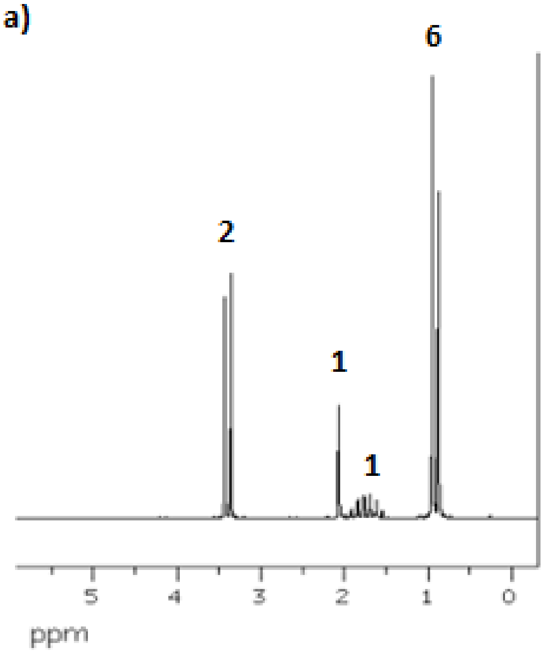
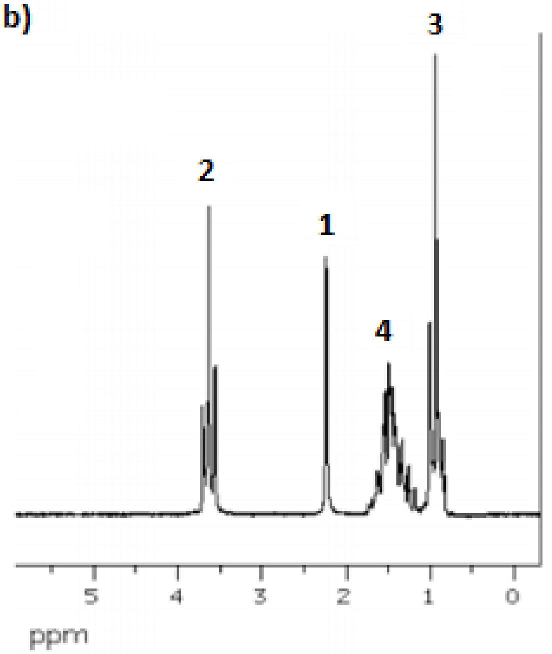
1. Below are shown the ^{1}H NMR spectra of 4 isomers of $C_4H_{10}O$. Each isomer is alcohol and OH proton is visible. Draw the structure which corresponds to each isomer next to the appropriate ^{1}H NMR spectra. Numbers are equal to integral intensity.

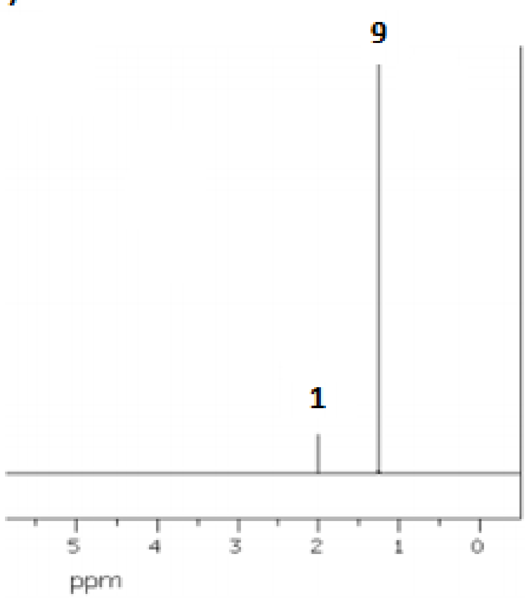
a)



