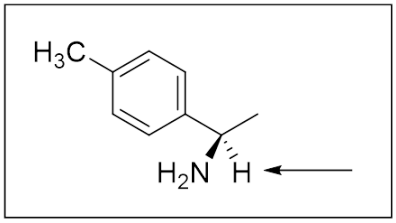
Part A: Multiple Choice (20 questions 2.5 marks each, 50 marks 50% of exam)

Choose the one alternative that best completes the statement or answers the question

1. Which of the following best represents the predicted chemical shift and splitting pattern for the hydrogen indicated by the arrow in the structure below?



A. 2.5 ppm, quartet **B. 4.0 ppm, quartet** C. 2.5 ppm, sextet D. 4.0 ppm, sextet E. 1.5 ppm, sextet

2. In IR spectroscopy, what is the main reason why a C-H stretch comes in at a higher frequency than a C-D stretch?

A. The C-H bond is stronger than a C-D bond

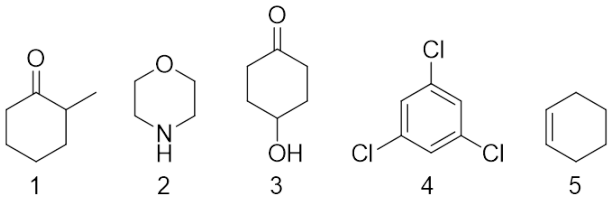
B. The C-D bond is stronger than a C-H bond

C. C-H has a higher reduced mass than C-D

D. C-H has a lower reduced mass than C-D

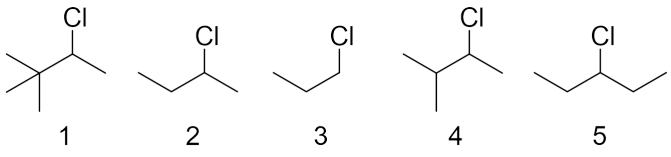
E. the C-H bond is more polar than C-D

3. Which of the following compounds would you expect to have a doublet in it's ^{1}H NMR spectrum?



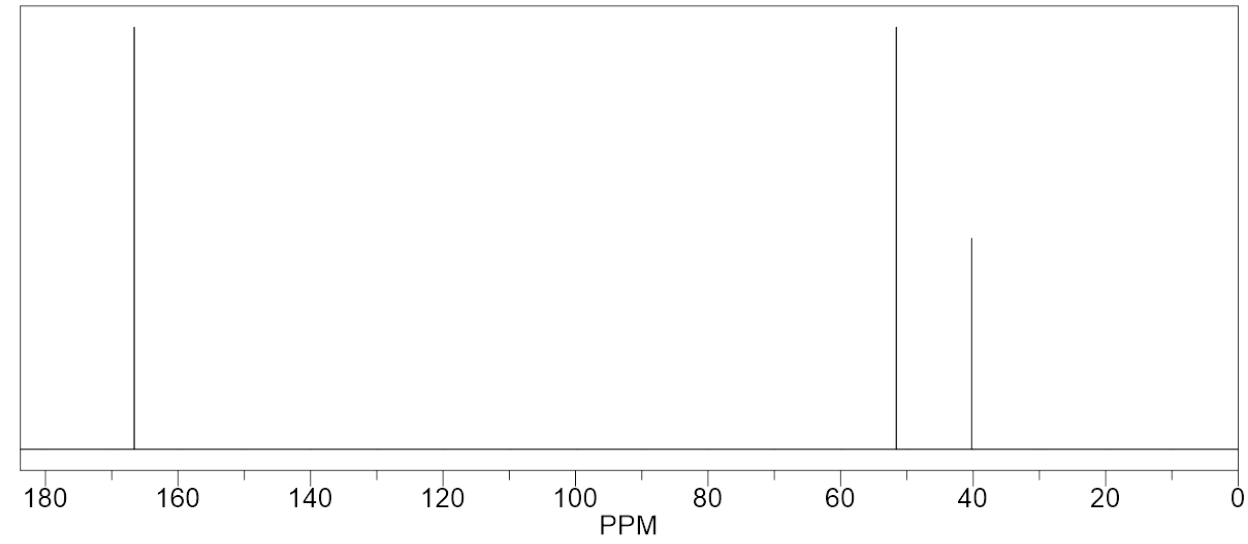
A. 1 B. 2 C. 3 D. 4 E. 5

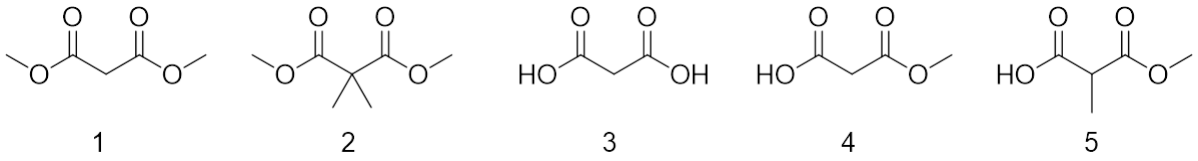
4. Which of these compounds would have a ^{1}H NMR spectrum that consists only of one singlet, one doublet and one quartet?



