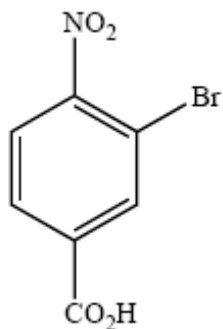
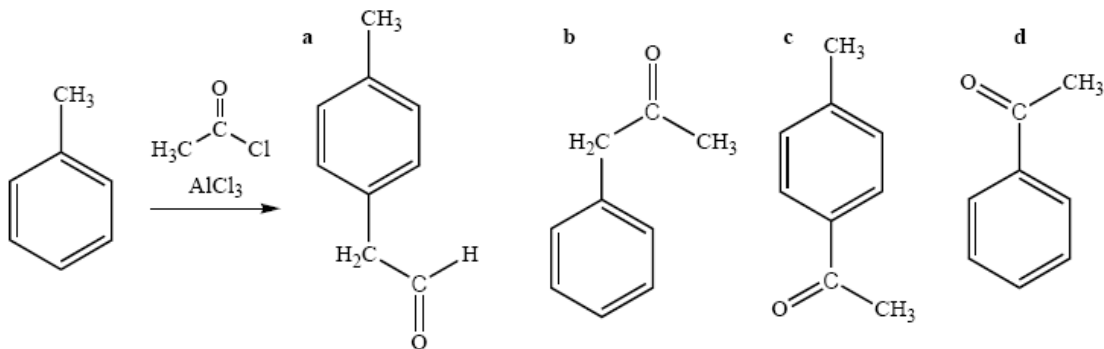


1. What is the IUPAC name of the following compound? (2)

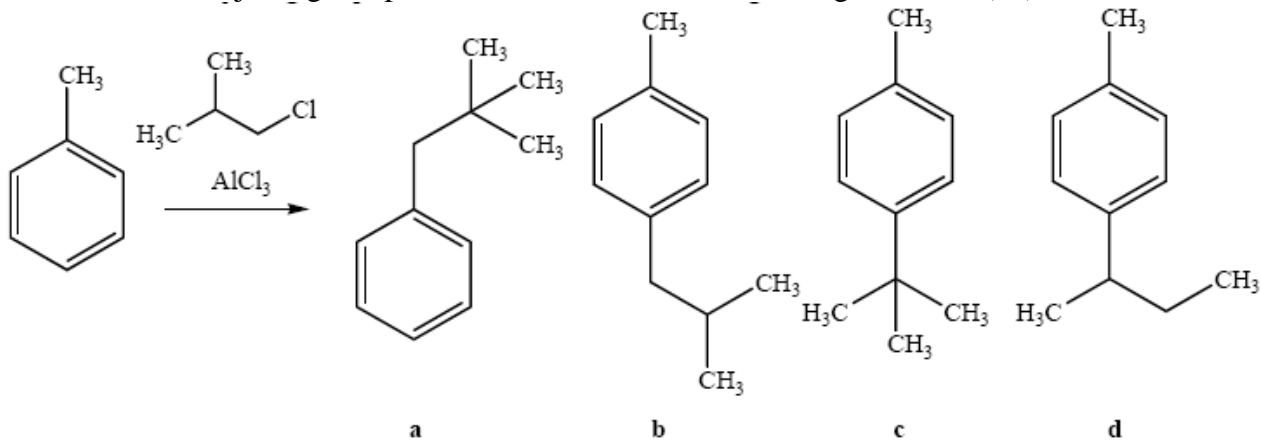


2. Which of the following statements is not true about the structure of benzene? (4)
- the carbon-carbon bonds are all the same length
  - the structure rapidly transforms between two resonance contributors
  - the structure is an average of two resonance contributors
  - the ring of six carbon atoms is planar
3. Which of the following compounds is aromatic? (6)
- ethane
  - cyclobuta-1,3-diene
  - benzene
  - cycloocta-1,3,5,7-tetraene

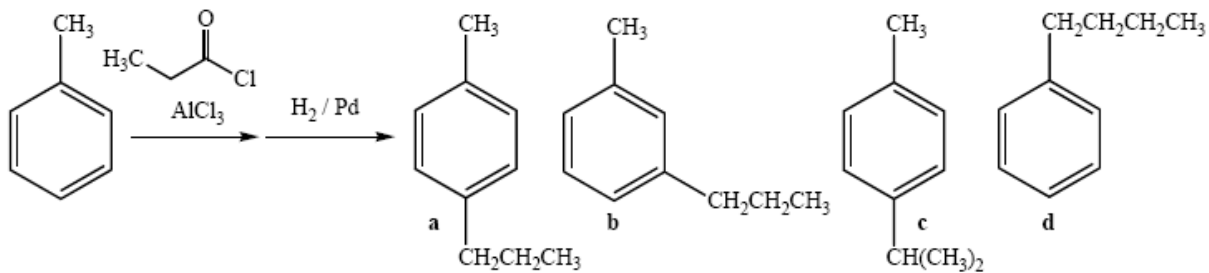
4. What is the major organic product obtained from the following reaction? (9)