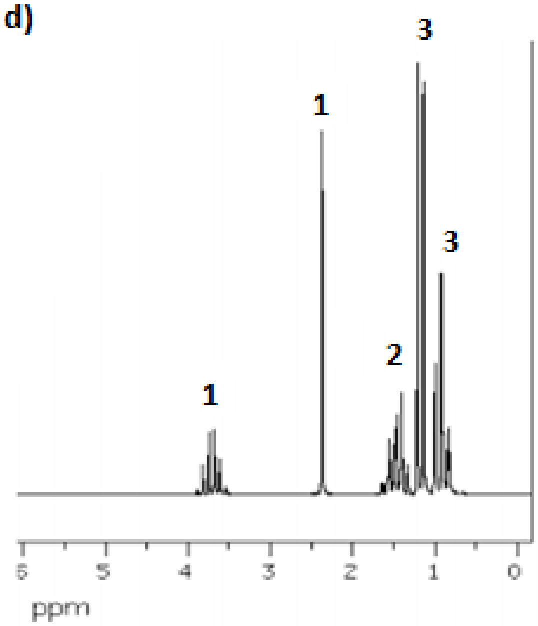
b)



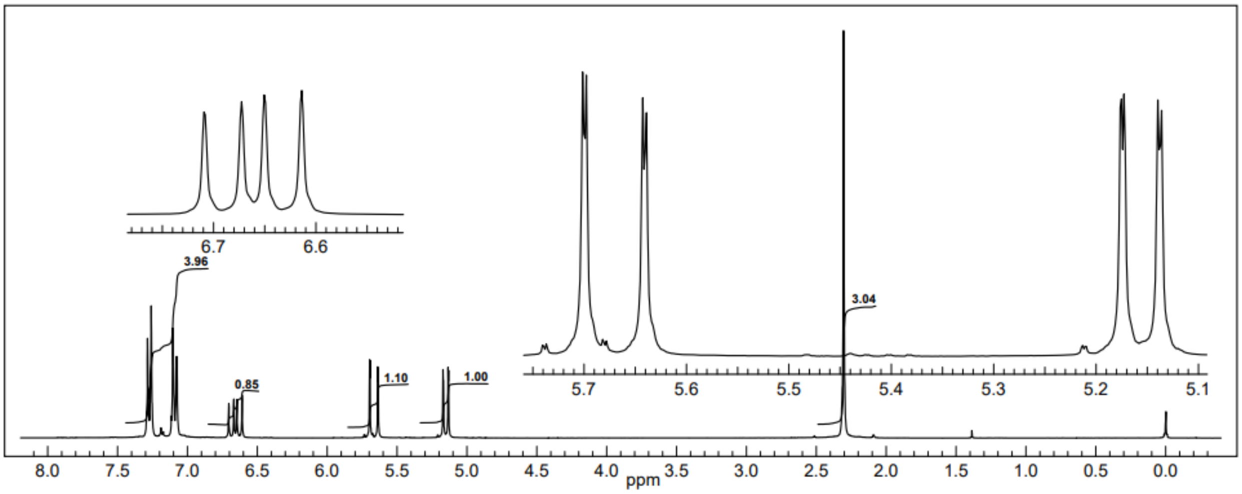
c)



