

Organic chemistry

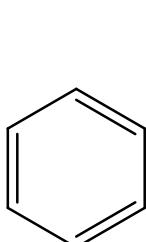
II

Chapter one

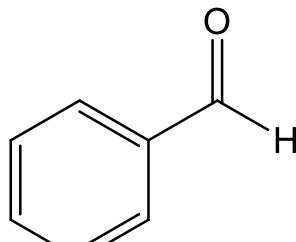
**Aromatic Compounds**

# Aromatic Compounds

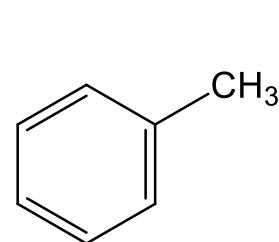
- **Aromatic** was used to described some **fragrant compounds** in early 19<sup>th</sup> century
  - **Not correct:** later they are grouped by **chemical behavior** (unsaturated compounds that undergo **substitution** rather than **addition**)
- Currently, the term **aromatic** is used to refer to the class of compounds related structurally to benzene
- They are distinguished from **aliphatic** compounds by **electronic configuration**



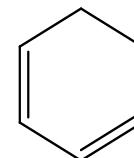
Benzene



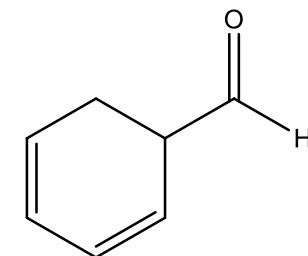
Benzaldehyde



Toluene



cyclohexa-1,3-diene



cyclohexa-2,4-dienecarbaldehyde

Aromatic compounds

Aliphatic compounds

## **1. Sources of Aromatic Hydrocarbons**

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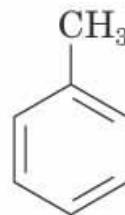
- There are two main sources of simple aromatic hydrocarbons:
  - i. coal
  - ii. petroleum

## i. High temperature distillation of coal tar

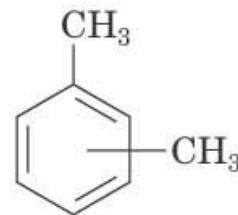
- Coal is a mixture of benzene-like rings joined together. Under high temperature, it produces coal tar which, upon fractional distillation, yields:



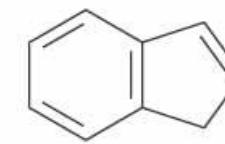
Benzene  
(bp 80°C)



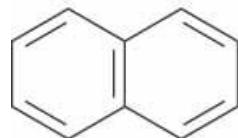
Toluene  
(bp 111°C)



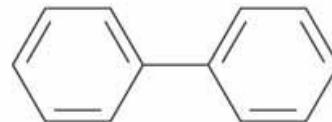
Xylene  
(bp: ortho, 144°C;  
meta, 139°C; para, 138°C)



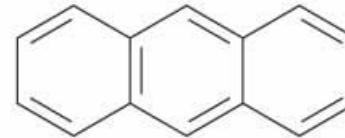
Indene  
(bp 182°C)



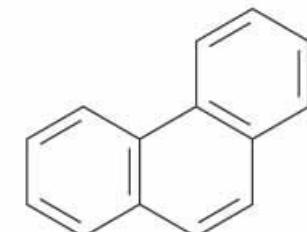
Naphthalene  
(mp 80°C)



Biphenyl  
(mp 71°C)



Anthracene  
(mp 216°C)



Phenanthrene  
(mp 101°C)

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## ii. Heating petroleum at high temperature under high pressure over a catalyst

- Petroleum consists mainly of alkanes which, at high temperature under pressure over a catalyst, convert into aromatic compounds.

## **2. Naming Aromatic Compounds**

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- Aromatic compounds are named according to the system devised by the International Union of Pure and Applied Chemistry (**IUPAC**).

**Prefix—Parent—Suffix**

Where are the substituents?



How many  
carbons?

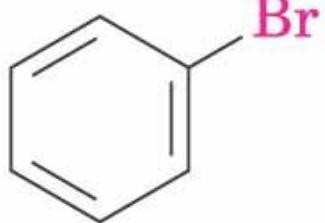
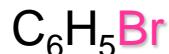
What family?

- 
- Aromatic compounds have many common names that have been accepted by IUPAC:
    - **Toluene** = methylbenzene
    - **Phenol** = hydroxybenzene
    - **Aniline** = aminobenzene

# Monosubstituted benzenes

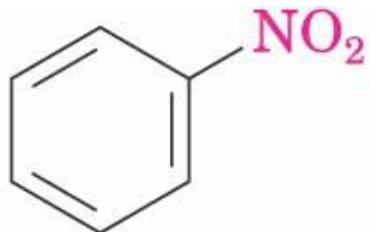
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- Monosubstituted benzenes, like hydrocarbons, are systematically named with *-benzene* as the parent name

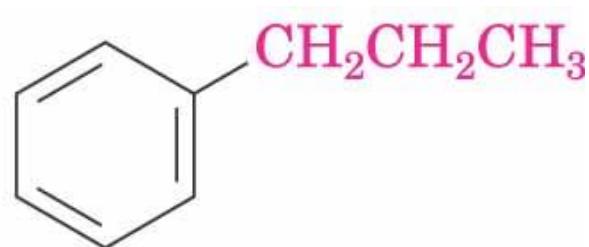


**Bromobenzene**

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**Nitrobenzene**

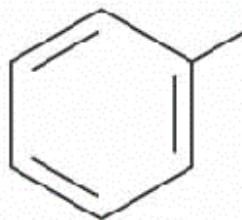


**Propylbenzene**

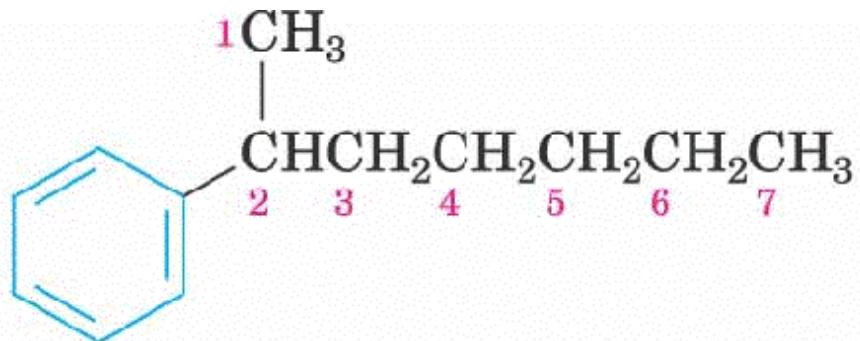
# Arenes

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- Arenes are alkyl-substituted benzenes
  - If # C<sub>substituent</sub> < or = 6, then the arene is named as an **alkyl-substituted benzene**
  - If # C<sub>substituent</sub> > 6, then the arene is named as a **phenyl-substituted alkane**



**Propylbenzene**

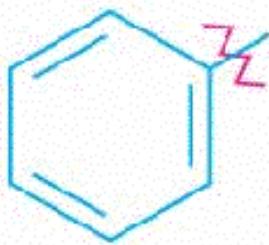


**2-Phenylheptane**

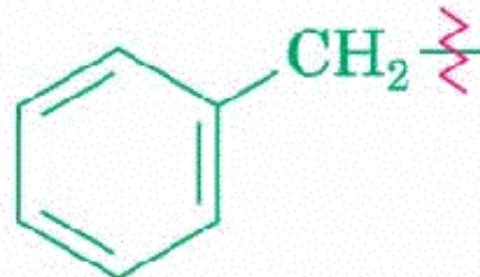
# Aryl groups

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- “**Phenyl**” refers to  $\text{C}_6\text{H}_5$   
  - It is used when a benzene ring is a substituent
  - “Ph” or “ $\phi$ ” can also be in place of “ $\text{C}_6\text{H}_5$ ”
- “**Benzyl**” refers to “ $\text{C}_6\text{H}_5\text{CH}_2$ ”



