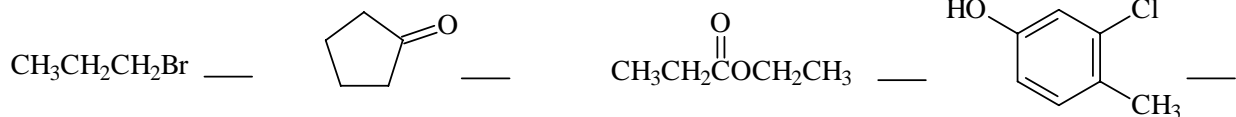
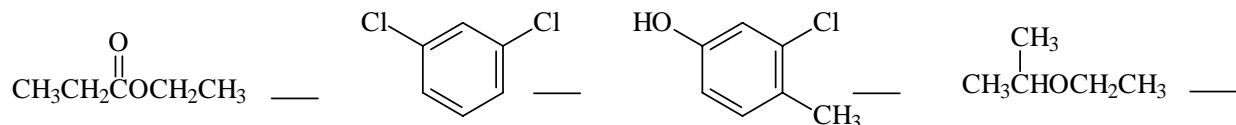


1. (4) Write on the line provided the number of **carbon** resonance lines you would expect in the  $^{13}\text{C}$  NMR spectrum of the following:



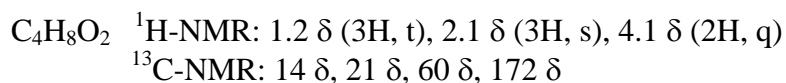
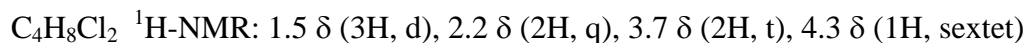
2. (4) Write on the line provided the number of unique **proton** environments in each of the following:



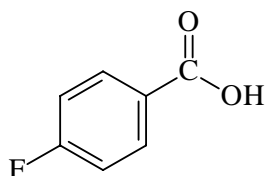
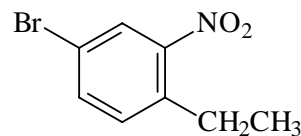
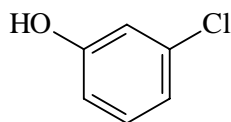
3. (4) Match the letter of the expected proton NMR splitting pattern with the structure:

- |   |                        |
|---|------------------------|
| _____ $\text{CH}_3\text{CHBr}_2$          | A. doublet and triplet |
| _____ $\text{CH}_3\text{CH}_2\text{Br}$   | B. quartet and triplet |
| _____ $\text{BrCH}_2\text{CH}_2\text{Br}$ | C. two triplets        |
| _____ $(\text{CH}_3)_2\text{CHBr}$        | D. septet and doublet  |
|   | E. two doublets        |
|   | F. quartet and doublet |
|   | G. none of the above   |

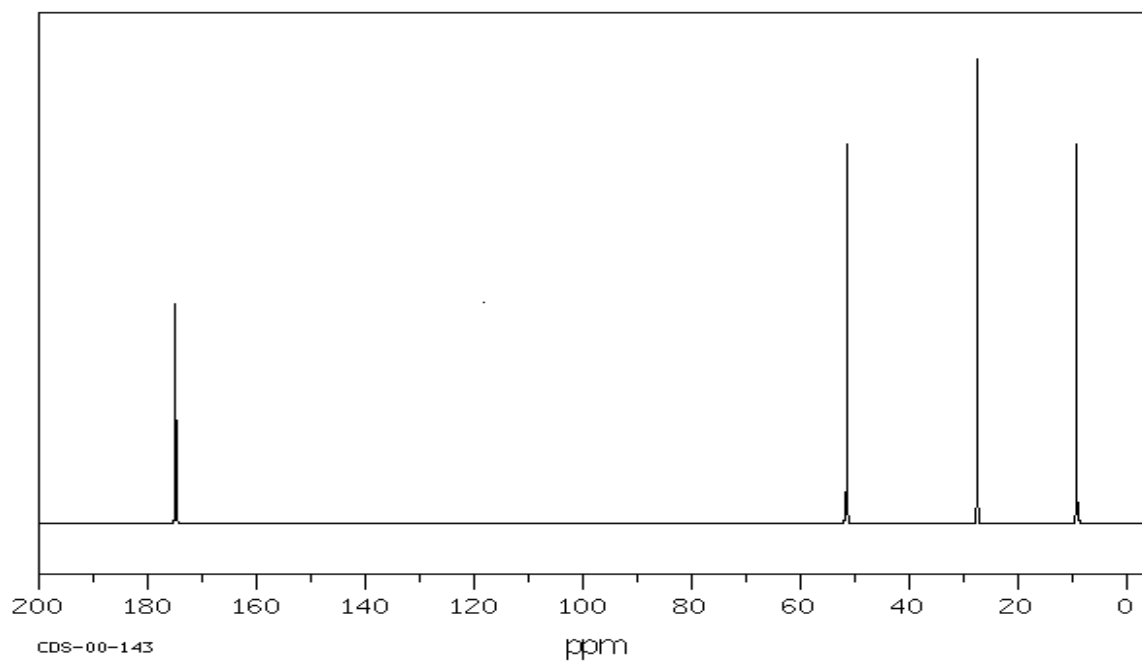
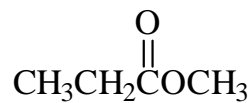
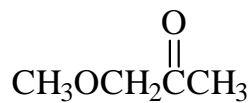
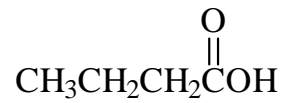
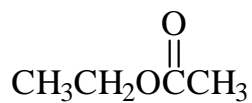
4. (6) Draw structures consistent with the following data:



