1. Give the complete mechanism for any two of the following:

a. Friedel-Craft acylation of benzene  
   b. Nitration of benzene  
   c. Sulfonation of benzene  
   d. Halogenation of benzene

2. Give all the possible resonances for the following:

3. Label if the following groups are activating or deactivating the benzene ring for electrophilic substitution:

- Br  -COOH,  - NH₂  - NO₂

4. Among the compounds in each bracket, circle one that has greater electrophilic substitution reactivity:

5. I. Give one example each of the following:
   a. resonance hybrid intermediate of elect. subst. rxn  
   b. a benzylic radical

II. Name the following:

6. From what you know from benzene chemistry, and with the use of proper resonance structures, identify the sites that are activated towards nitration in amino napthalene.
7. **Explain** with all the resonance structures, the directing effect of any one of the following groups.

\[-\text{SO}_3\text{H} \quad -\text{Cl} \quad -\text{CH}_3\]

(5)

8. Give brief explanations: Structures are essential to support your explanation!!!

   a. Benzene can not undergo electrophilic addition reaction as do most of alkenes.

   b. Reaction of benzene with butyl chloride gives a rearranged product

9. Give the structure of the products in the following reactions:

   a. Benzene (large excess) + Cl\text{CH-CHCl}_2 + \text{AlCl}_3 \rightarrow C_{26}H_{22} (has 4 benzene rings)

   (5)

   b. \[\text{A}][\text{I}][\text{C}][\text{L}_3] \rightarrow \text{a neutral compound, C}_{11}H_{14}\]

   (5)

10. How would you prepare the following two compounds starting from benzene? (Proper sequence of steps with proper reagents necessary for each step must be given)
11. Complete the following reactions:

a.\[ \text{KMnO}_4 / \text{heat} \]
   \[ \text{C}_7\text{H}_8 \]
   \[ \xrightarrow{1.} \] \[ \text{Br} \]
   \[ \xrightarrow{2.} \]
   \[ \text{Br} \text{NH}_2 \]

b.\[ \text{Br} \]
   \[ \xrightarrow{\text{Br} / \text{AlCl}_3} \]


c.\[ \text{HO-} \]
   \[ \xrightarrow{\text{I}_2 / \text{CuCl}_2} \]

d.\[ \xrightarrow{1. \_ \_ \_ \_ \_ \_ \_ \_} \]
   \[ \xrightarrow{2. \_ \_ \_ \_ \_ \_ \_ \_} \]
   \[ \xrightarrow{3. \_ \_ \_ \_ \_ \_ \_ \_} \]

f.\[ \text{OH} \]
   \[ \xrightarrow{1. \_ \_ \_ \_ \_ \_ \_ \_} \]
   \[ \xrightarrow{2. \_ \_ \_ \_ \_ \_ \_ \_} \]

h.\[ \text{C}_7\text{H}_8 \]
   \[ \xrightarrow{1. \text{CH}_3\text{CH}_2\text{Cl} / \text{AlCl}_3} \]
   \[ \xrightarrow{2. \text{KMnO}_4} \]
   \[ \xrightarrow{3. \text{HNO}_3 / \text{H}_2\text{SO}_4} \]
   \[ \xrightarrow{4. \text{SnCl}_2 / \text{H}_3\text{O}^+} \]

i.\[ \text{Br}_2 / \text{FeBr}_3 \]
   \[ \xrightarrow{\text{Br}_2 / \text{FeBr}_3} \]
   \[ \xrightarrow{\text{AlCl}_3} \]

j.\[ \text{Cl} / \text{AlCl}_3 \]
   \[ \xrightarrow{1. \_ \_ \_ \_ \_ \_ \_ \_} \]
   \[ \xrightarrow{2. \_ \_ \_ \_ \_ \_ \_ \_} \]
   \[ \xrightarrow{3. \text{KMnO}_4} \]