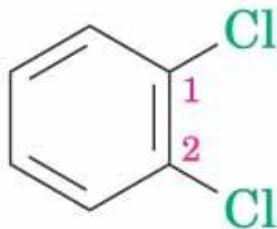
**A phenyl group**



**A benzyl group**

# Disubstituted benzenes

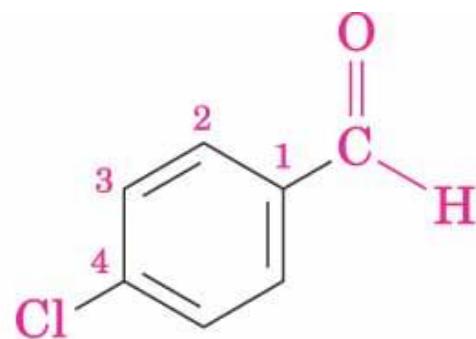
- Relative positions on a disubstituted benzene ring:
  - ortho- (o)** on adjacent carbons (**1,2 disubstituted**)
  - meta- (m)** separated by one carbon (**1,3 disubstituted**)
  - para- (p)** separated by two carbons (**1,4 disubstituted**)



**ortho-Dichlorobenzene**  
1,2 disubstituted



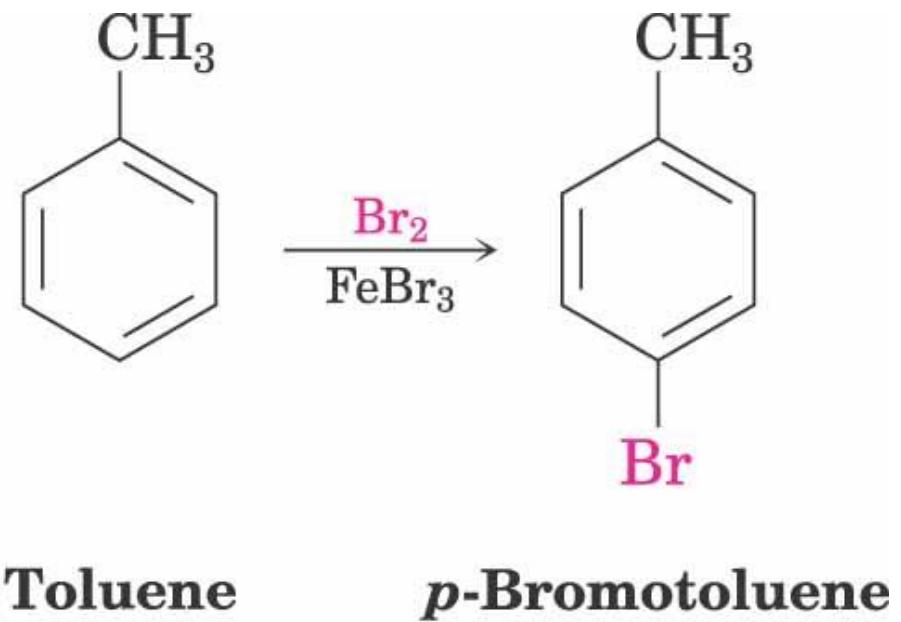
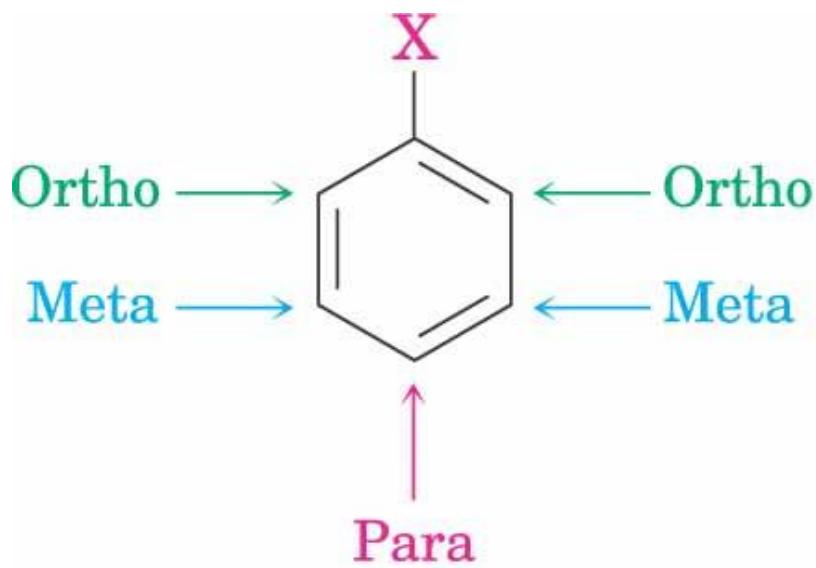
**meta-Xylene**  
1,3 disubstituted



**para-Chlorobenzaldehyde**  
1,4 disubstituted

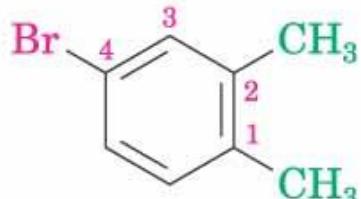
- The *ortho*- (*o*), *meta*- (*m*), and *para*- (*p*) nomenclature is useful to describe reaction patterns

Example: “Reaction of toluene with  $\text{Br}_2$  occurs at the para position”



# Multisubstituted benzenes

- Multisubstituted benzenes (more than two substituents) are named as follows:
  - Choose the sequence when the substituents have the lowest possible number
  - List substituents alphabetically with hyphenated numbers
  - Use common names, such as “toluene”, as parent name (as in TNT)

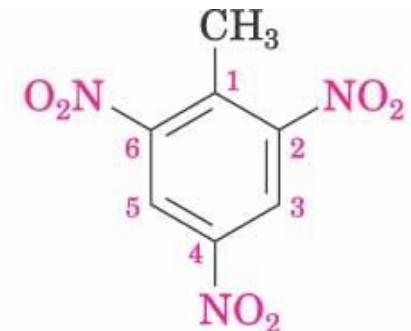


**4-Bromo-1,2-dimethylbenzene**

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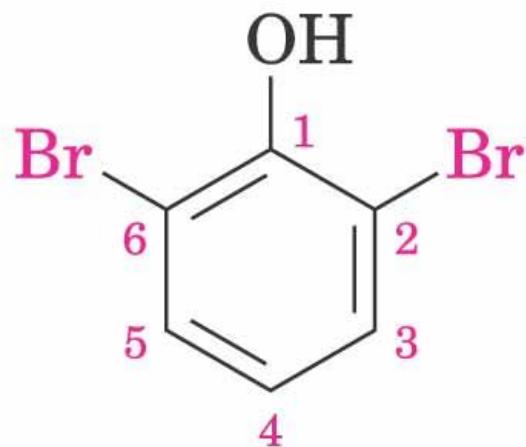


**2-Chloro-1,4-dinitrobenzene**



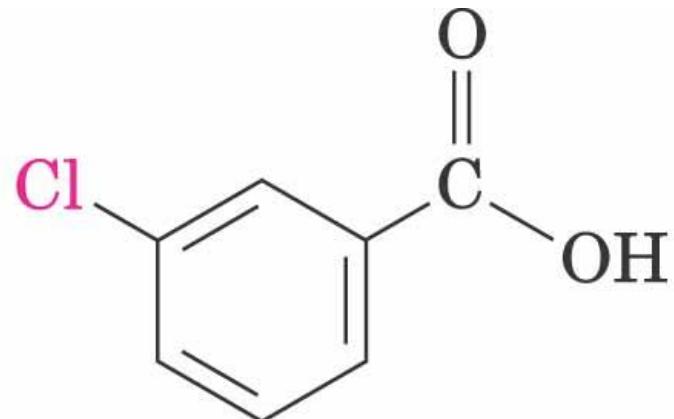
**2,4,6-Trinitrotoluene (TNT)**

- Use common names, such as “toluene”, as parent name
  - The principal substituent is assumed to be on C1



**2,6-Dibromophenol**

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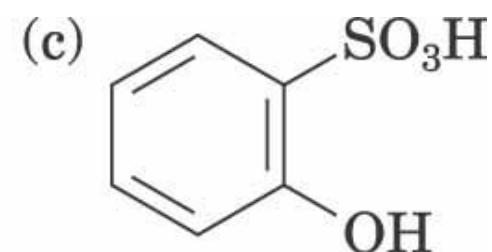
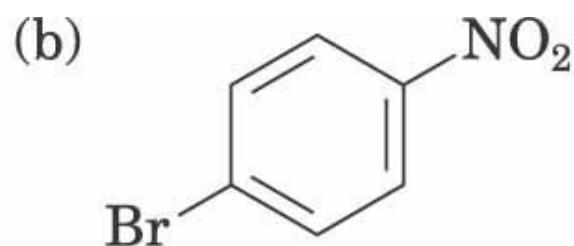
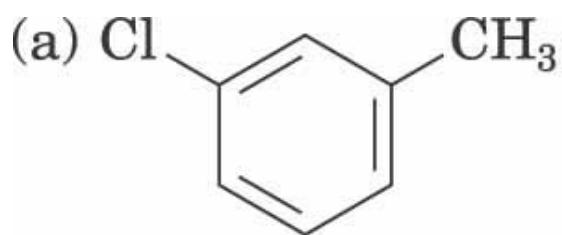