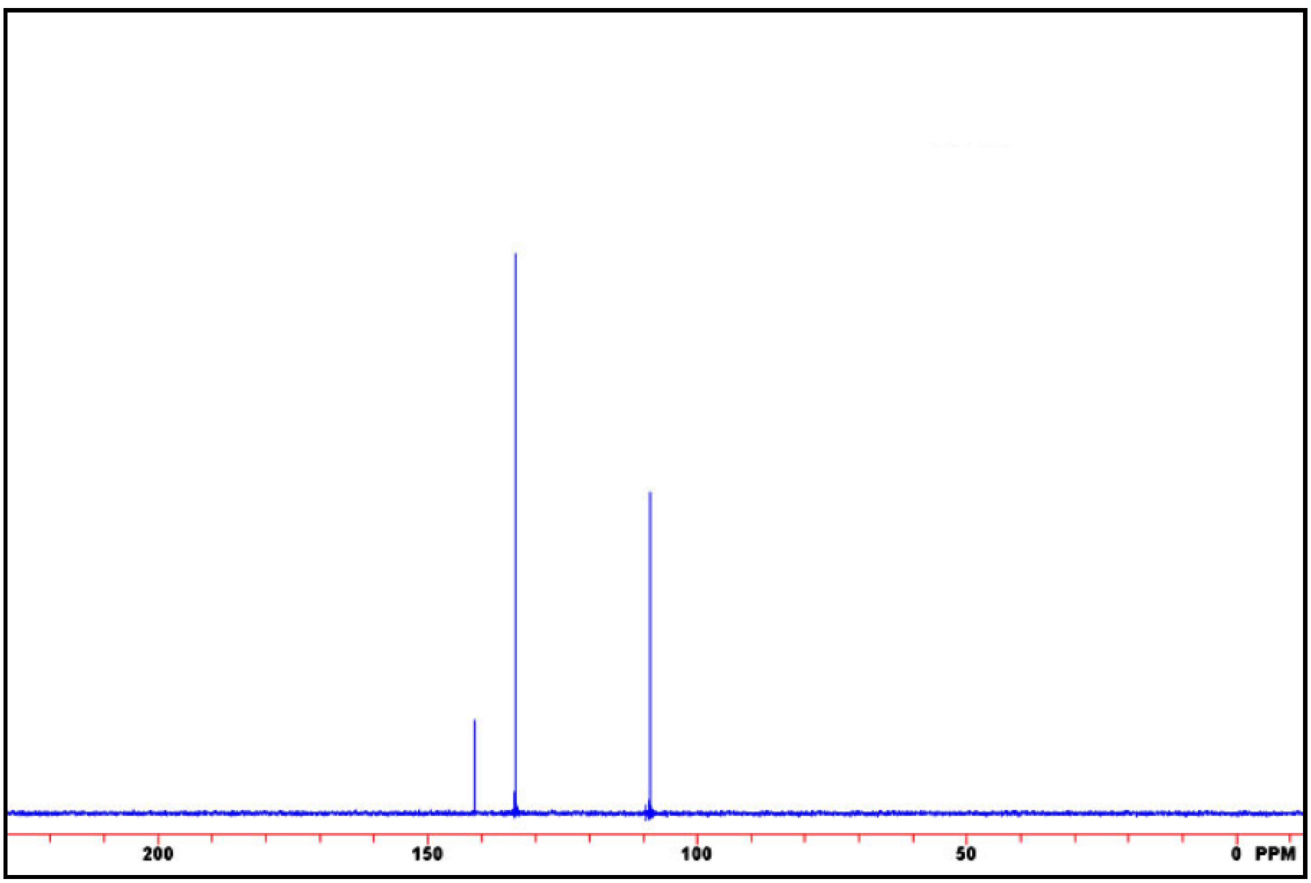
d)



