

Chapter 15: Reactions of Substituted Benzenes

Learning Objectives:

1. Be able to recognize and utilize the oxidative and reductive reactions involving the substituents on benzene.
2. Recognize whether a substituent on a benzene ring is activating or deactivating toward electrophilic aromatic substitution reaction, and why it is so.
3. Predict the effect a substituent will have on the regioselectivity of an electrophilic substitution reaction.
4. Predict the effect a substituent will have on pK_a .
5. Be able to design the synthesis of a multisubstituted benzene.
6. Be able to recognize and utilize the reactions involving arenediazonium salts.
7. Recognize and be able to write the mechanism of nucleophilic aromatic substitution.
8. Recognize the structure of benzyne, be able to explain how it is formed, and how it reacts.

Sections:

- 15.1 Nomenclature of Disubstituted and Polysubstituted Benzenes
- 15.2 Some Substituents Increase the Reactivity of a Benzene Ring and Some Decrease Its Reactivity*
- 15.3 The Effect of Substituents on Orientation (Regioselectivity)*
- 15.4 The Effect Substituent on pK_a
- 15.5 The Ortho-Para ratio
- 15.6 Additional Considerations Regarding Substituent Effects
- 15.7 Designing a Synthesis III: Synthesis of monosubstituted and Disubstituted Benzenes*
- 15.8 Synthesis of Trisubstituted Benzenes
- 15.9 Synthesis of Substituted Benzenes Using Arenediazonium Salts*
- 15.10 The Arenediazonium Ion as an Electrophile*
- 15.11 Mechanism for the Reaction of Amines with Nitrous Acid*
- 15.12 Nucleophilic Aromatic Substitution Reactions: An Addition-Elimination Mechanism*
- 15.13 Nucleophilic Aromatic Substitution Reactions: An Elimination-Addition Mechanism That Forms a Benzyne Intermediate
- 15.14 Polycyclic Benzenoid Hydrocarbons[#]

* Sections that will be focused

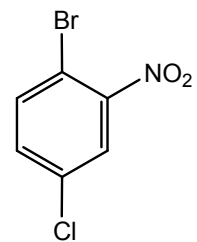
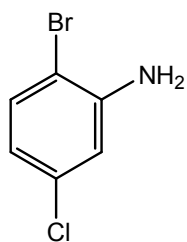
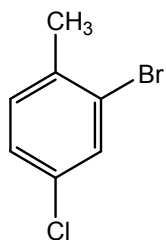
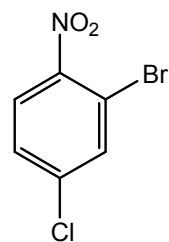
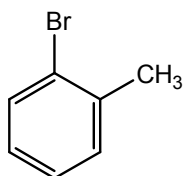
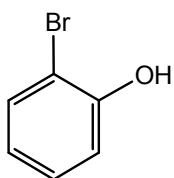
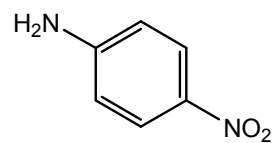
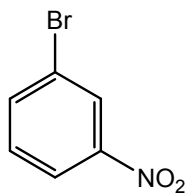
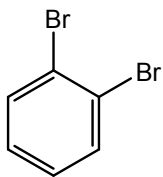
[#] Sections that will be skipped

Recommended additional problems

15.34 – 15.69

Class Note

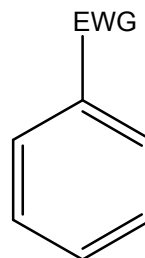
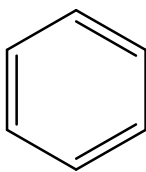
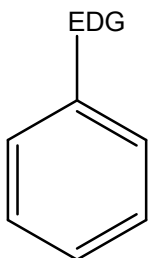
15.1 Nomenclature of Disubstituted and Polysubstituted Benzenes