***m*-Chlorobenzoic acid**

*Practice Problem:*

Tell whether the following compounds are *ortho*-, *meta*-, or *para*-disubstituted

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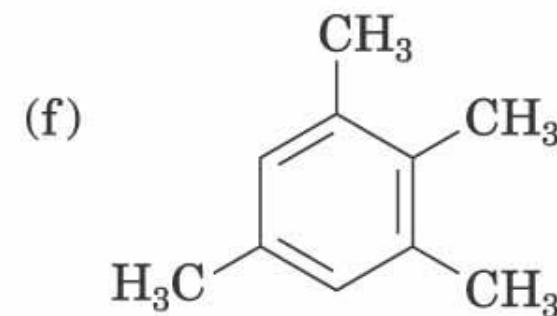
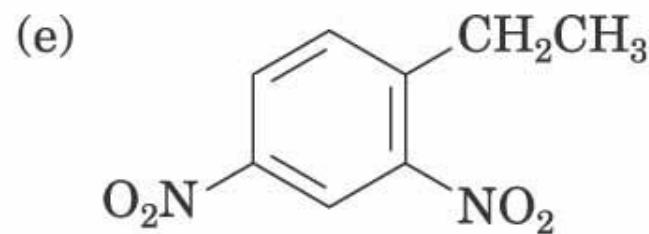
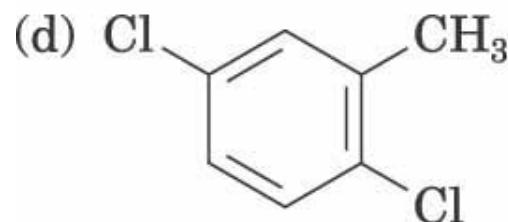
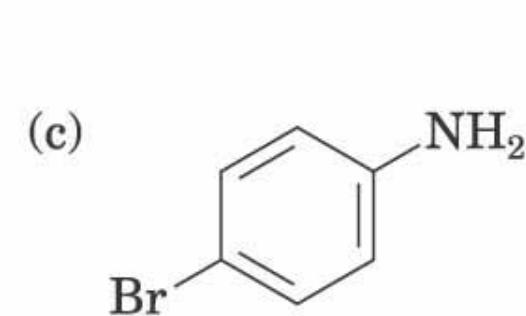
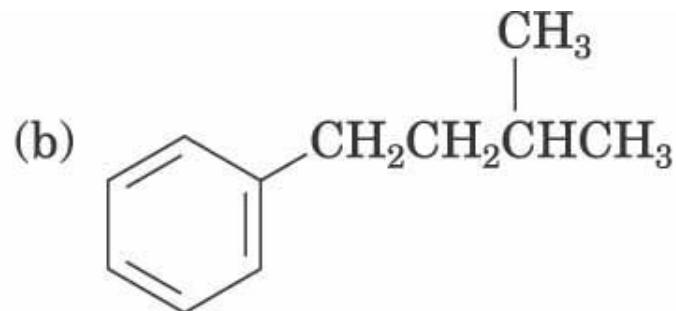
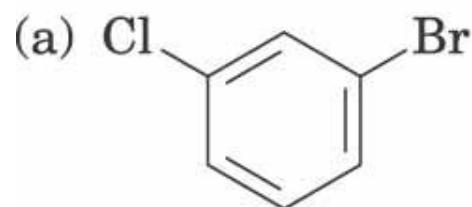
(a) *Meta*

(b) *Para*

(c) *Ortho*

*Practice Problem:* Give IUPAC names for the following compounds

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(a) *m*-Bromochlorobenzene

(c) *p*-Bromoaniline

(e) 1-Ethyl-2,4-dinitrobenzene

(b) (3-Methylbutyl)benzene

(d) 2,5-Dichlorotoluene

(f) 1,2,3,5-Tetramethylbenzene

*Practice Problem:* Draw structures corresponding to the following IUPAC names:

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- a) p-Bromochlorobenzene
- b) p-Bromotoluene
- c) m-Chloroaniline
- d) 1-Chloro-3,5-dimethylbenzene

### 3. Structure and Stability of Benzene

- Benzene is very stable

- It undergoes substitution rather than the rapid addition reaction common to compounds with C=C, suggesting that in benzene there is a higher barrier
- Example: Benzene reacts slowly with Br<sub>2</sub> to give bromobenzene (where Br replaces H)



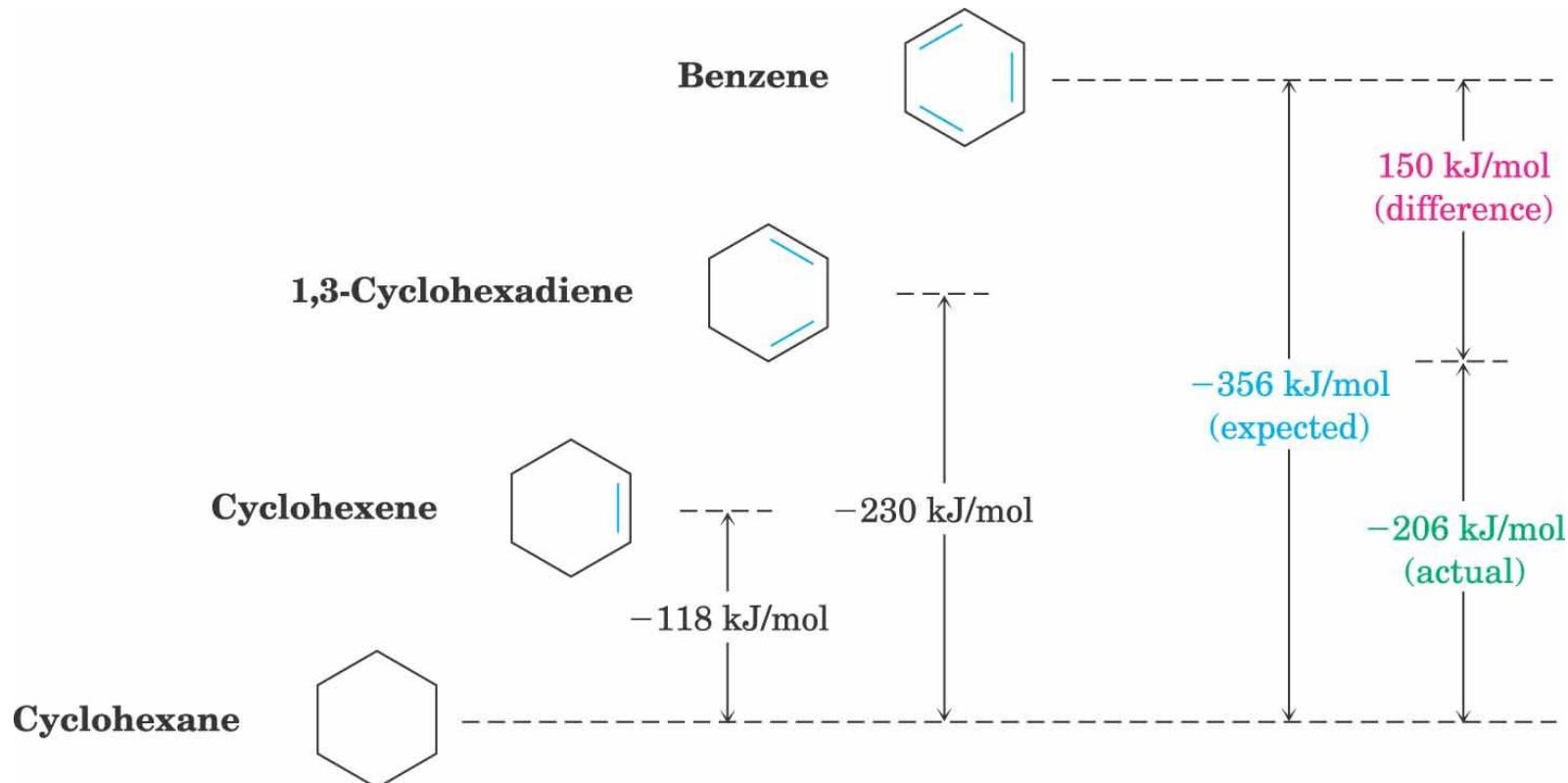
Benzene

Bromobenzene  
(substitution product)

