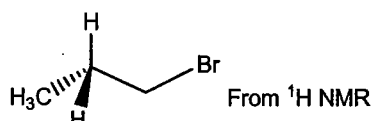


2. Which molecular formula has molecular ions ratio as: $M^+/[M+2]^+=1/1$?

- (a) $C_7H_{18}Cl_2$
- (b) $C_9H_{10}Cl$
- (c) $C_{10}H_{16}Br_2$
- (d) $C_{11}H_{14}Br$
- (e) None of the above

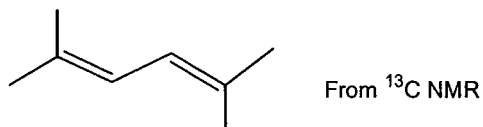
How many types of peaks (signals) would you expect to see in the 1H or ^{13}C NMR spectrum for the following compounds from Q.3 to Q.10?

3.



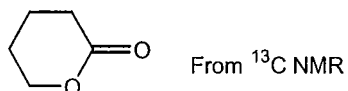
- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above

4.



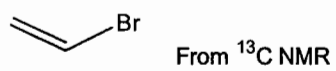
- (a) 3
- (b) 4
- (c) 5
- (d) 6
- (e) None of the above

5.



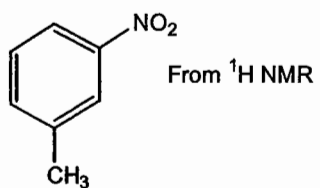
- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above

6.



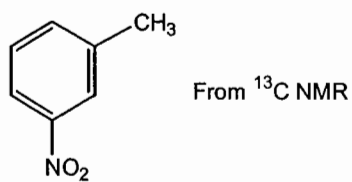
- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above

7.



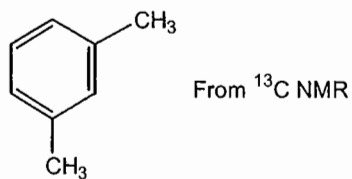
- (a) 3
- (b) 4
- (c) 5
- (d) 6
- (e) None of the above

8.



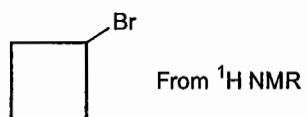
- (a) 4
- (b) 5
- (c) 6
- (d) 7
- (e) None of the above

9.



- (a) 4
- (b) 5
- (c) 6
- (d) 7
- (e) None of the above

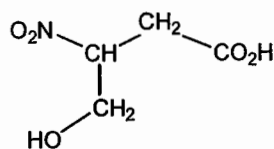
10.



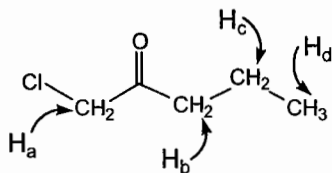
- (a) 3
- (b) 4
- (c) 5
- (d) 6
- (e) None of the above

11. For the following compound, how many **types** of proton (H) can be exchanged with deuterium (D) when CD_3OD is used as the solvent?

- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above



12. For the following compound, what is correct of decreasing chemical shift (from the highest chemical shift to the lowest)?



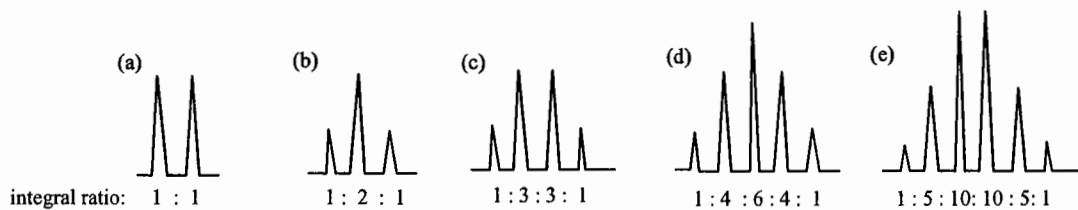
From $^1\text{H NMR}$

- (a) $\text{H}_a > \text{H}_b > \text{H}_c > \text{H}_d$
- (b) $\text{H}_b > \text{H}_a > \text{H}_c > \text{H}_d$
- (c) $\text{H}_b > \text{H}_c > \text{H}_a > \text{H}_d$
- (d) $\text{H}_a > \text{H}_c > \text{H}_b > \text{H}_d$
- (e) None of the above

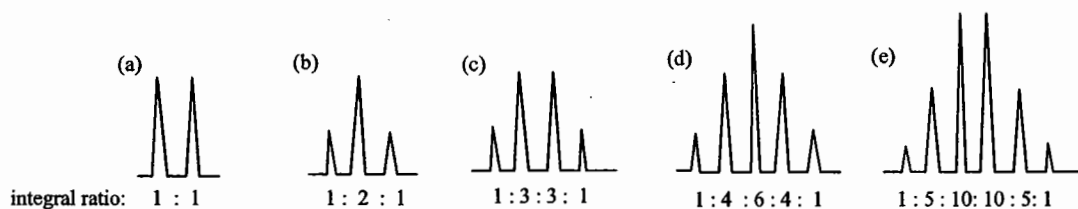
13. From the compound in Q.12, what will be the appearance (splitting pattern) of H_a signal?

- (a) singlet
- (b) doublet
- (c) triplet
- (d) quartet
- (e) None of the above

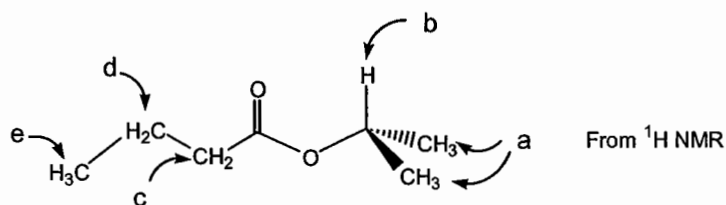
14. From the compound in Q.12, what could be the appearance (splitting pattern) of H_b signal?