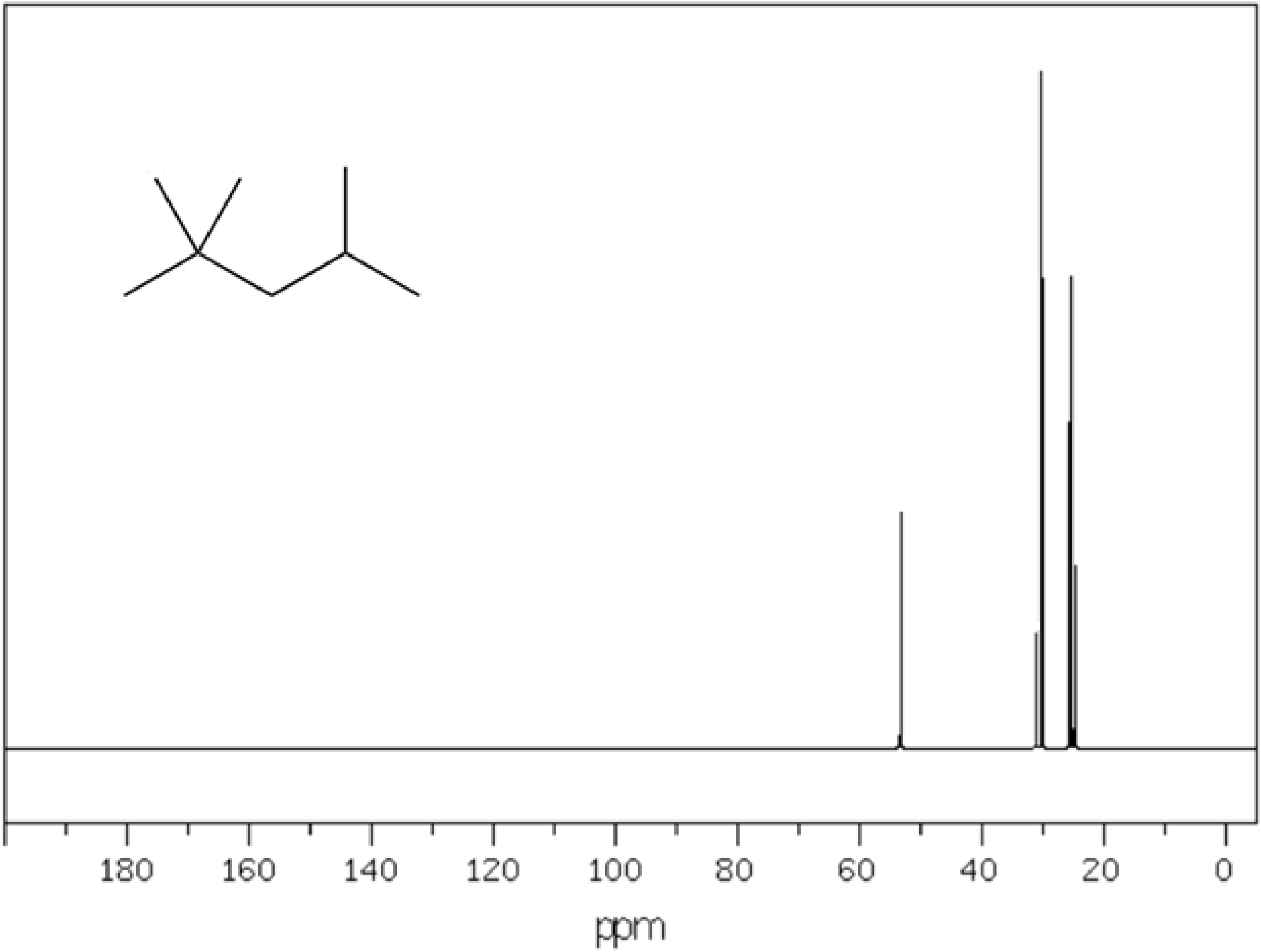
2. **Draw structural formula of compound with summary formula C_9H_{10} in $CDCl_3$ (use 1D [1]1H NMR spectrum to find the right structure).**