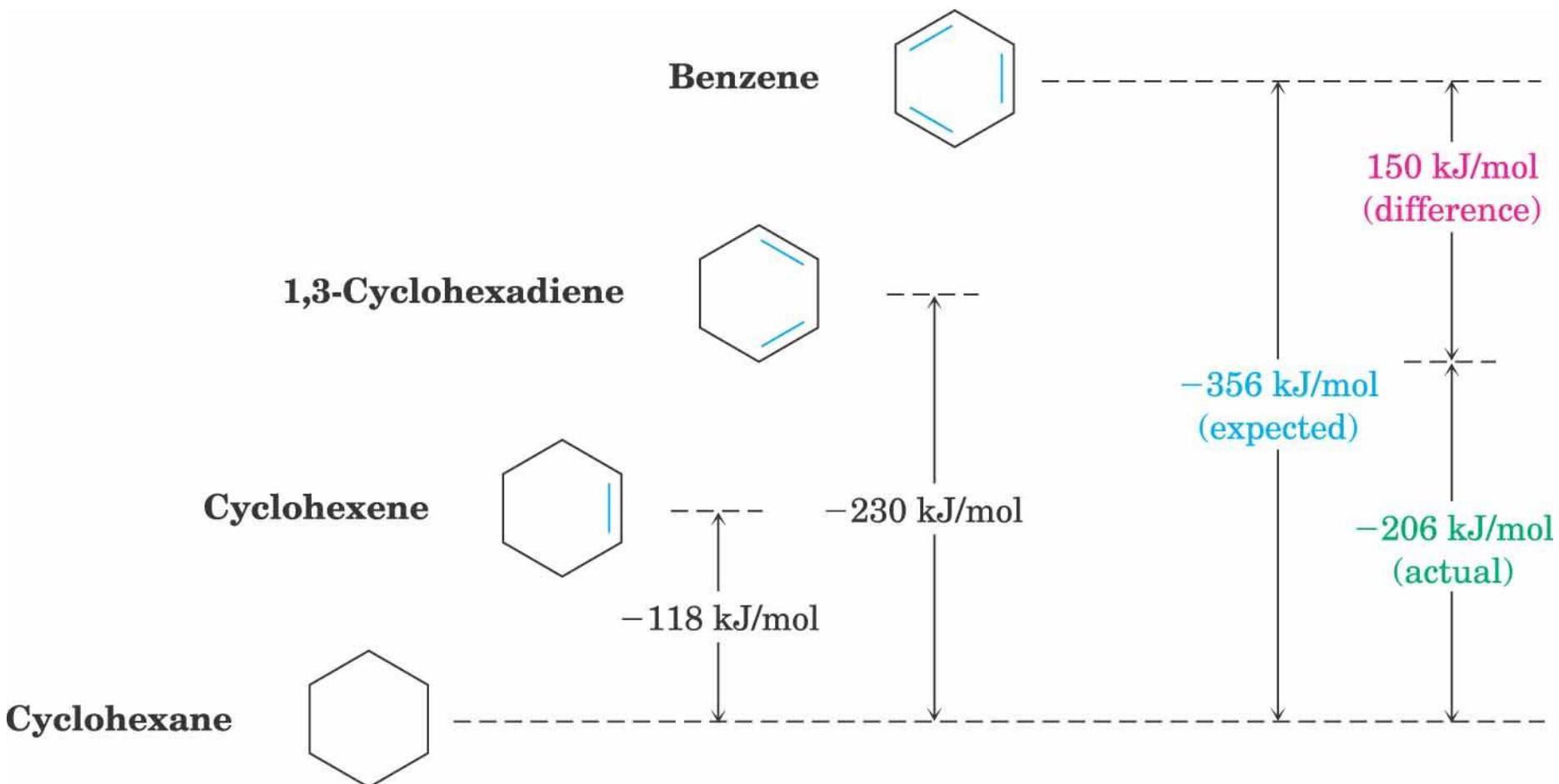


# Heats of Hydrogenation as Indicators of Stability

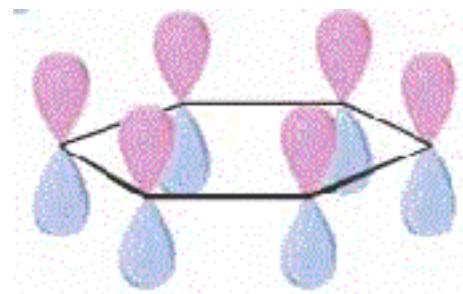
- The addition of  $\text{H}_2$  to  $\text{C}=\text{C}$  normally gives off about 118 kJ/mol – 3 double bonds would give off 356 kJ/mol
  - Two conjugated double bonds in cyclohexadiene add 2  $\text{H}_2$



- Benzene has 150 kJ/mol more “stability” than expected for “cyclohexatriene”



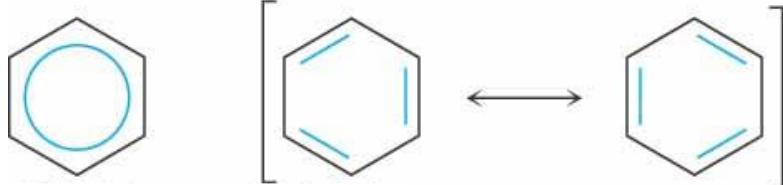
- 
- Structure is planar, hexagonal
  - All C–C–C bond angles are 120°
  - Each C is  $sp^2$ -hybridized and has a  $p$  orbital perpendicular to the plane of the six-membered ring



# Drawing Benzene and Its Derivatives

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- The two benzene resonance forms can be represented by a single structure with a circle in the center to indicate the equivalence of the carbon–carbon bonds



Alternative representations of benzene.  
The “circle” representation must be used carefully since it doesn’t indicate the number of  $\pi$  electrons in the ring.

- This does not indicate the number of  $\pi$  electrons in the ring but shows the delocalized structure
- One of the resonance structures will be used to represent benzene for ease in keeping track of bonding changes in reactions

## **4. Aromaticity and the Hückel 4n + 2 Rule**

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The Hückel  $4n + 2$  rule:

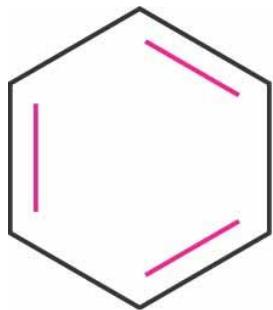
- was devised by Eric Hückel in 1931
- states that planar, monocyclic conjugated systems with a total of  $4n + 2 \pi$  electrons where n is an integer ( $n = 0, 1, 2, 3, \dots$ ) are aromatic

# Aromatic compounds with $4n + 2 \pi$ electrons

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- Benzene

- It has  $6 \pi$  electrons:  $4n + 2 = 6$ , thus  $n = 1$
- It is aromatic: it is stable and the electrons are delocalized



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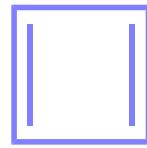
## Benzene

**Three double bonds;  
six  $\pi$  electrons**

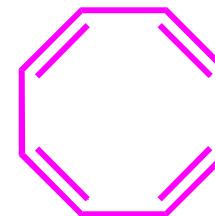
Compounds with  $4n \pi$  electrons are NOT aromatic (May be Anti-aromatic)

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- Planar, cyclic conjugated molecules with  $4n \pi$  electrons are antiaromatic
  - They are much *less* stable than expected
  - They will distort out of plane and behave like ordinary alkenes



cyclobutadiene



cyclooctatetraene

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Which of the above is antiaromatic?