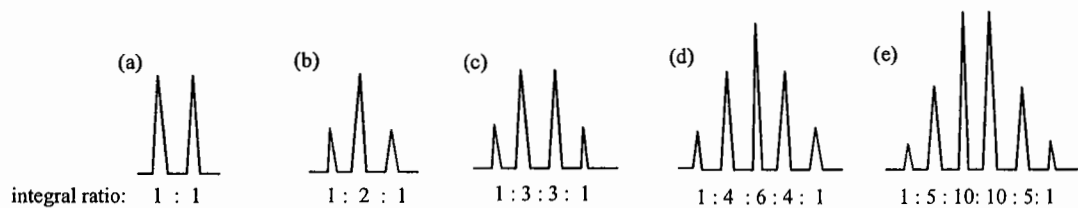
15. From the compound in Q.12, what could be the appearance (splitting pattern) of H_c signal?



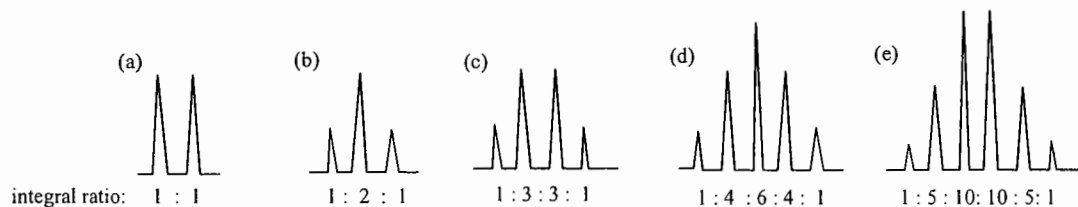
Answer Q.16 to Q.19 base on the ¹H NMR of the following compounds.



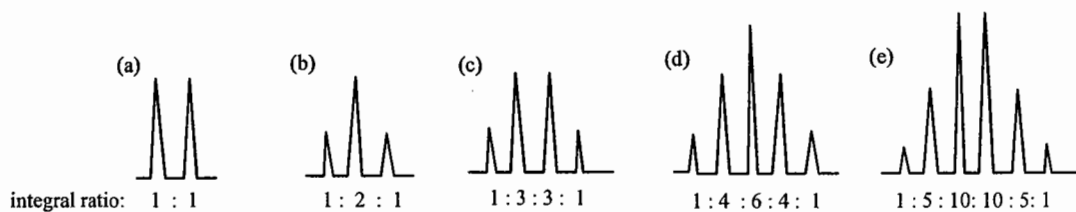
16. What could be the appearance (splitting pattern) of H_a signal?



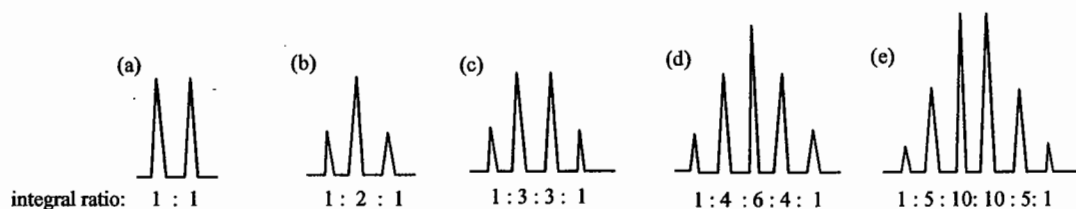
17. What could be the appearance (splitting pattern) of H_c signal?



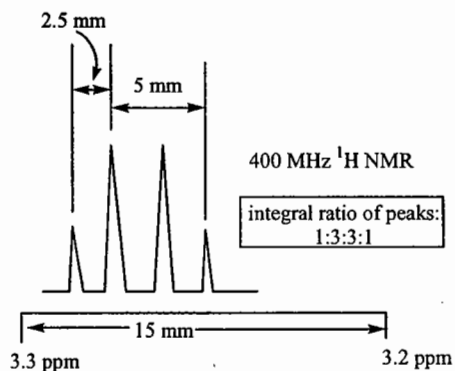
18. What could be the appearance (splitting pattern) of H_d signal?



19. What could be the appearance (splitting pattern) of H_e signal?



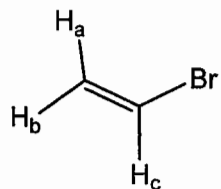
20. Base on the following enlarged signal from a 400 MHz ¹H NMR spectrum, what could be the coupling constant(s)



- (a) 6.7 Hz and 13.3 Hz
- (b) 6.7 Hz
- (c) 13.3 Hz
- (d) 5 Hz
- (e) None of the above

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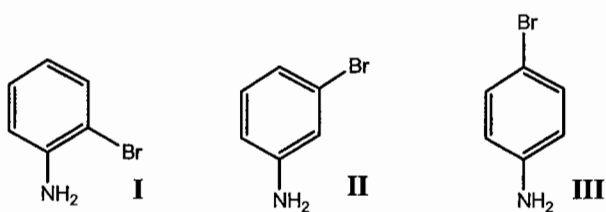
II. For the indicated protons (H_a , H_b , and H_c) of the compound below, draw the splitting patterns according to the given coupling constants (J values) from 1H NMR (5 points each, 15 point total).



$$\begin{aligned} J_{ab} &= 2 \text{ Hz} \\ J_{ac} &= 15 \text{ Hz} \\ J_{bc} &= 7 \text{ Hz} \end{aligned}$$