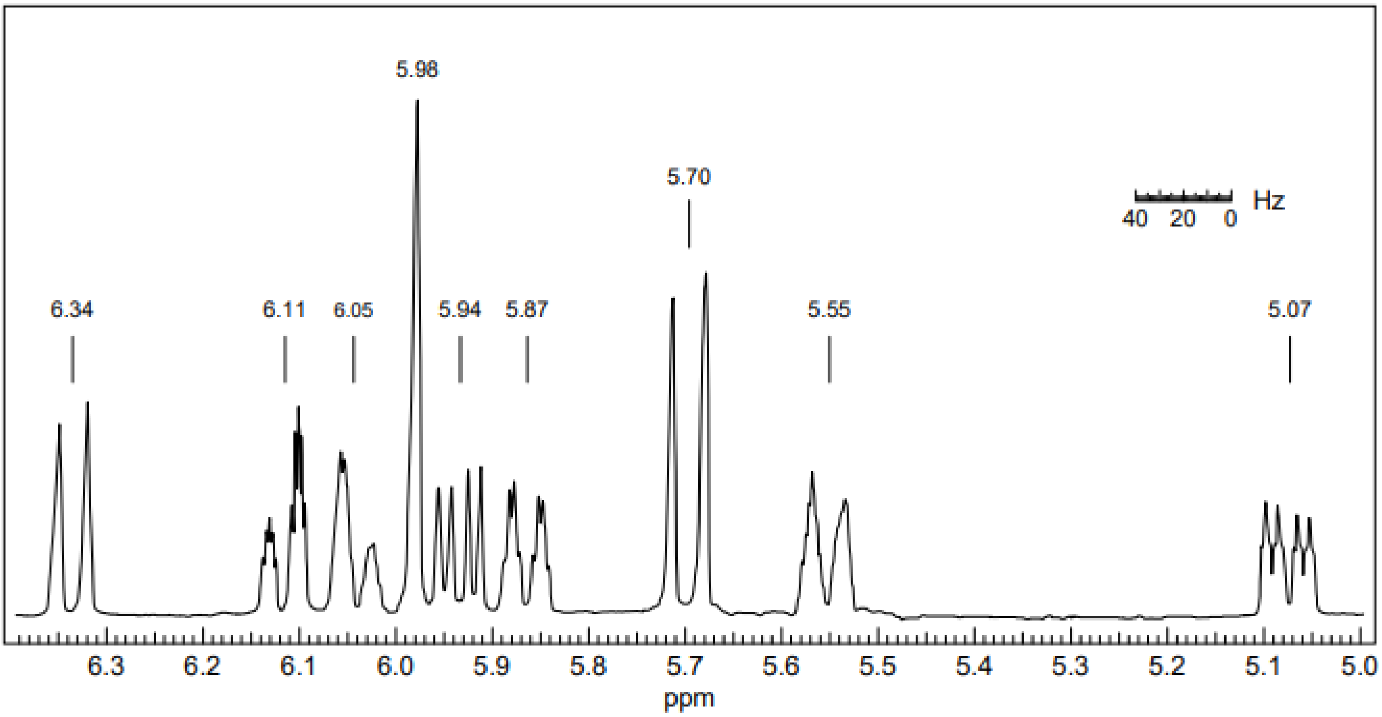
3. **Draw structural formula of compound with summary formula $C_6H_4NBr_3$ (use 1D ^{13}C NMR spectrum to find the right structure).**



4. **Below is shown the ^{13}C NMR spectrum of 2,2,4-trimethylpentane. Match the signals to corresponding carbons in the structure.**



5. **Assign the individual signals of the compound ($C_{12}H_{15}N$) whose ^1H NMR spectrum ($CDCl_3$, -10 °C) is given below. Use couplings, chemical shifts and intensities in your analysis.**



δ

6.34 ___

6.11 ___

6.05 ___

5.98 ___

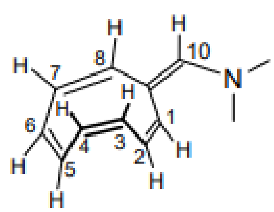
5.94 ___

5.87 ___

5.70 ___

5.55 ___

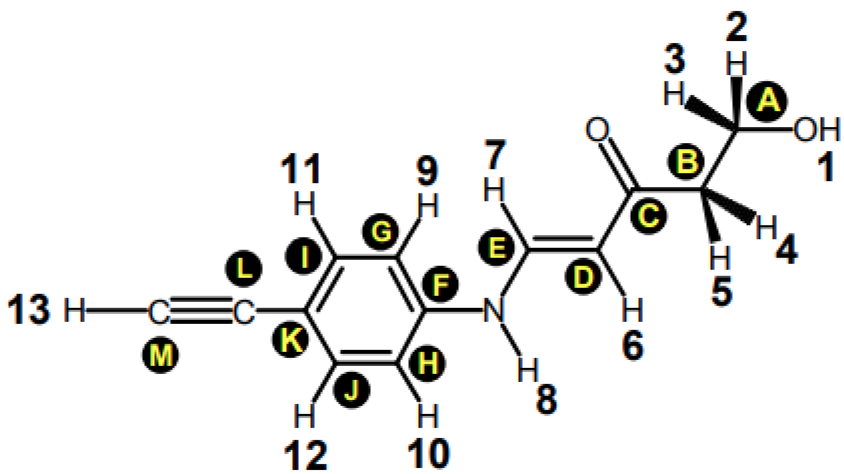
5.07 ___



6. **Completely deuterated t-butanol, $(CD_3)_3C\text{-}OD$ shows 2 signals at 62 and 18 ppm in the $^{13}C\{^1H\}$ NMR spectrum. How many lines would you expect for the resonance at 62 ppm at room temperature?**

a) 1 b) 3 c) 6 d) 9 e) 10 f) 13 g) 18 h) 19 i) 21 j) 38

7. **Protons in this molecule are labeled with numbers and carbon with yellow letters in black circles.**



a) **Which protons in this molecule will be exchangable in D_2O solution?**

a) H1 b) H6 c) H8 d) H10 e) H13 f) H1 and H8 g) H1 and H13 h) H8 and H13 i) H1, H8 and H13 j) H1 and H6