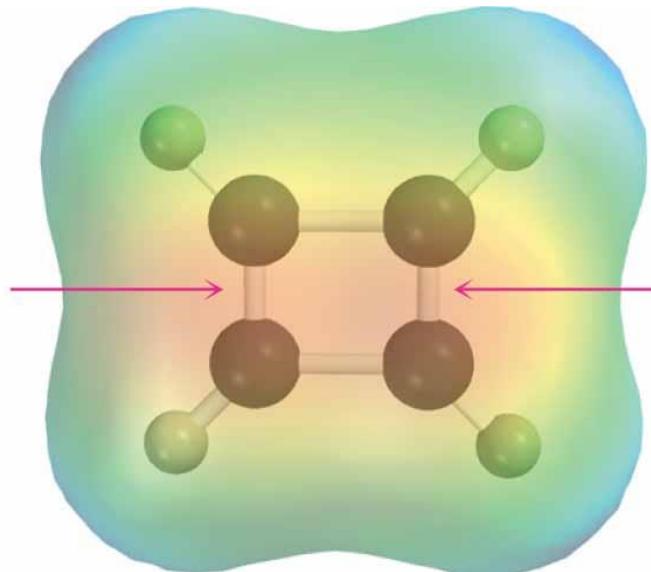
## • Cyclobutadiene

- It has  $4 \pi$  electrons:  $4n + 2 = 4$ , thus  $n = \frac{1}{2}$  (not an integer)
- It is antiaromatic: The  $\pi$  electrons are localized into two double bonds



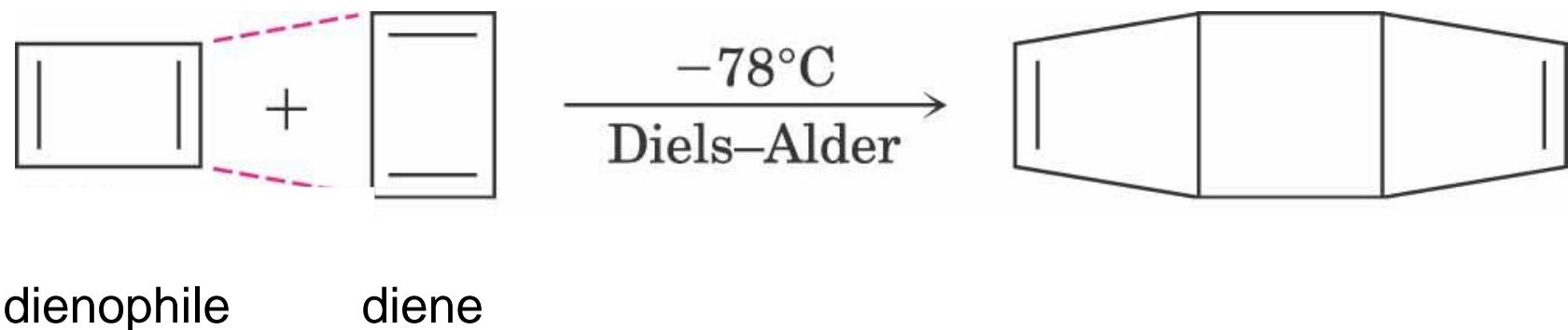
**Cyclobutadiene**

Two double bonds;  
four  $\pi$  electrons



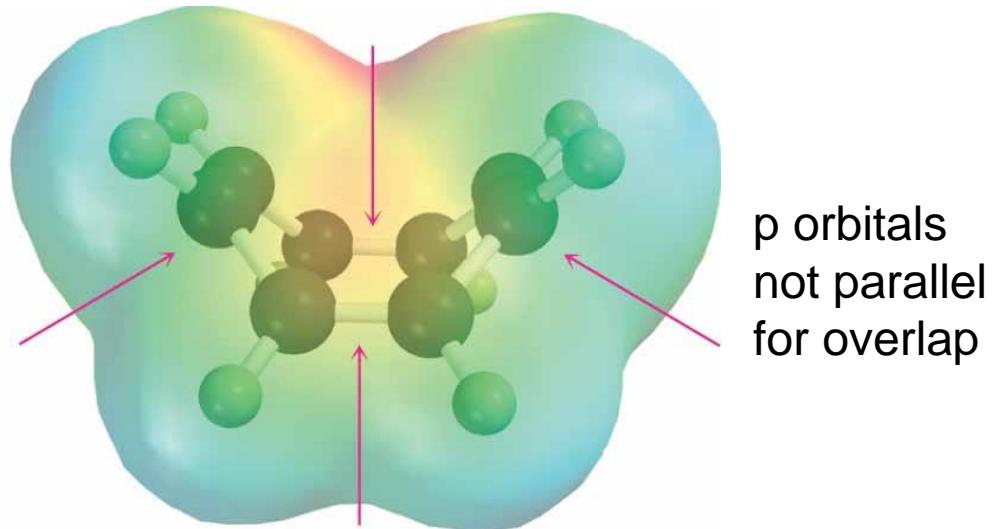
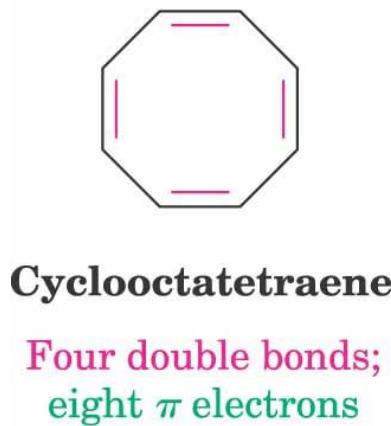
localized  $\pi$   
electrons

- Cyclobutadiene
- It has  $4 \pi$  electrons:  $4n + 2 = 4$ , thus  $n = \frac{1}{2}$  (not an integer)
- It is antiaromatic: The  $\pi$  electrons are localized into two double bonds
- It is so unstable that it dimerizes by a self-Diels-Alder reaction at low temperature



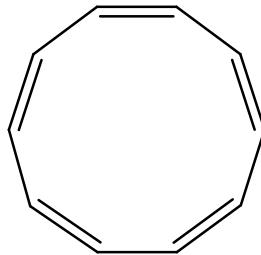
## • Cyclooctatetraene

- It has  $8 \pi$  electrons:  $4n + 2 = 8$ , thus  $n = 3/2$  (not an integer)
- It is nonaromatic:
  - the  $\pi$  electrons are localized into four double bonds
  - it is tub-shaped not planar
  - it has four double bonds, reacting with  $\text{Br}_2$ ,  $\text{KMnO}_4$ , and  $\text{HCl}$  as if it were four alkenes



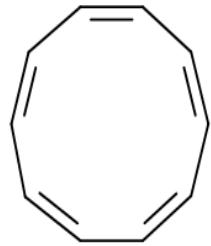
*Practice Problem:* To be aromatic, a molecule must have  $4n + 2\pi$  electrons and must have cyclic conjugation. Is cyclodecapentaene aromatic?

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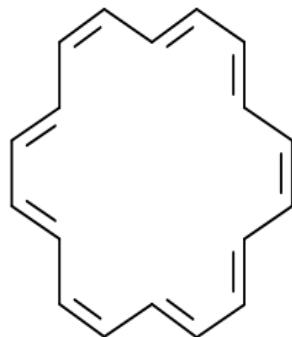


- It has  $10 \pi$  electrons:  $4n + 2 = 10$ , thus  $n = 2$  (an integer)
- It is not planar due to steric strain, thus the neighboring p orbitals are not properly aligned for overlap. It is not conjugated. Thus it is not aromatic.

◆ **Annulene**: A cyclic hydrocarbon with a continuous alternation of single and double bonds.



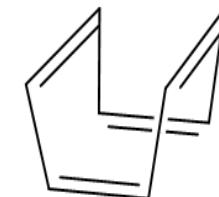
cyclodecapentaene  
[10]-annulene



[18]-annulene



cyclobutadiene



cyclooctatetraene

aromatic

antiaromatic

•

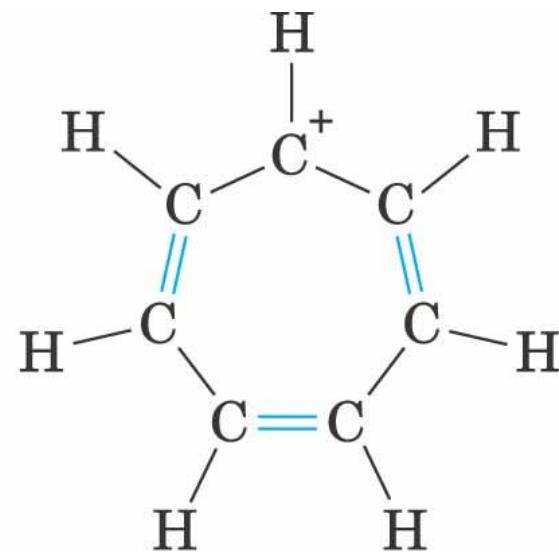
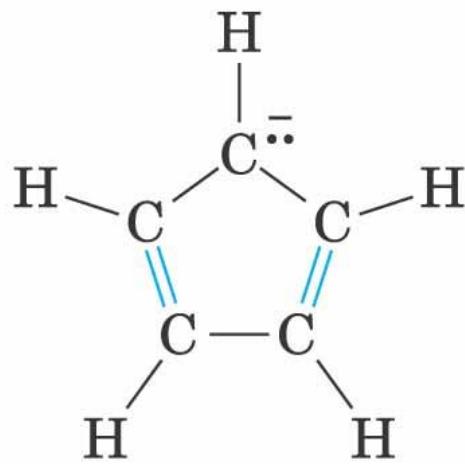
## **6. Aromatic Ions**

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- The Hückel  $4n + 2$  rule applies to ions as well as to neutral species:
  - To be aromatic, a molecule must be planar, cyclic conjugated system with  $4n + 2 \pi$  electrons
  - Example: Both the cyclopentadienyl *anion* and the cycloheptatrienyl *cation* are aromatic.