Continue to the Next Page

III. Assign the spectra to the corresponding compounds list below. (5 points)

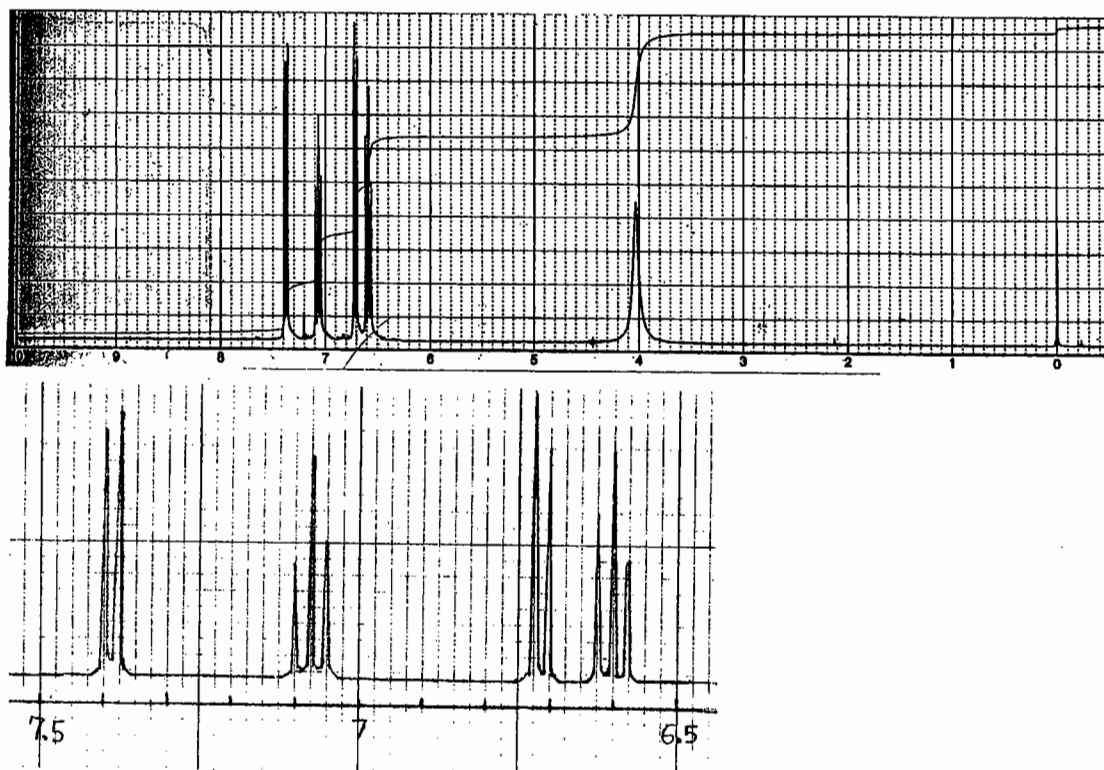


Spectrum A: _____

Spectrum B: _____

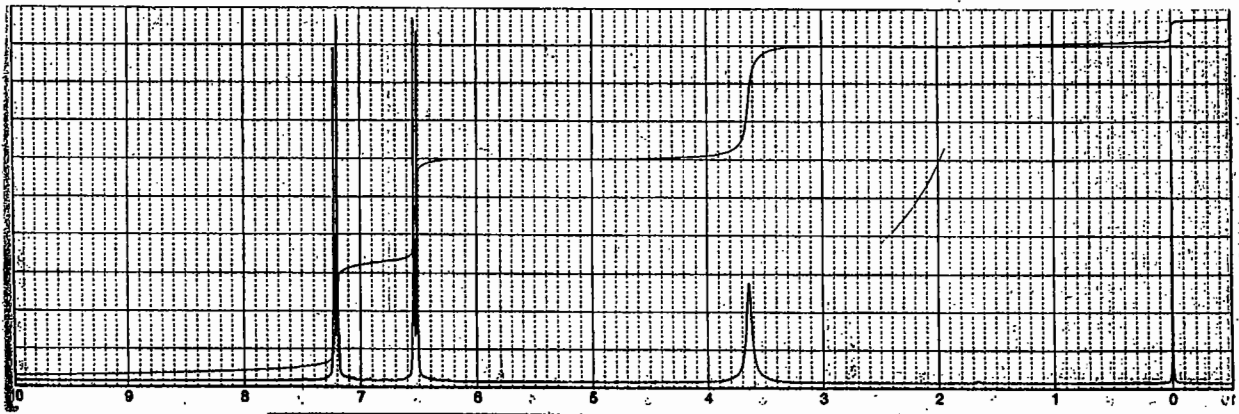
Spectrum C: _____

Spectrum A

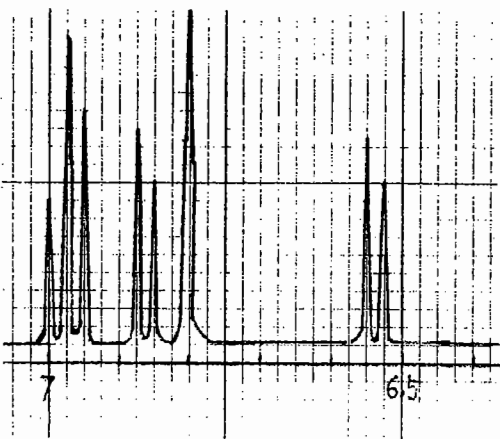
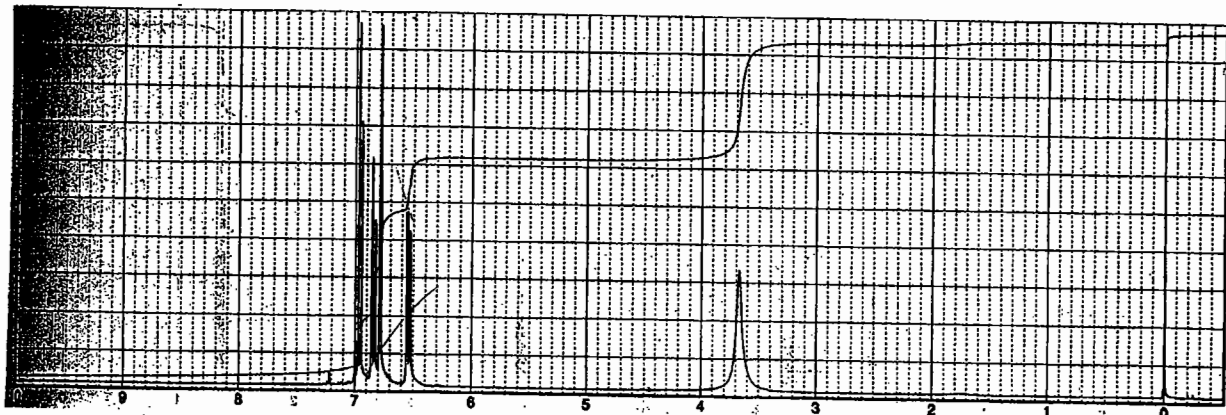


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Spectrum B