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

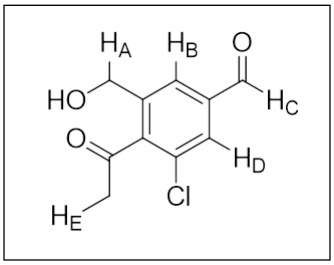
5. Which of the molecules below is most likely to have given the following ^{13}C NMR spectrum?





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

6. For the following boxed compound, which hydrogen would you expect to have the most deshielded chemical shift?



A. H_A B. H_B **C. H_C** D. H_D E. H_E

7. In IR spectroscopy, an alkyne C≡C stretch comes in a frequency range of 2100 - 2260 cm^{-1} whereas an imine C=N stretch comes in a frequency range of 1640 - 1690 cm^{-1} . What factor explains why the alkyne C≡C stretch comes in at a higher frequency?

   A. C≡C is a more polar bond than C=N

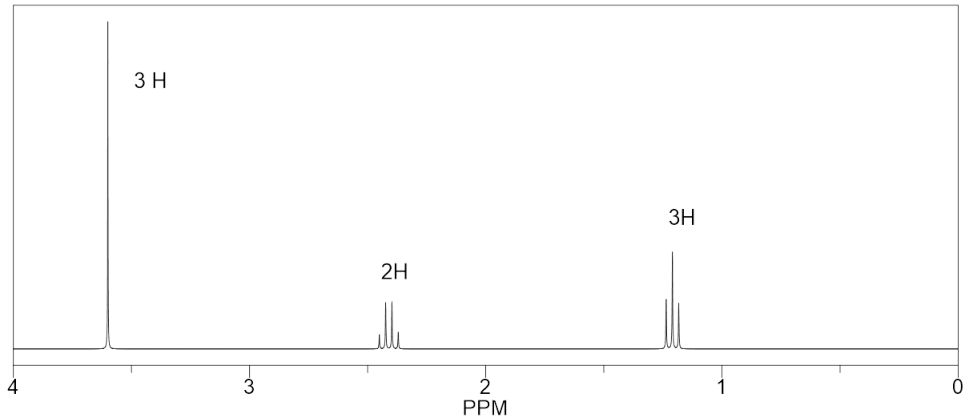
   B. C≡C has a larger reduced mass than C=N