- Example: Both the cyclopentadienyl *anion* and the cycloheptatrienyl *cation* are aromatic.

The key feature of both is that they contain 6  $\pi$  electrons in a ring of continuous p orbitals



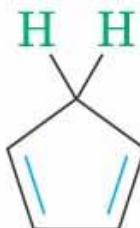
**Cyclopentadienyl anion**

**Cycloheptatrienyl cation**

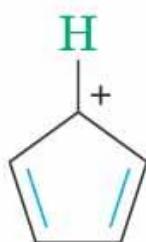
**Six  $\pi$  electrons; aromatic ions**

# Aromaticity of the Cyclopentadienyl Anion

Not fully conjugated and not aromatic



Cyclopentadiene



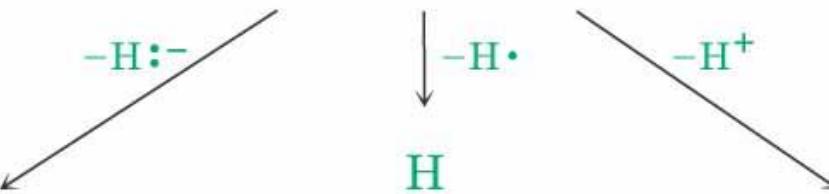
Cyclopentadienyl  
cation: **four  $\pi$  electrons**



Cyclopentadienyl  
radical: **five  $\pi$  electrons**



Cyclopentadienyl  
anion: **six  $\pi$  electrons**



Unstable and nonaromatic

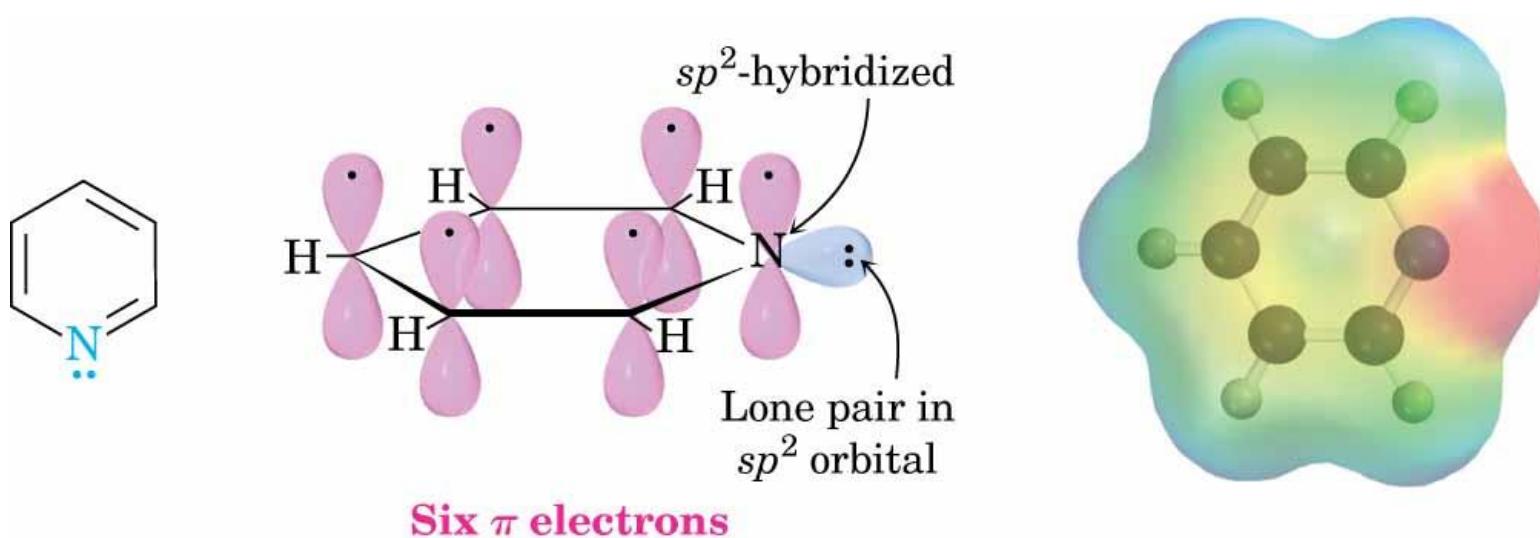
## **7. Aromatic Heterocycles: Pyridine and Pyrrole**

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- A heterocycle is a cyclic compound that contains an atom or atoms other than carbon in its ring, such as N, O, S, P
  - There are many heterocyclic aromatic compounds and many are very common
  - Cyclic compounds that contain only carbon are called carbocycles (not homocycles)
  - Nomenclature is specialized
  - Example: Pyridine and Pyrrole

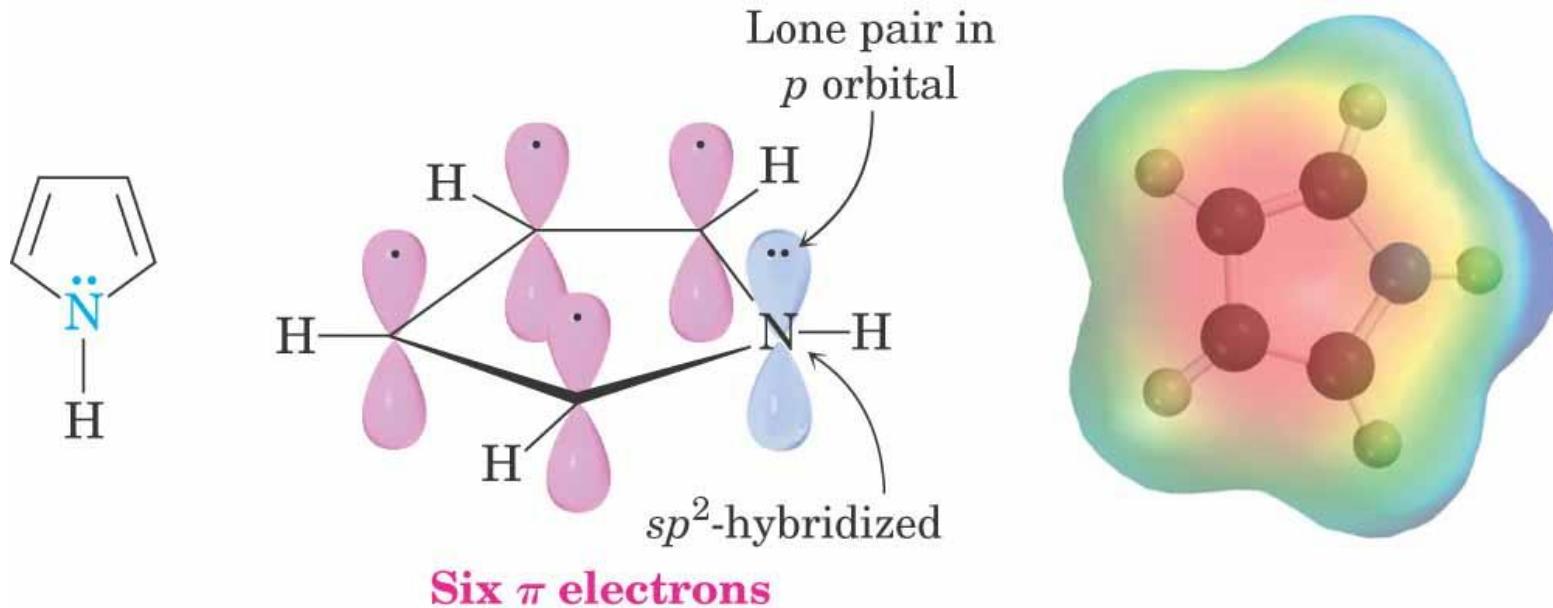
# Pyridine

- Pyridine is a six-membered heterocycle with a nitrogen atom in its ring
  - $\pi$  electron structure resembles benzene (6 electrons)
  - The nitrogen lone pair electrons are in  $sp^2$  orbital, not part of the  $\pi$  aromatic system (perpendicular orbital)
  - Pyridine is a relatively weak base compared to normal amines but protonation does not affect aromaticity