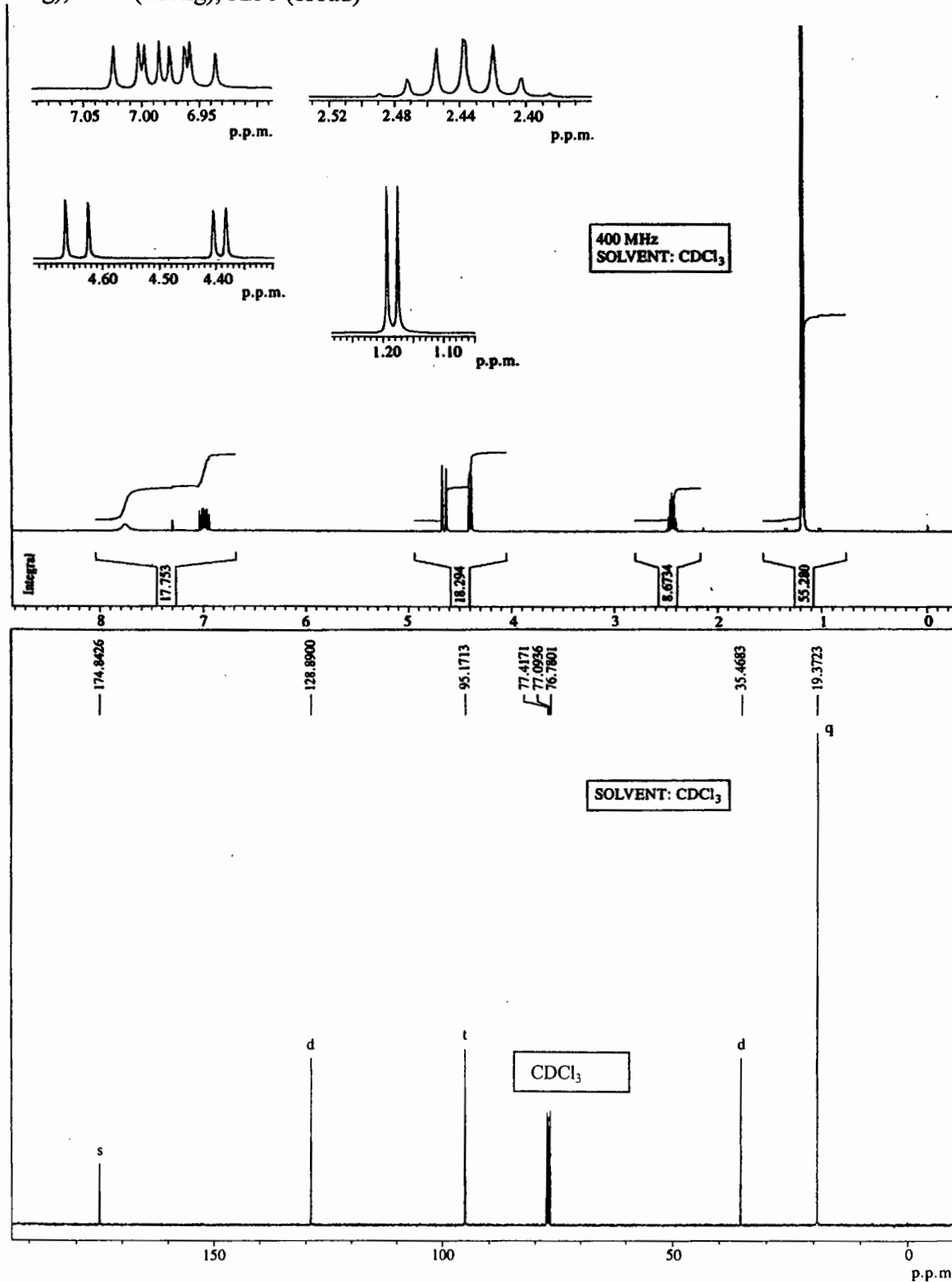
Spectrum C



Continue to the Next Page

IV. Use the table on page 11, and provide your analysis and the compound structure from the given information. (20 points)

From Mass Spec: $M^+ = 113$. From elemental analysis: C: 63.7%; H: 9.7%; N: 12.4%. From IR (cm^{-1}): 1665 (strong), 1680 (strong), 3250 (broad)