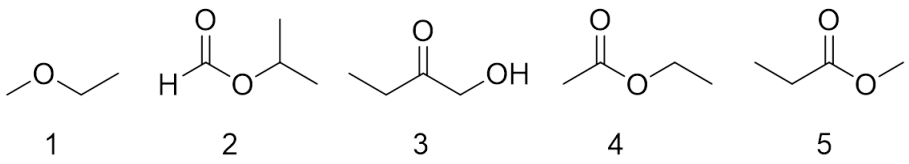
   C. C≡C is a weaker bond than C=N

   D. C≡C is a stronger bond than C=N

   E. Not enough information to tell

8. Which of the molecules below is most likely to have given the following ^1H NMR spectrum?

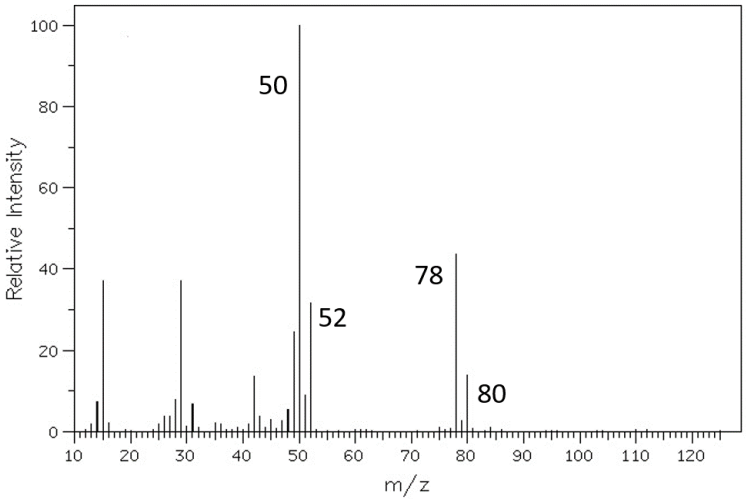




1 2 3 4 5

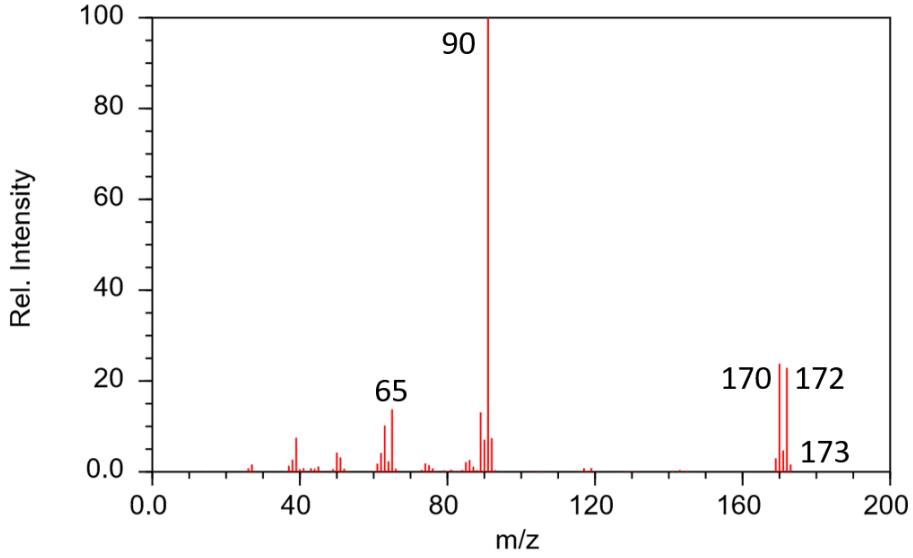
A. 1 B. 2 C. 3 D. 4 **E. 5**

9. Which heteroatom is most likely present in the compound that produces the following mass spectrum?



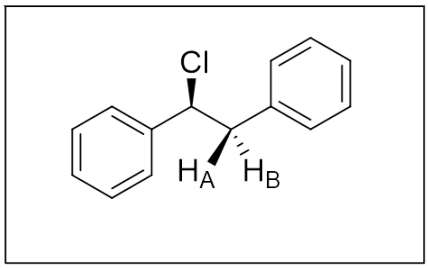
A. Bromine **B. Chlorine** C. Sulfur D. Nitrogen E. Fluorine

10. Identify the base peak in the following mass spectrum.



A. m/z 65 **B. m/z 90** C. m/z 170 D. m/z 172 E. m/z 173

11. In NMR terminology, what classification do we give H_A and H_B in the compound below?



A. Homotopic B. Heterotopic C. Enantiotopic **D. Diastereotopic**

12. For the following chemical reaction, what significant change would be expected in the IR spectrum of the product compared to that of the starting material?

A. A sharp peak at around 1720 cm^{-1} would disappear and a broad peak at around 3300 cm^{-1} would appear.

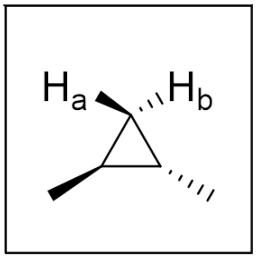
B. A broad peak at around 1720 cm^{-1} would appear and a sharp peak at around 3300 cm^{-1} would disappear.

C. A sharp peak at around 1720 cm^{-1} would appear and a broad peak at around 3300 cm^{-1} would disappear.

D. A sharp peak at around 1720 cm^{-1} would appear and no significant new peaks would disappear.

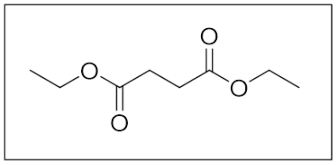
E. No significant peaks would appear and a broad peak at around 3300 cm^{-1} would disappear.

13. In NMR terminology, what classification do we give H_A and H_B in the compound below?



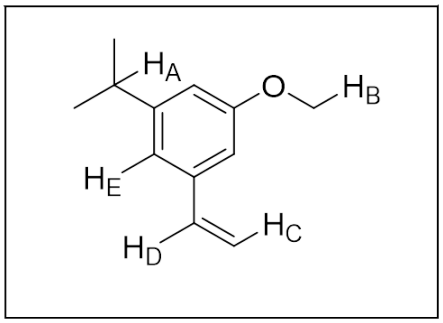
A. Homotopic B. Heterotopic C. Enantiotopic D. Diastereotopic