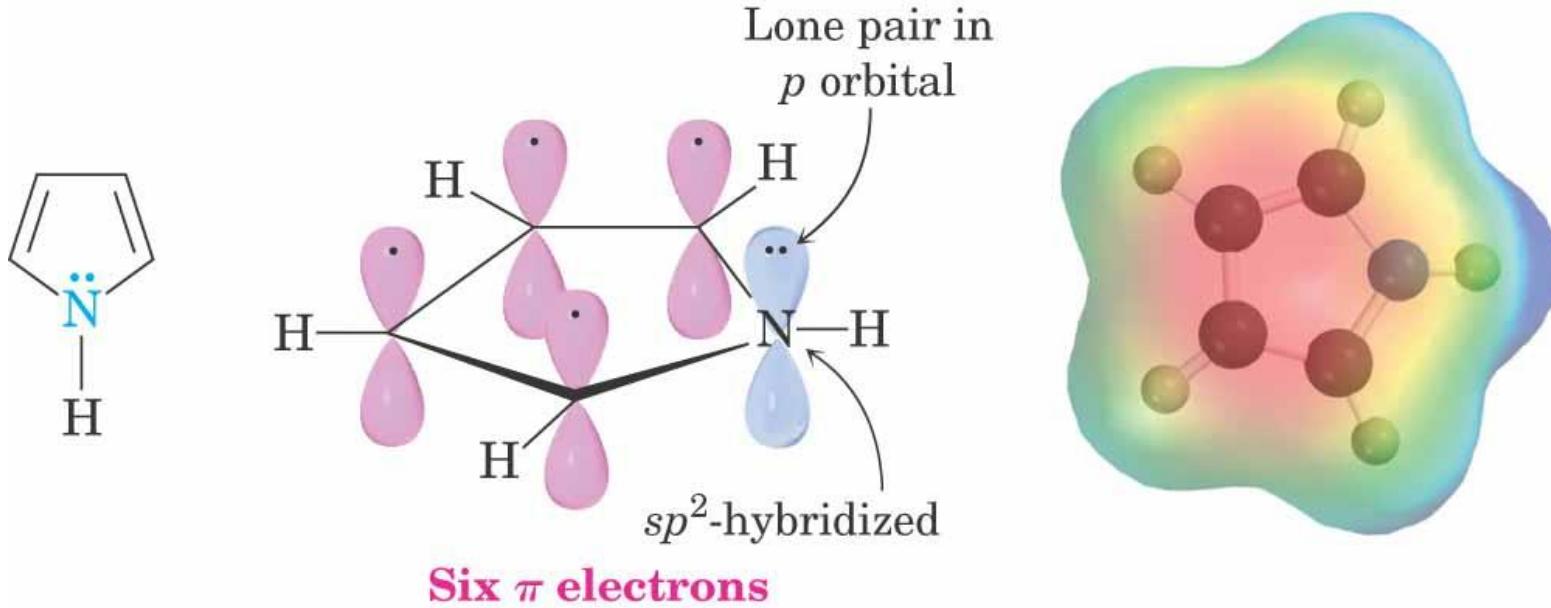
# Pyrrole

- Pyrrole is a five-membered heterocycle with a nitrogen atom in its ring
  - $\pi$  electron system is similar to that of cyclopentadienyl anion
  - Four  $sp^2$ -hybridized carbons with 4  $p$  orbitals perpendicular to the ring and 4  $p$  electrons



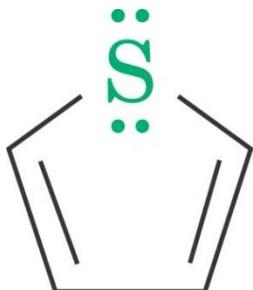
# Pyrrole

- Nitrogen atom is  $sp^2$ -hybridized, and lone pair of electrons occupies a  $p$  orbital ( $6 \pi$  electrons)
- Since lone pair electrons are in the aromatic ring, protonation destroys aromaticity, making pyrrole a very weak base



*Practice Problem:* Thiophene, a sulfur-containing heterocycle, undergoes typical aromatic substitution reactions rather than addition reactions.

Explain why thiophene is aromatic.

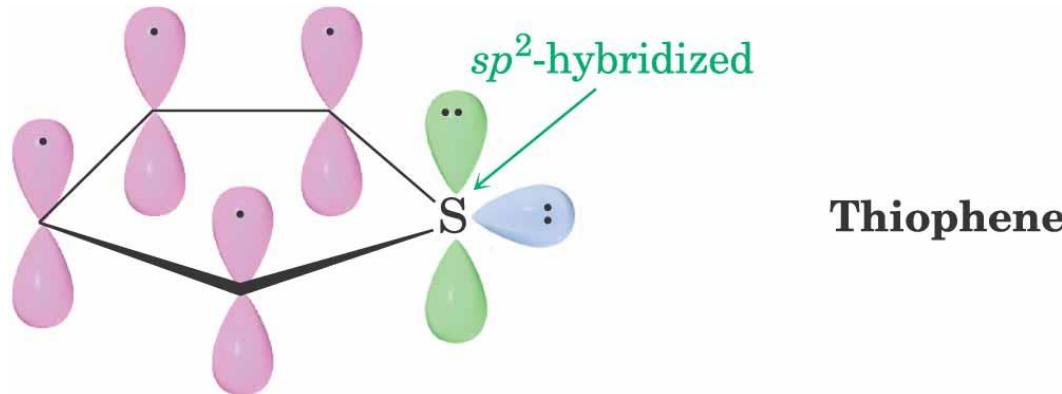


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## Thiophene

It has  $6 \pi$  electrons:  $4n + 2 = 6$ , thus  $n = 1$  (an integer)

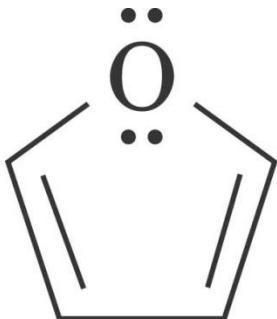
It has a lone pair of electrons in a p orbital perpendicular to the plane



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*Practice Problem:* Draw an orbital picture of furan to show how the molecule is aromatic

the

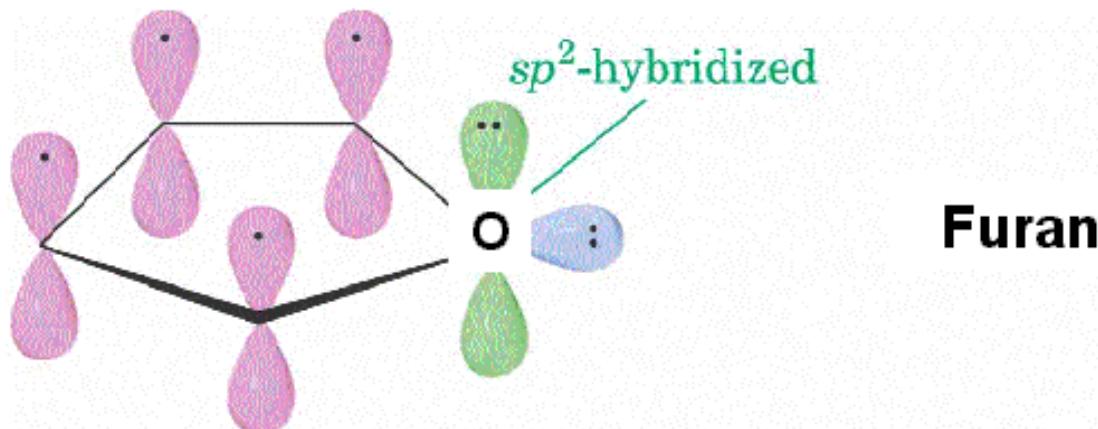


Furan

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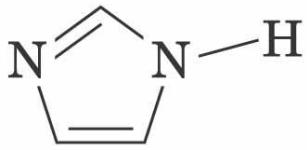
It has  $6 \pi$  electrons:  $4n + 2 = 6$ , thus  $n = 1$  (an integer)

It has a lone pair of electrons in a p orbital perpendicular to the plane



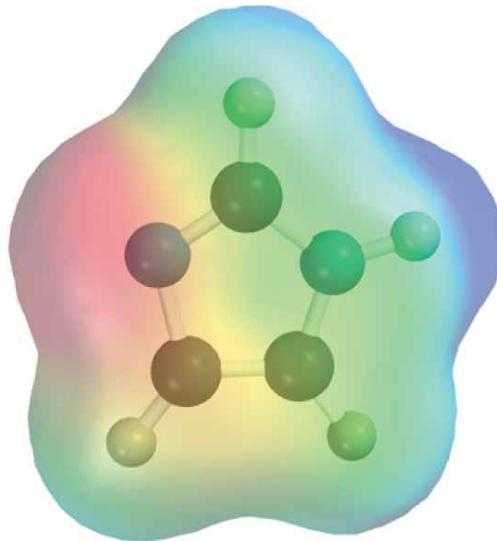
*Practice Problem:* Draw an orbital picture of imidazole, and account for its aromaticity. Which nitrogen atom is pyridine-like, and which is pyrrole-like? Which nitrogen atom is more electron-rich, and why?