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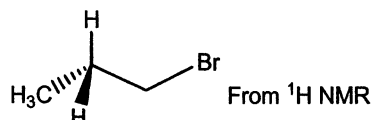
Molecular Formula:	(1 point)		
¹ H NMR (12 points)	Chemical shift	Number of H	Your interpretation
¹³ C NMR (5 points)	Chemical shift	Number of H attached	Your interpretation
Your proposed structure (2 points)			
Any additional information which may support your analysis			

2. Which molecular formula has molecular ions ratio as: $M^+/[M+2]^+=1/1$?

- (a) $C_7H_{18}Cl_2$
- (b) $C_9H_{10}Cl$
- (c) $C_{10}H_{16}Br_2$
- (d) $C_{11}H_{14}Br$
- (e) None of the above

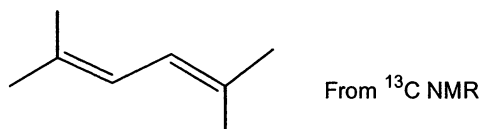
How many types of peaks (signals) would you expect to see in the 1H or ^{13}C NMR spectrum for the following compounds from Q.3 to Q.10?

3.



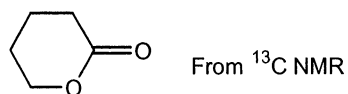
- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above

4.



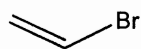
- (a) 3
- (b) 4
- (c) 5
- (d) 6
- (e) None of the above

5.



- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above

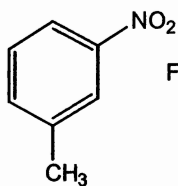
6.



From ^{13}C NMR

- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above

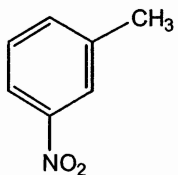
7.



From ^1H NMR

- (a) 3
- (b) 4
- (c) 5
- (d) 6
- (e) None of the above

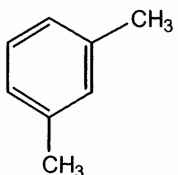
8.



From ^{13}C NMR

- (a) 4
- (b) 5
- (c) 6
- (d) 7
- (e) None of the above

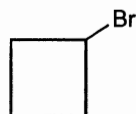
9.



From ^{13}C NMR

- (a) 4
- (b) 5
- (c) 6
- (d) 7
- (e) None of the above

10.

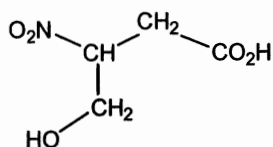


From ^1H NMR

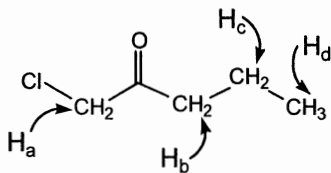
- (a) 3
- (b) 4
- (c) 5
- (d) 6
- (e) None of the above

11. For the following compound, how many **types** of proton (H) can be exchanged with deuterium (D) when CD_3OD is used as the solvent?

- (a) 2
- (b) 3
- (c) 4
- (d) 5
- (e) None of the above



12. For the following compound, what is correct of decreasing chemical shift (from the highest chemical shift to the lowest)?



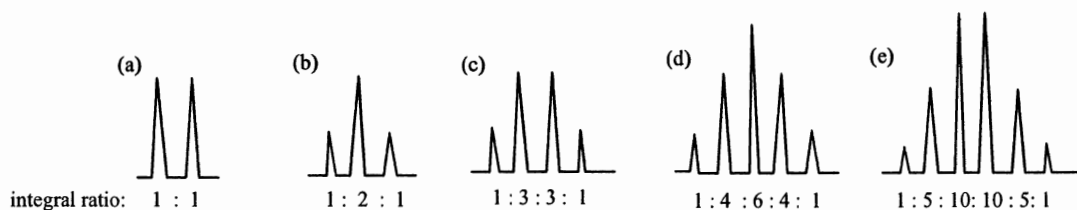
From ^1H NMR

- (a) $\text{H}_a > \text{H}_b > \text{H}_c > \text{H}_d$
- (b) $\text{H}_b > \text{H}_a > \text{H}_c > \text{H}_d$
- (c) $\text{H}_b > \text{H}_c > \text{H}_a > \text{H}_d$
- (d) $\text{H}_a > \text{H}_c > \text{H}_b > \text{H}_d$
- (e) None of the above

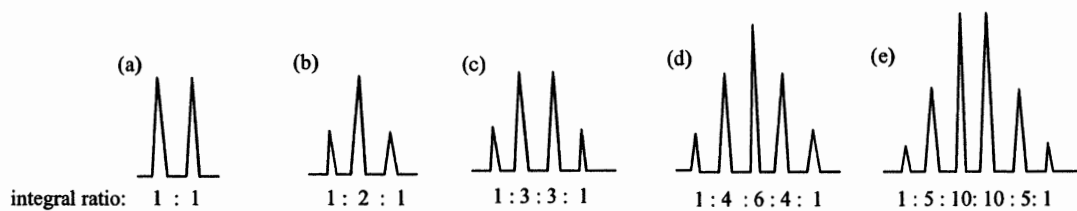
13. From the compound in Q.12, what will be the appearance (splitting pattern) of H_a signal?

- (a) singlet
- (b) doublet
- (c) triplet
- (d) quartet
- (e) None of the above

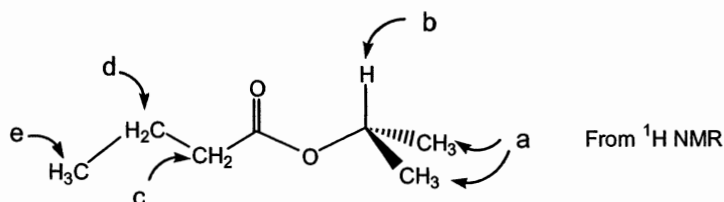
14. From the compound in Q.12, what could be the appearance (splitting pattern) of H_b signal?