15.2 Some Substituents Increase the Reactivity of a Benzene Ring and Some Decrease Its Reactivity* and 15.3 The Effect of Substituents on Orientation (Regioselectivity)*

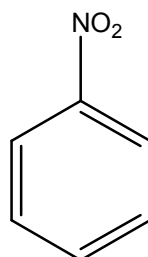
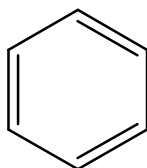
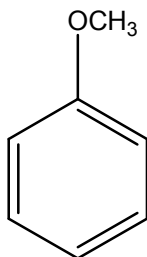
electron donation group (EDG)

electron withdrawing group (EWG)



A. Relative rate of electrophilic aromatic substitution

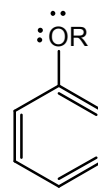
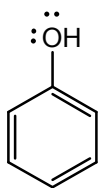
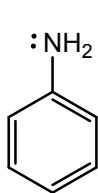
Examples:



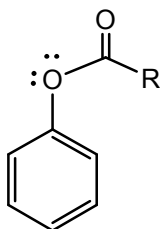
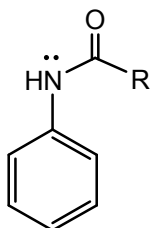
- Rate-determining step (r.d.s)
- Resonance effect and inductive effect

B. Relative reactivity and regioselectivity of substituted benzenes

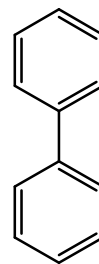
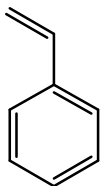
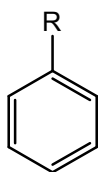
Strong activating groups (substituents)



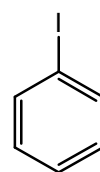
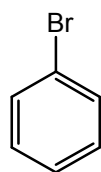
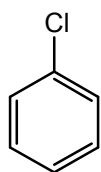
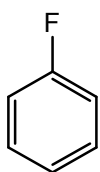
Moderate activating groups (substituents)



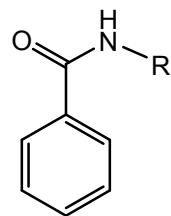
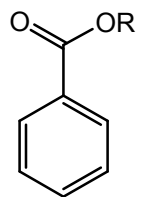
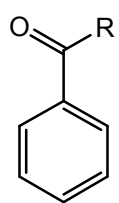
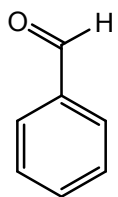
Weak activating groups (substituents)



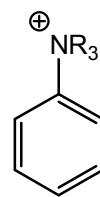
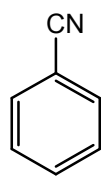
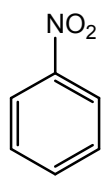
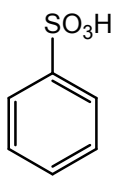
Weak deactivating groups (substituents)



Moderate deactivating groups (substituents)

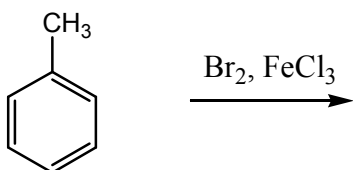


Strong deactivating groups (substituents)

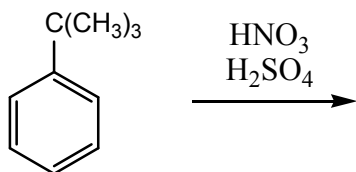
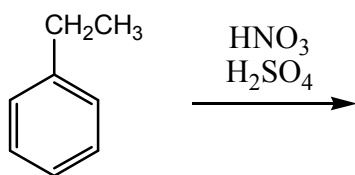
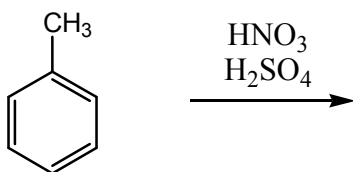