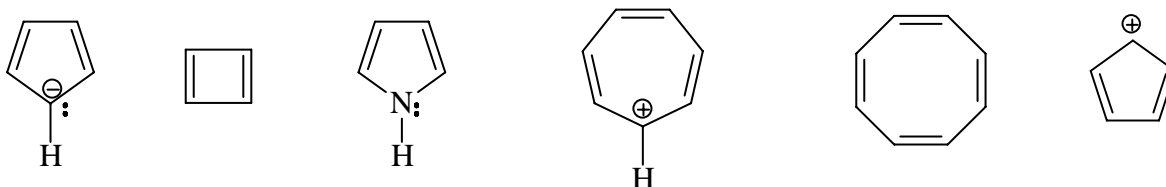
5. (6) Write the correct name under each of the following:



6. (4) Circle the structure that corresponds the following  $^{13}\text{C}$  NMR and  $^1\text{H}$  NMR spectra:

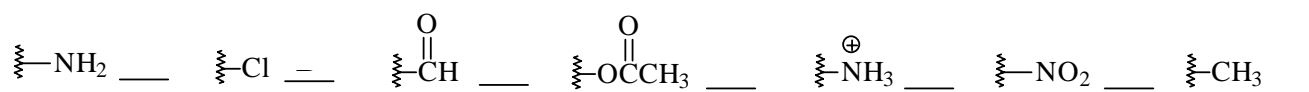


7. (6) Circle all the structures below that are **aromatic** according to Hückel's rule:

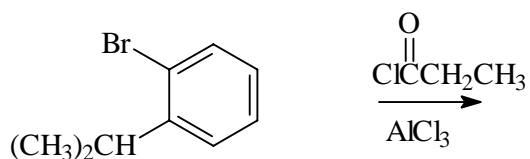
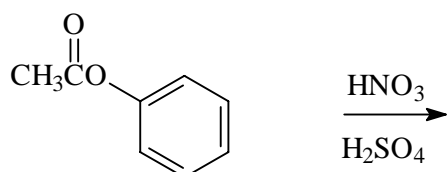
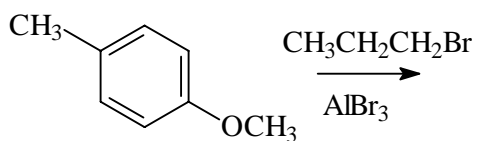
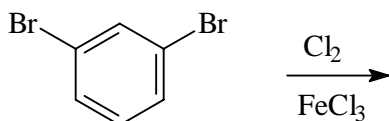


8. (7) Classify the substituents (on an aromatic ring) below according to their directing and reactivity effects toward electrophilic aromatic substitution, using the following abbreviations:

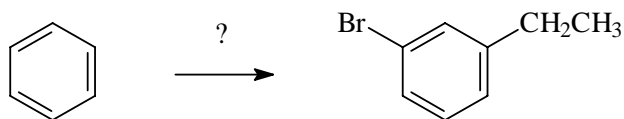
**A** = o- and p- directing Activators  
**D** = o- and p- directing Deactivators  
**M** = m- directing deactivators



9. (10) Draw the structure of the major organic product of each of the following:

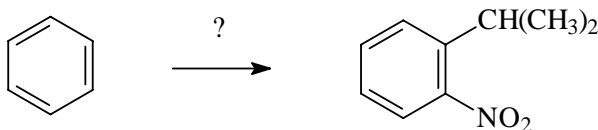


10. (3) Circle your choice of the following reaction sequences as the best method to perform the indicated transformation:



- a. alkylation, bromination
- b. alkylation, sulfonation, bromination, desulfonation
- c bromination, acylation, reduction
- d. bromination, sulfonation, acylation, reduction, desulfonation
- e. bromination, alkylation
- f. acylation, bromination, reduction

11. (3) Circle your choice of the following reaction sequences as the best method to perform the indicated transformation:



- a. nitration, alkylation
- b. nitration, sulfonation, alkylation, desulfonation
- c. alkylation, nitration
- d. alkylation, sulfonation, nitration, desulfonation
- e. nitration, alkylation, oxidation-reduction
- f. sulfonation, nitration, alkylation, desulfonation

12. (3) Indicate with an arrow where an incoming electrophile would be most likely to attack each of the following (only one arrow per structure)