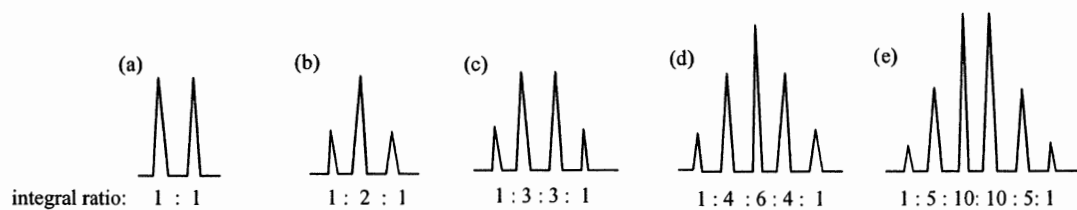
15. From the compound in Q.12, what could be the appearance (splitting pattern) of H_c signal?



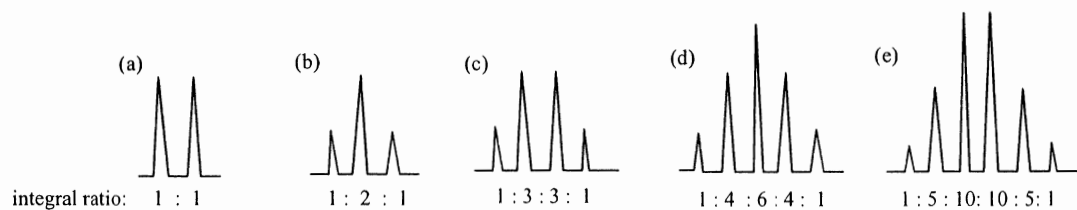
Answer Q.16 to Q.19 base on the ¹H NMR of the following compounds.



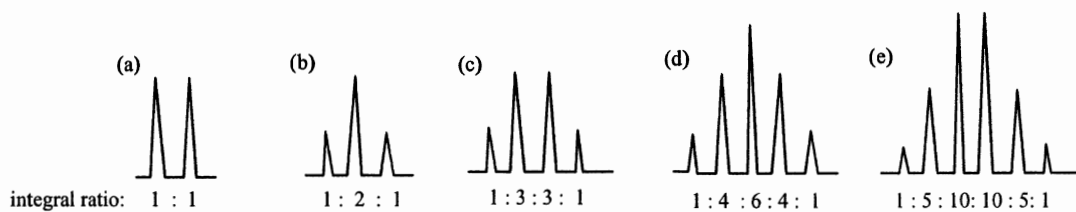
16. What could be the appearance (splitting pattern) of H_a signal?



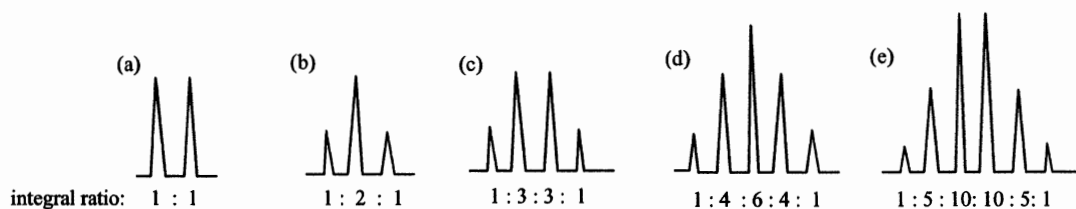
17. What could be the appearance (splitting pattern) of H_c signal?



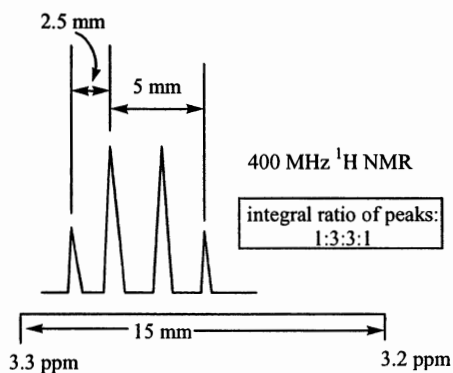
18. What could be the appearance (splitting pattern) of H_d signal?



19. What could be the appearance (splitting pattern) of H_e signal?



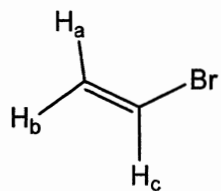
20. Base on the following enlarged signal from a 400 MHz ¹H NMR spectrum, what could be the coupling constant(s)



- (a) 6.7 Hz and 13.3 Hz
- (b) 6.7 Hz
- (c) 13.3 Hz
- (d) 5 Hz
- (e) None of the above

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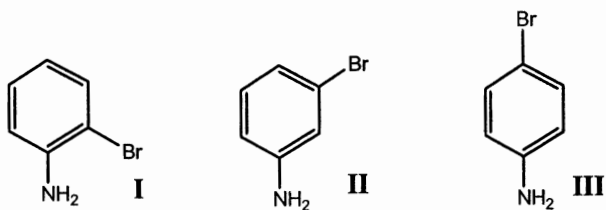
II. For the indicated protons (H_a , H_b , and H_c) of the compound below, draw the splitting patterns according to the given coupling constants (J values) from 1H NMR (5 points each, 15 point total).



$$\begin{aligned} J_{ab} &= 2 \text{ Hz} \\ J_{ac} &= 15 \text{ Hz} \\ J_{bc} &= 7 \text{ Hz} \end{aligned}$$