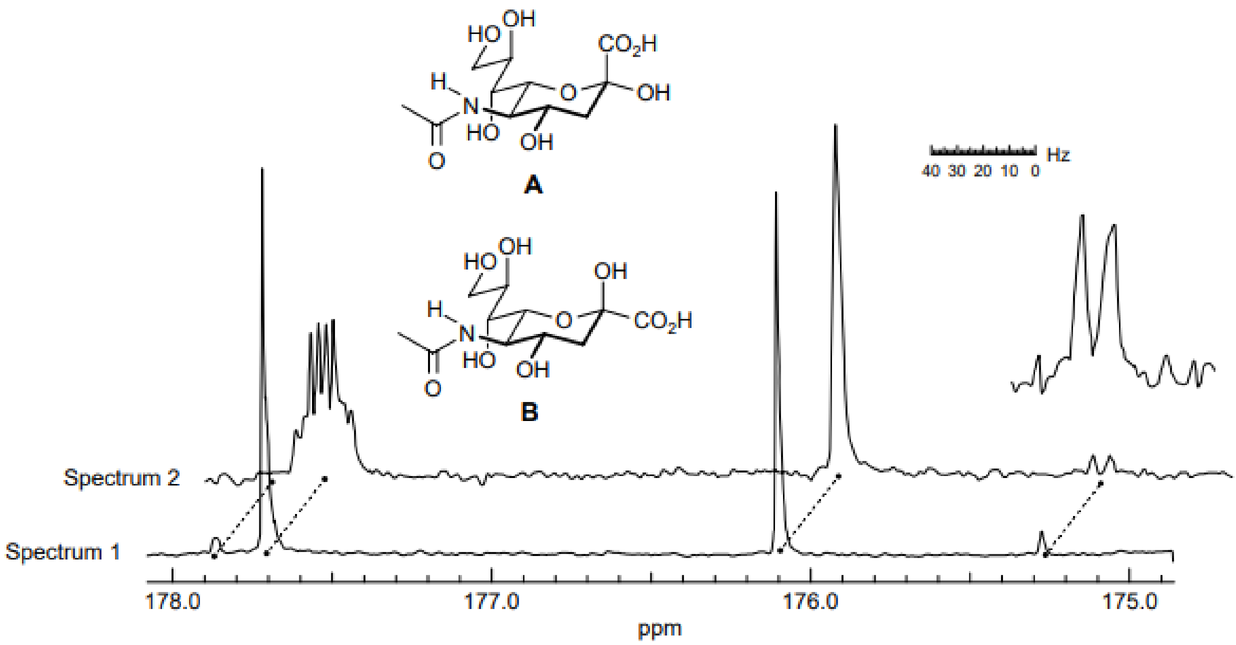
b) **Which of the pairs of protons in this molecule are chemically equivalent?**

a) H2 and H3 b) H4 and H5 c) H9 and H10 d) H11 and H12 e) none of the pairs in (a)-(d) f) all of the pairs in (a)-(d)

c) **Which carbon of this molecule could have a negative phase resonance at 71 ppm in the ^{13}C DEPT-135 spectrum?**

a) A b) B c) C d) D e) E f) F g) G h) J i) L j) M

8. Below is shown a part of the ^{13}C NMR spectrum in D_2O of a 10:1 mixture of two isomers of sialic acid (A and B). Spectrum 1 is the fully ^{1}H-decoupled. Spectrum 2 has the decoupler turned off.



a) Which carbons of sialic acid are shown here? Mark the shifts on the structures.

b) Describe the multipicity of the signal at 177.7 ppm in the coupled spectrum (2).

c) Which is the major isomer (A or B)? _____

Give your reasoning below.