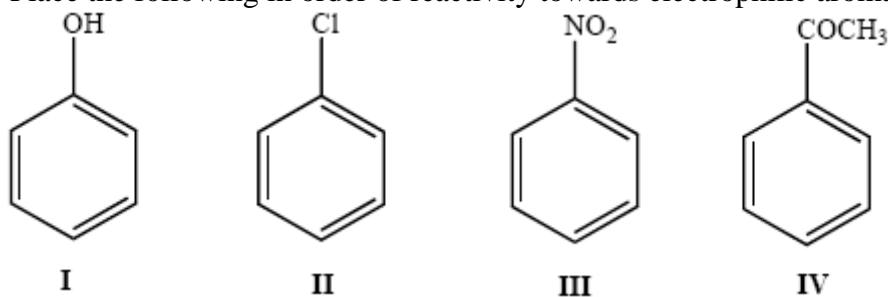
5. Which of the following undergoes the most rapid sulfonation upon treatment with fuming sulfuric acid? (11)
- benzene
  - benzoic acid
  - benzonitrile
  - nitrobenzene
6. Which of the following sets of substituents are all ortho/para directing in electrophilic aromatic substitution reactions? (13)
- Cl, CH<sub>3</sub>, CN
  - Br, OH, COCH<sub>3</sub>
  - Cl, OH, CH<sub>3</sub>
  - CN, NO<sub>2</sub>, COCH<sub>3</sub>
7. Which of the following sets of substituents are all deactivating groups in electrophilic aromatic substitution reactions? (15)
- Cl, CN, NO<sub>2</sub>
  - Cl, NH<sub>2</sub>, CH<sub>3</sub>
  - CH<sub>3</sub>, OCH<sub>3</sub>, COCH<sub>3</sub>
  - CH<sub>3</sub>, NH<sub>2</sub>, OCH<sub>3</sub>
8. What is the major organic product obtained from the following reaction? (19)



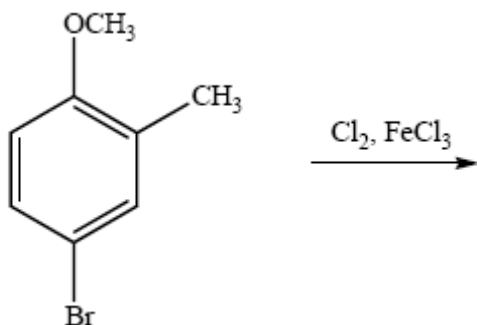
9. What is the major organic product obtained from the following sequence of reactions? (23)



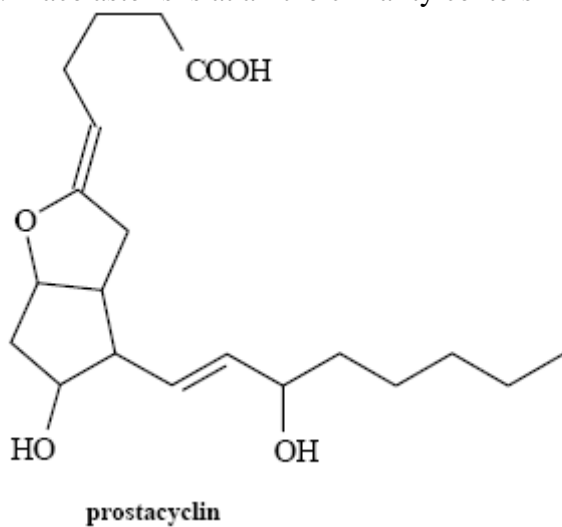
10. Place the following in order of reactivity towards electrophilic aromatic substitution. (28)



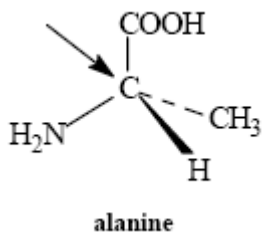
11. Predict the major product of the following reaction: (29)



12. Place asterisks at all the chirality centers in each molecule below. (8)

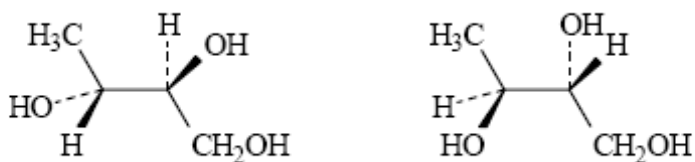


13. Assign R, S configurations to each indicated chirality center in the molecules below. (14)



14. Label each pair of stereoisomers below as: (20)

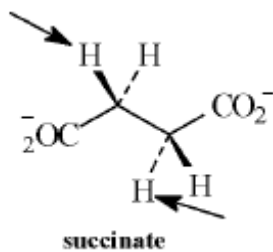
- a. enantiomers
- b. diastereomers
- c. identical



15. Which of the following is the definition of a pair of enantiomers? (27)

- a. A pair of structures that are superimposable mirror images of one another
- b. A pair of stereoisomers that are non-superimposable mirror images of one another
- c. A pair of stereoisomers that are not mirror images of one another
- d. A pair of stereoisomers that have equal specific rotations

16. Identify the indicated hydrogens in the following molecules as pro-R or pro-S. (25)



17. Which of the following compounds is/are chiral? (32)

