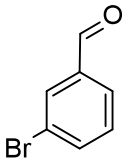
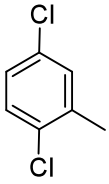
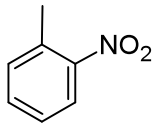
Nomenclature and Structural Formulas

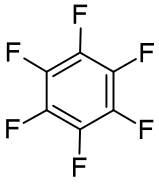
1. For the following compounds write the line structures:
   a. 1,3,5-tribromobenzene
   b. *o*-chlorotoluene
   c. *p*-diethylbenzene
   d. isopropylbenzene
   e. 2,3-diphenylbutane
   f. 2-bromo-4-ethyl-3,5-dinitrotoluene
   g. *m*-nitroanisole
   h. *m*-chlorobenzoic acid

2. Name the following compounds:

a. 

b. 

c. 

d. 

3. Give the structures and names for all possible isomers *(6 of them)* of dichloronitrobenzenes.

Aromaticity and Resonance

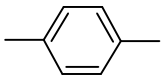
4. The observed amount of heat evolved when 1,3,5,7-cyclooctatetraene is hydrogenated is 460 kJ/mol. What does this tell you about the possible resonance energy of this compound?

5. The structure of the nitro group ($-NO_2$) is usually shown as

Yet experiments show that the two nitrogen-oxygen bonds have the same length of 1.21 Å. This length is intermediate between 1.36 Å for the N—O single bond and 1.18 Å for the N=O double bond. Draw structural formulas that explain this observation.

Mechanism of Electrophilic Aromatic Substitution

6. Write all of the steps in the mechanism for the reaction of

 + nitric acid (H_2SO_4 catalyst)

7. Draw all possible contributing structures to the carbocation intermediate in the chlorination of chlorobenzene. Explain why the major products are *o*- and *p*-dichlorobenzene.

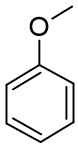
8. When benzene is treated with propene and sulfuric acid, two different monoalkylation products are possible. Draw their structures. Which one do you expect to be the major product and why?

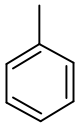
Reactions of Substituted Benzenes: Activating and Directing Effects

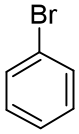
9. Predict whether the following substituents on the benzene ring are likely to be *ortho, para*-directing or *meta*-directing and whether they are likely to be ring-activating or ring-deactivating:

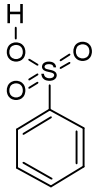
   a. —$NH(CH_3)_2$ b. —OCH_2CH_3

10. For each of the monosubstituted benzenes shown below indicate whether the substituent is *ortho, para*-directing or *meta*-directing and draw the structure(s) of the main monosubstitution product(s) for each of the reactions indicated:

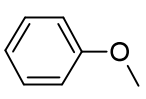
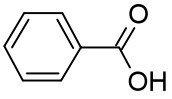
a.  + Cl_2 (Fe catalyst)

b.  + Br_2 (Fe catalyst)

c.  + concentrated H_2SO_4 (heat) + SO_3

d.  + concentrated HNO_3 (H_2SO_4 catalyst)

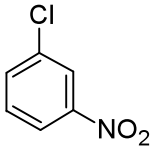
11. Which compound is more reactive toward electrophilic substitution, i.e. nitration:

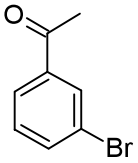
 or 

Electrophilic Aromatic Substitution Reactions and Synthesis

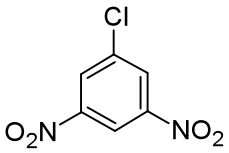
12. Draw the structure of each of the following compounds; using benzene or toluene as the only aromatic starting material, devise a synthesis of each compound:
    a. *p*-bromonitrobenzene b. *p*-toluenesulfonic acid

13. Using benzene or toluene as the only aromatic organic starting material, devise a synthesis for each of the following compounds and name the product:

a. 

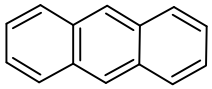
b. 

14. Show how pure 3,5-dintirochlorobenzene



can be prepared, starting from a disubstituted benzene.

15. How many possible monosubstitution products are there for anthracene and where may they be?



16. Bromination of anthracene gives mainly 9-bromoanthracene. Write the reaction mechanism of this reaction.