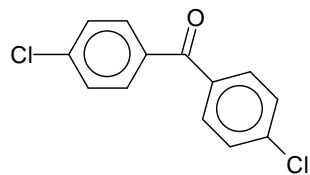


- A. Two three-bond coupling constants
B. One two bond coupling constant and two three-bond coupling constants
C. Two two-bond coupling constants
D. One two bond coupling constant, two three-bond coupling constants, and one four-bond coupling constant
E. One two bond coupling constant

24. In what units are coupling constants measured?

- A. They are measured in Hertz
B. They are dimensionless (no units apply)
C. They are measured in nanometers
D. They are measured in cm^{-1}
E. They are measured in Tesla

25. How many signals would you expect for a decoupled ^{13}C NMR spectrum of the ketone below?



- A. three B. four C. five D. six E. seven

26. This is exam version A. Please mark A on your scantron!

Key exam 232-01_1_100a:

1. E
2. A
3. A
4. C
5. B
6. C
7. D
8. C
9. C
10. E
11. D
12. E
13. C
14. C
15. A
16. A
17. D
18. E
19. E
20. B
21. E
22. A
23. B
24. A
25. C