Continue to the Next Page

III. Assign the spectra to the corresponding compounds list below. (5 points)

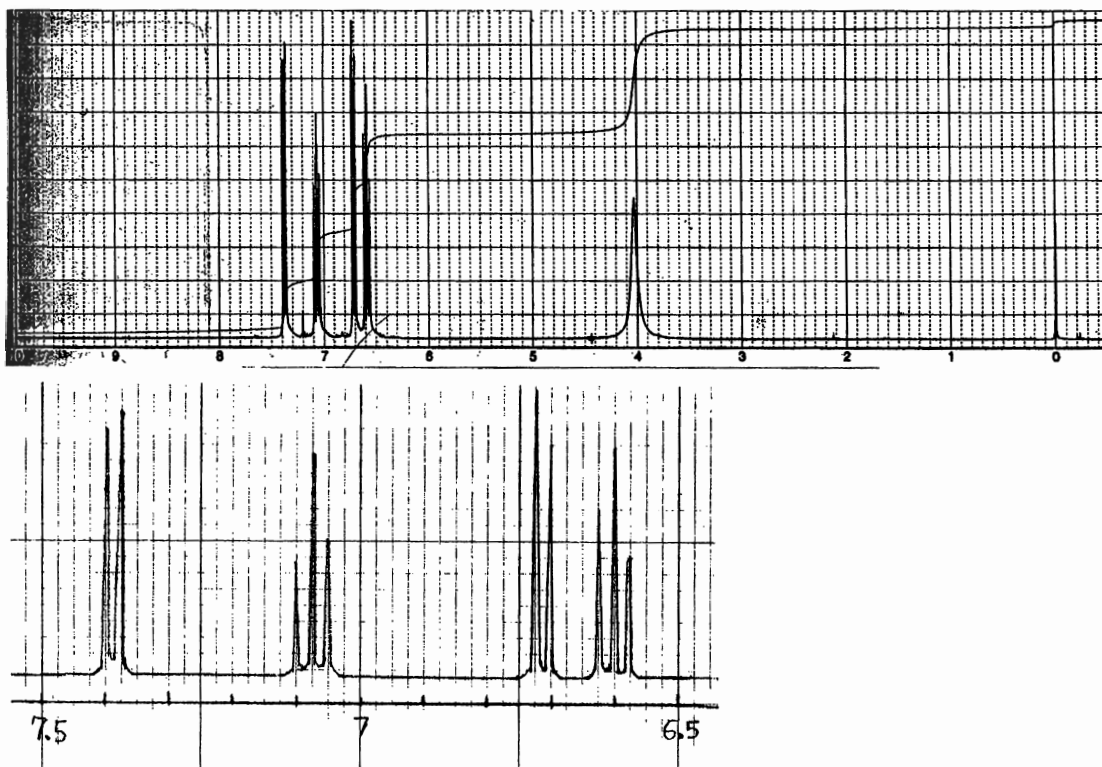


Spectrum A: _____

Spectrum B: _____

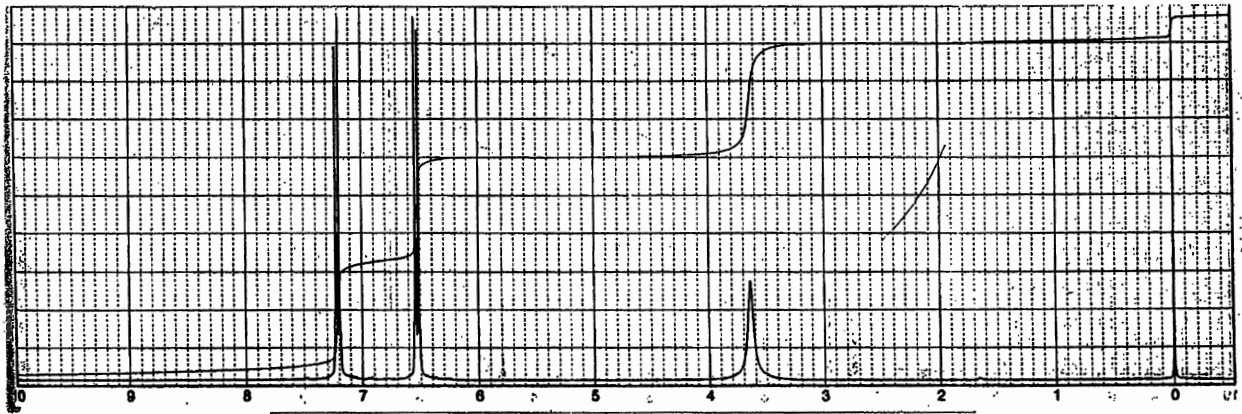
Spectrum C: _____

Spectrum A

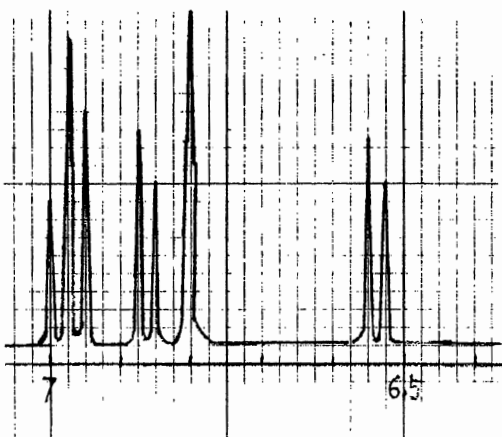
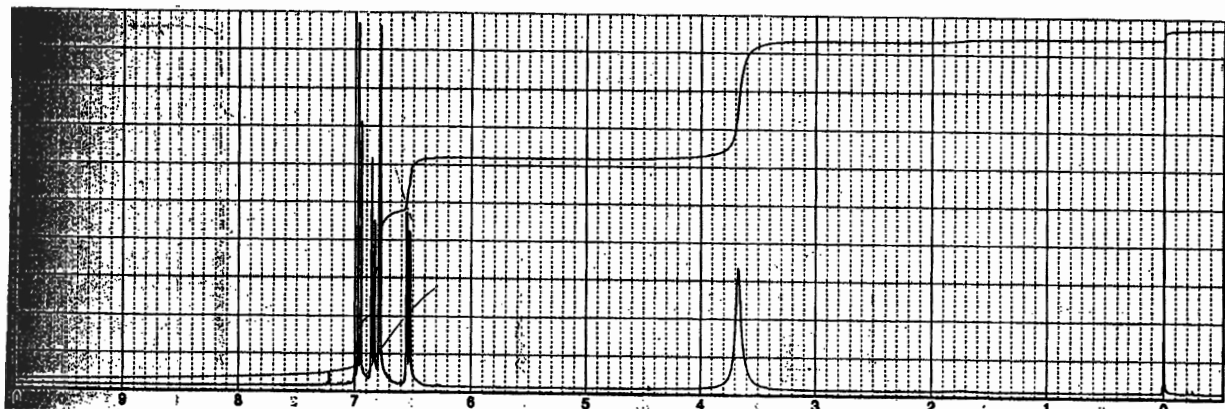