C. Examples (combined with 15.5 The Ortho-Para ratio and 15.6 Additional Considerations Regarding Substituent Effects)

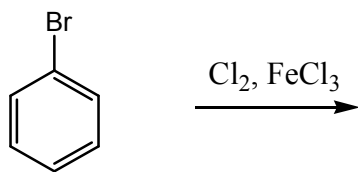
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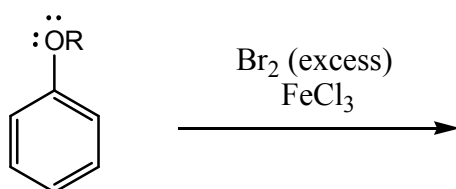
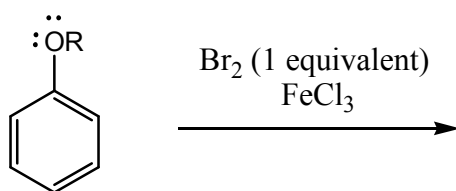
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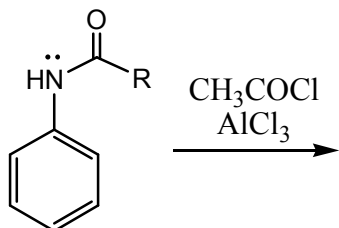
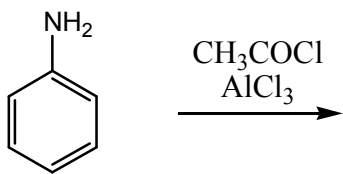
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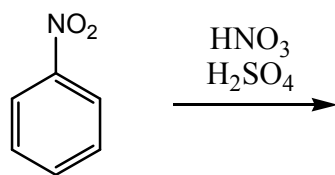
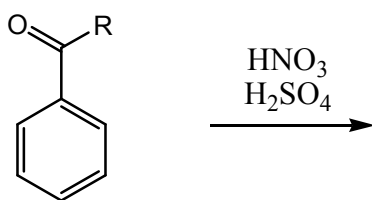
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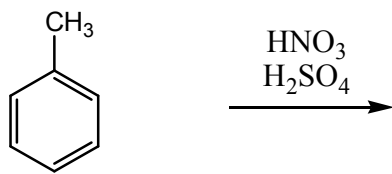
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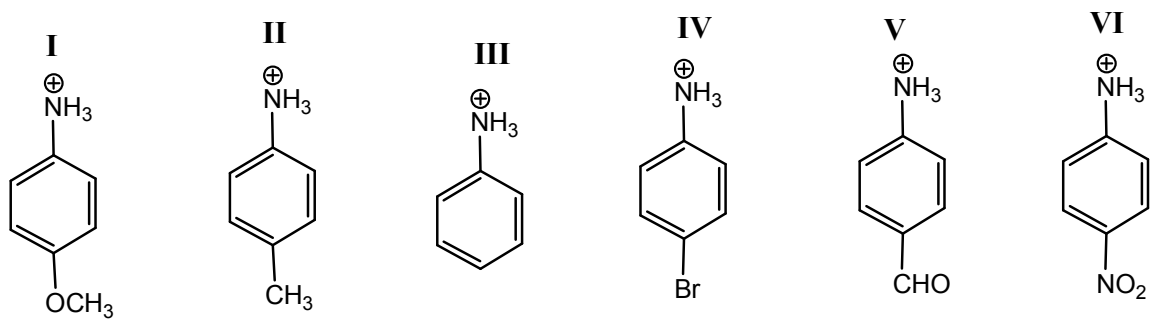
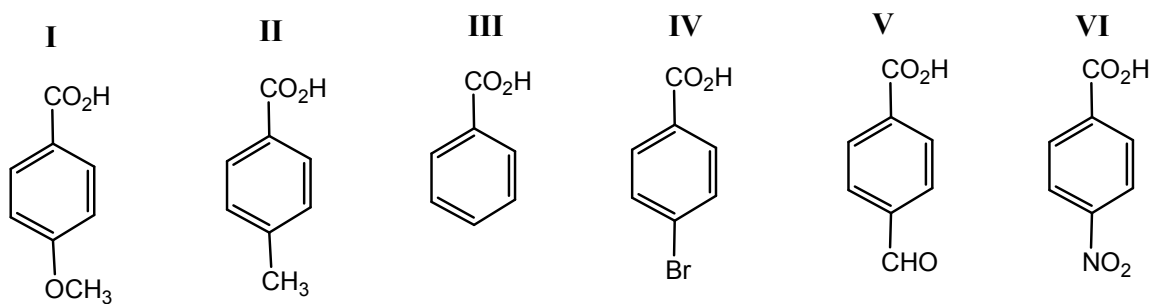
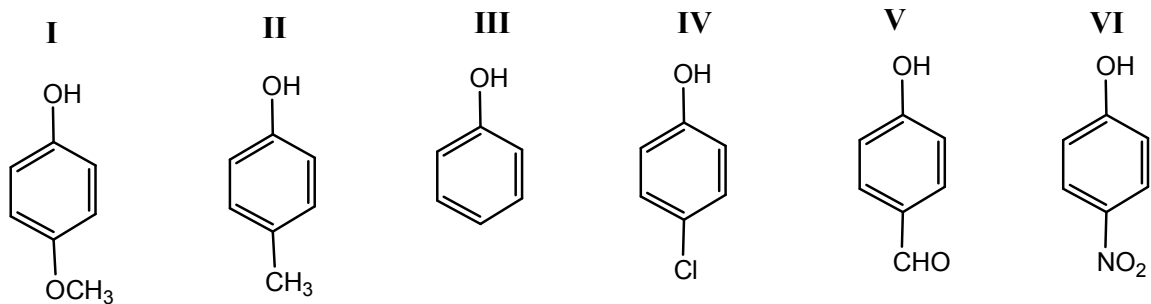
(vi)