14. For the following boxed compound, how many different signals would you expect to see in the ^{13}C NMR spectrum?



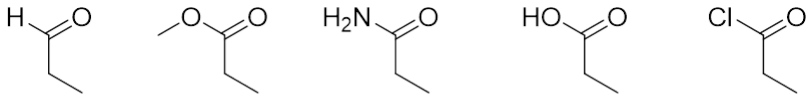
A. 3 **B. 4** C. 6 D. 7 E. 8

15. For the following boxed compound, which hydrogen would you expect to have the most shielded chemical shift?



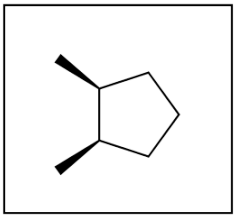
A. H_A B. H_B C. H_C D. H_D E. H_E

16. Which of the following C=O derivatives would have the lowest C=O stretching frequency?



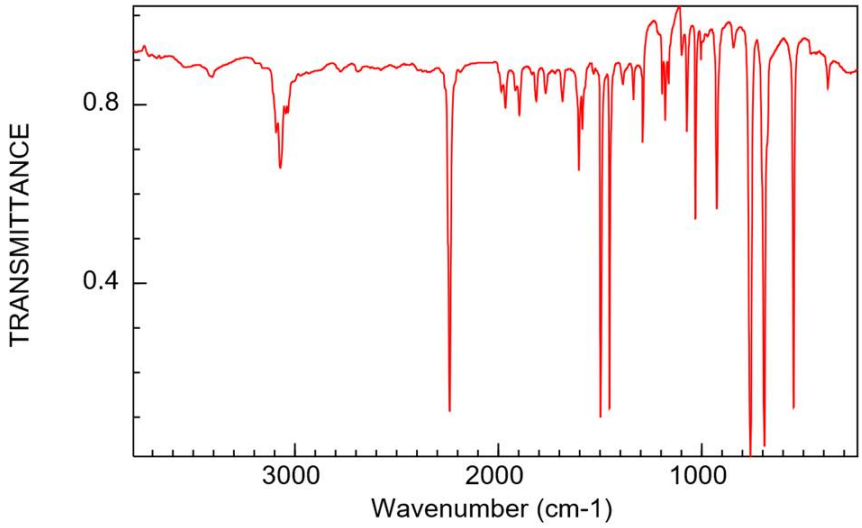
A. 1 B. 2 **C. 3** D. 4 E. 5

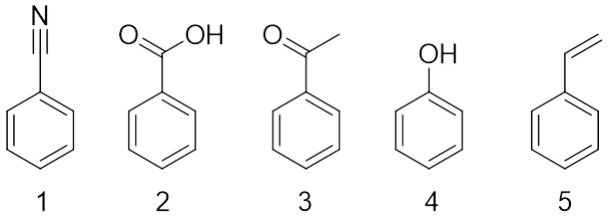
17. For the following boxed compound, how many different signals would you expect to see in the ^{1}H NMR spectrum?



A. 4 B. 5 **C. 6** D. 7 E. 10

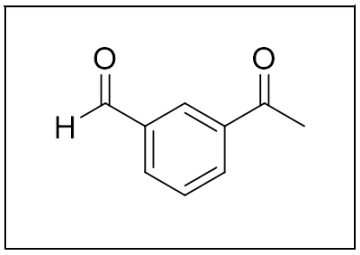
18. Which compound would most likely correspond to the IR spectrum below?





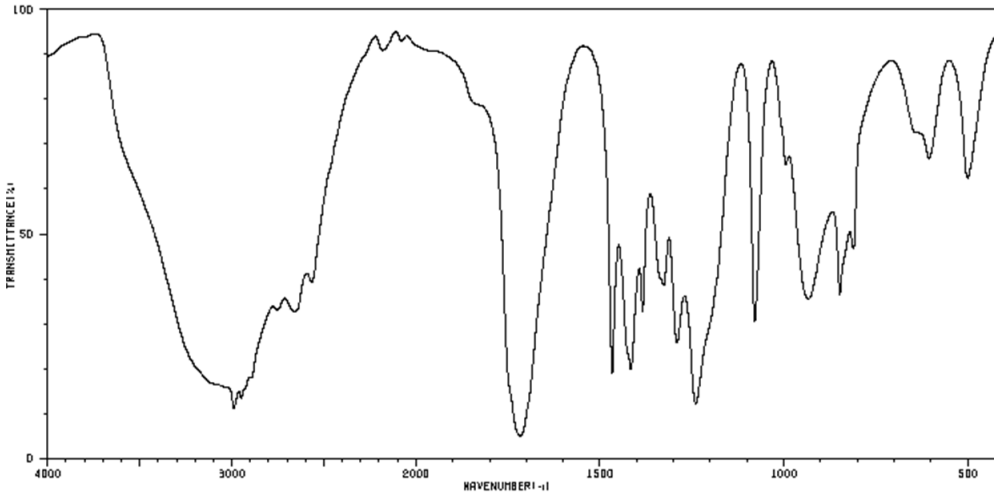
A. 1 B. 2 C. 3 D. 4 E. 5

19. For the following boxed compound, how many different signals would you expect to see in the ^{13}C NMR spectrum?



A. 5 B. 6 C. 7 D. 8 **E. 9**

20. Which compound would most likely correspond to the IR spectrum below?



A. propanol B. propanal C. ethyl acetate D. acetone **E. propanoic acid**