Continue to the Next Page

Spectrum B



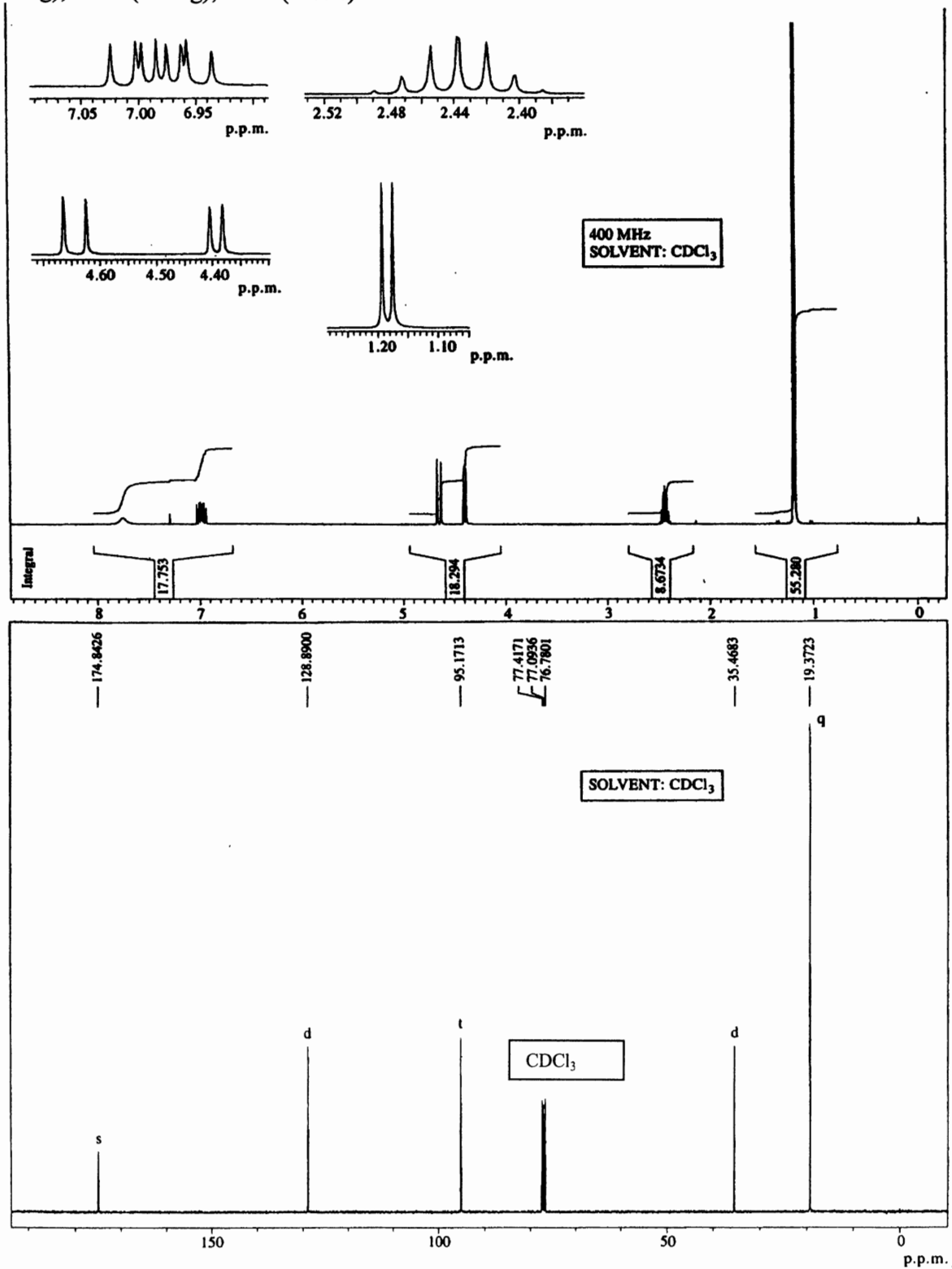
Spectrum C



Continue to the Next Page

IV. Use the table on page 11, and provide your analysis and the compound structure from the given information. (20 points)

From Mass Spec: $M^+ = 113$. From elemental analysis: C: 63.7%; H: 9.7%; N: 12.4%. From IR (cm^{-1}): 1665 (strong), 1680 (strong), 3250 (broad)



Continue to the Next Page

Molecular Formula:	(1 point)		
¹ H NMR (12 points)	Chemical shift	Number of H	Your interpretation
¹³ C NMR (5 points)	Chemical shift	Number of H attached	Your interpretation
Your proposed structure (2 points)			
Any additional information which may support your analysis			