(vii) Synthesis of trinitrotoluene



15.4 The Effect Substituent on pK_a



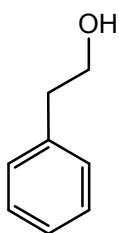
15.7 Designing a Synthesis III: Synthesis of monosubstituted and Disubstituted Benzenes* and 15.8 Synthesis of Trisubstituted Benzenes

Design multiple-step synthesis:

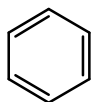
- * Selectivity: chemoselectivity, regioselectivity, and stereoselectivity
- * Retrosynthetic analysis: breaking and formation of chemical bonds

A. Examples

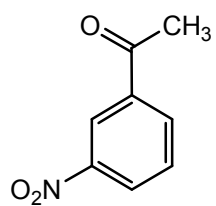
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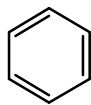
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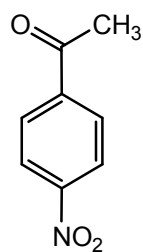
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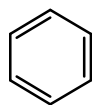
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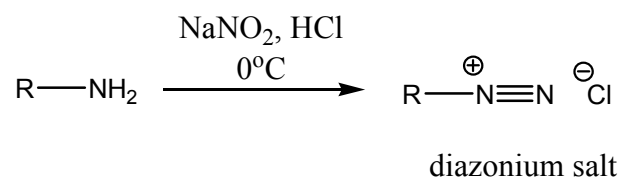


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15.9 Synthesis of Substituted Benzenes Using Arenediazonium Salts and 15.11
Mechanism for the Reaction of Amines with Nitrous Acid*

A. Formation of diazonium salt



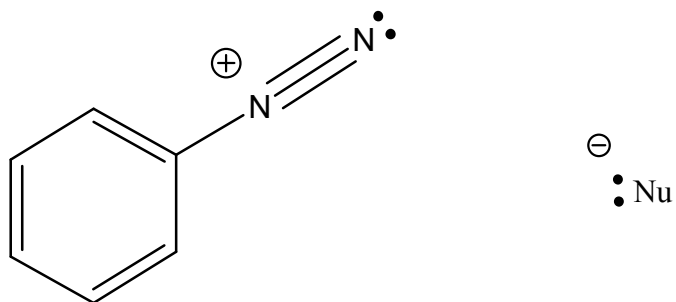
Mechanism:

B. Reaction of arenediazonium salt with nucleophiles

Sandmeyer reaction (CuBr, CuCl, and CuCN)

Reaction with KI, HBF₄, H₃O⁺, and H₃PO₂

15.10 The Arenediazonium Ion as an Electrophile*



- * Nucleophile better be bulky
- * Terminal nitrogen reacts with nucleophile

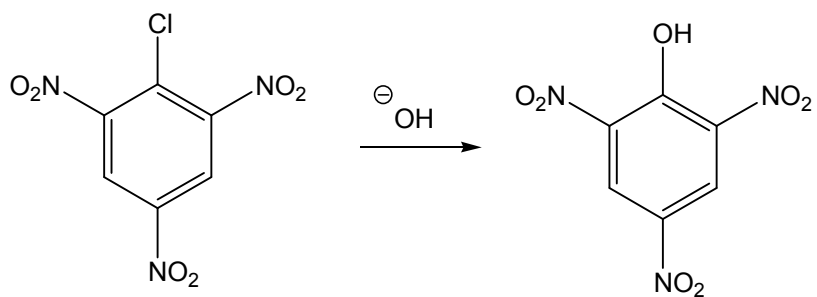
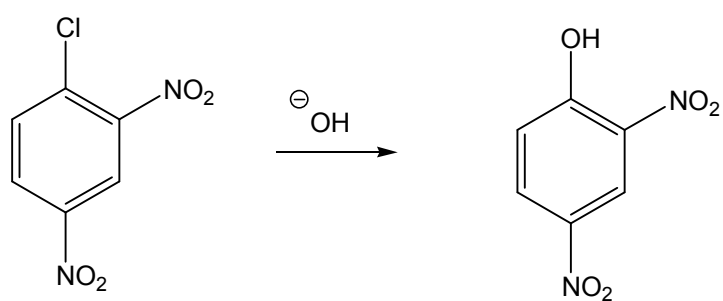
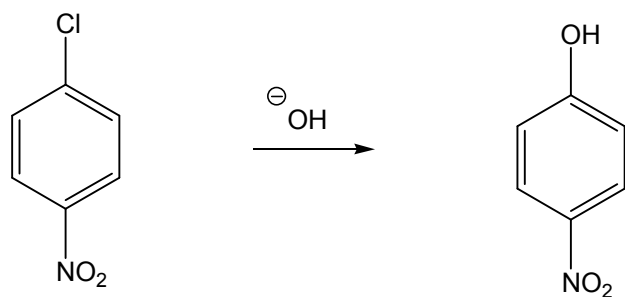
15.12 Nucleophilic Aromatic Substitution Reactions (S_NAr): An Addition-Elimination Mechanism*

A. Comparison of S_NAr , S_N1 , and S_N2

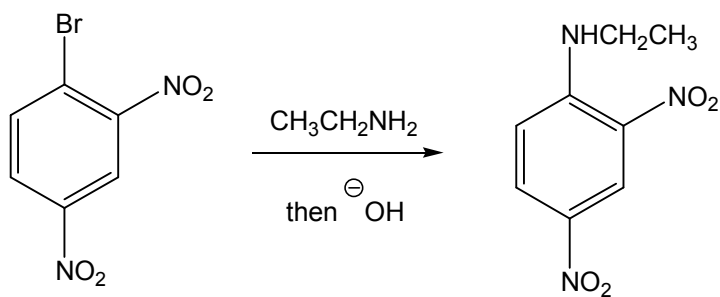
B. General mechanism

C. Examples

(i)



(ii)



15.13 Nucleophilic Aromatic Substitution Reactions: An Elimination-Addition Mechanism That Forms a Benzyne Intermediate