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**Imidazole**

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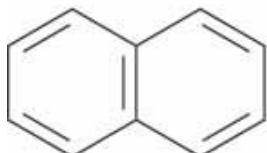
## **9. Polycyclic Aromatic Compounds:**

### **Naphthalene**

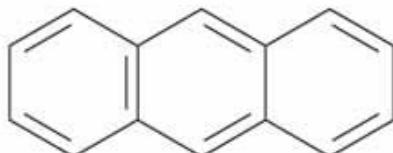
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- Polycyclic aromatic compounds are

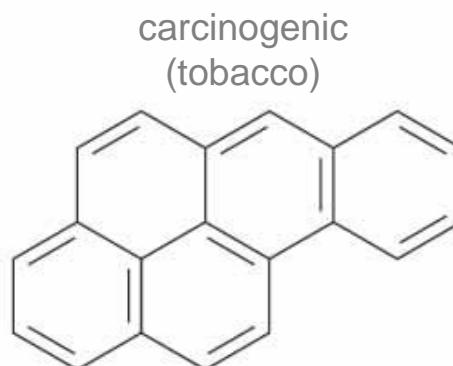
- aromatic compounds with rings that share a set of carbon atoms (fused rings)
- compounds from fused benzene or aromatic heterocycle rings



**Naphthalene**

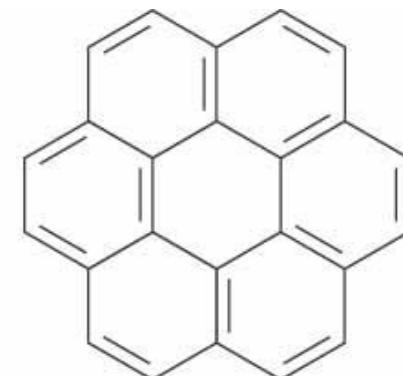


**Anthracene**



**Benzo[a]pyrene**

carcinogenic  
(tobacco)



**Coronene**

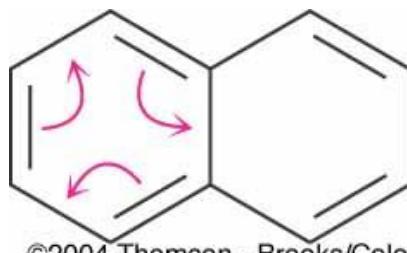
# Characteristics of Polycyclic Aromatic Compounds

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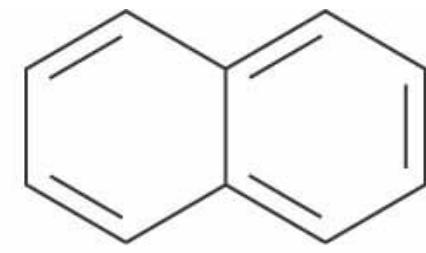
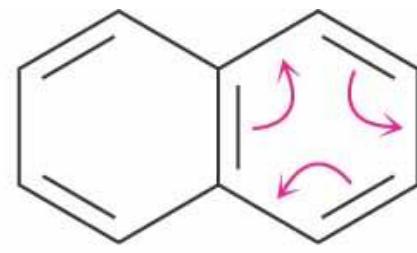
- They are cyclic, planar and conjugated molecules
- They are unusually stable
- They react with electrophiles to give substitution products, in which cyclic conjugation is retained, rather than electrophilic addition products
- They can be represented by different resonance forms
- They have  $4n + 2$  p electrons, delocalized over the ring

# Naphthalene

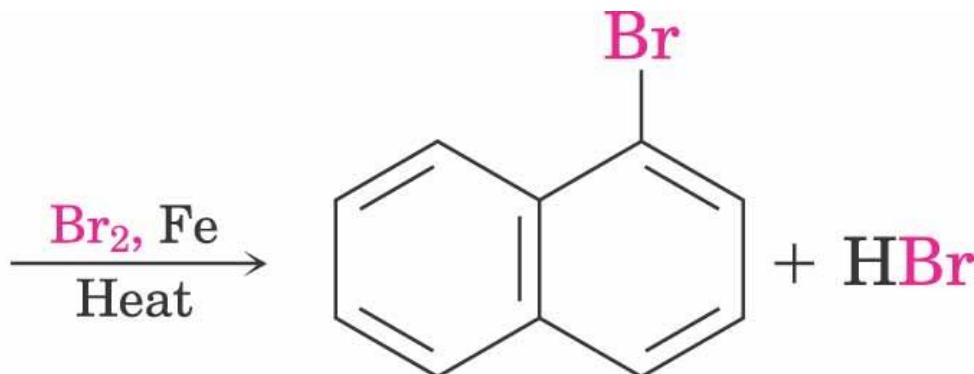
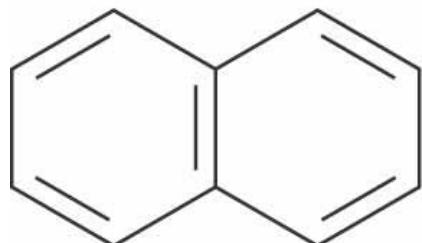
- Naphthalene has three resonance forms



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- Naphthalene reacts slowly with electrophiles to give substitution products



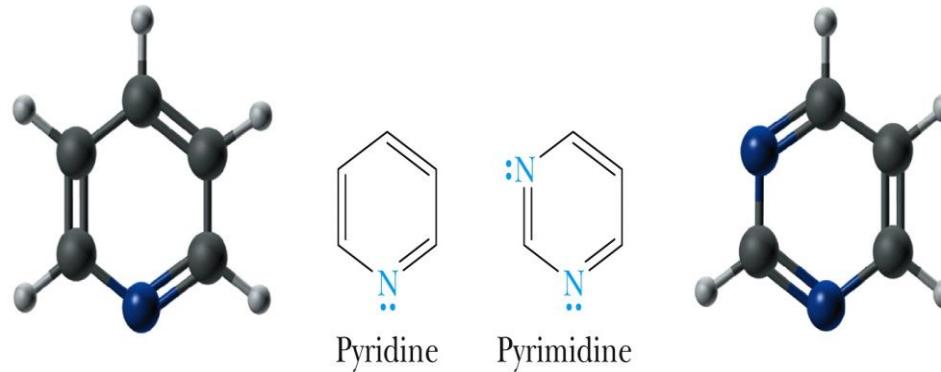
**Naphthalene**

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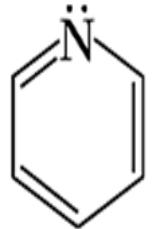
**1-Bromonaphthalene (75%)**

# Heterocyclic Aromatic compounds

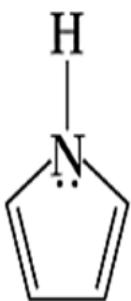
- **Heterocyclic compound:** A compound that contains one or more atoms other than carbon (**heteroatoms**) in its ring (nitrogen, oxygen, sulfur, etc...).
- **Heterocyclic aromatic compound:** A heterocyclic compound whose ring is aromatic.
- Pyridine and pyrimidine are heterocyclic analogs of benzene; each is aromatic.



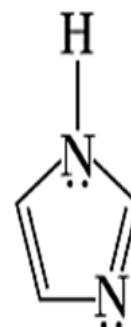
# Other heterocyclic aromatic compounds



Pyridine



Pyrrole



Imidazole



Furan

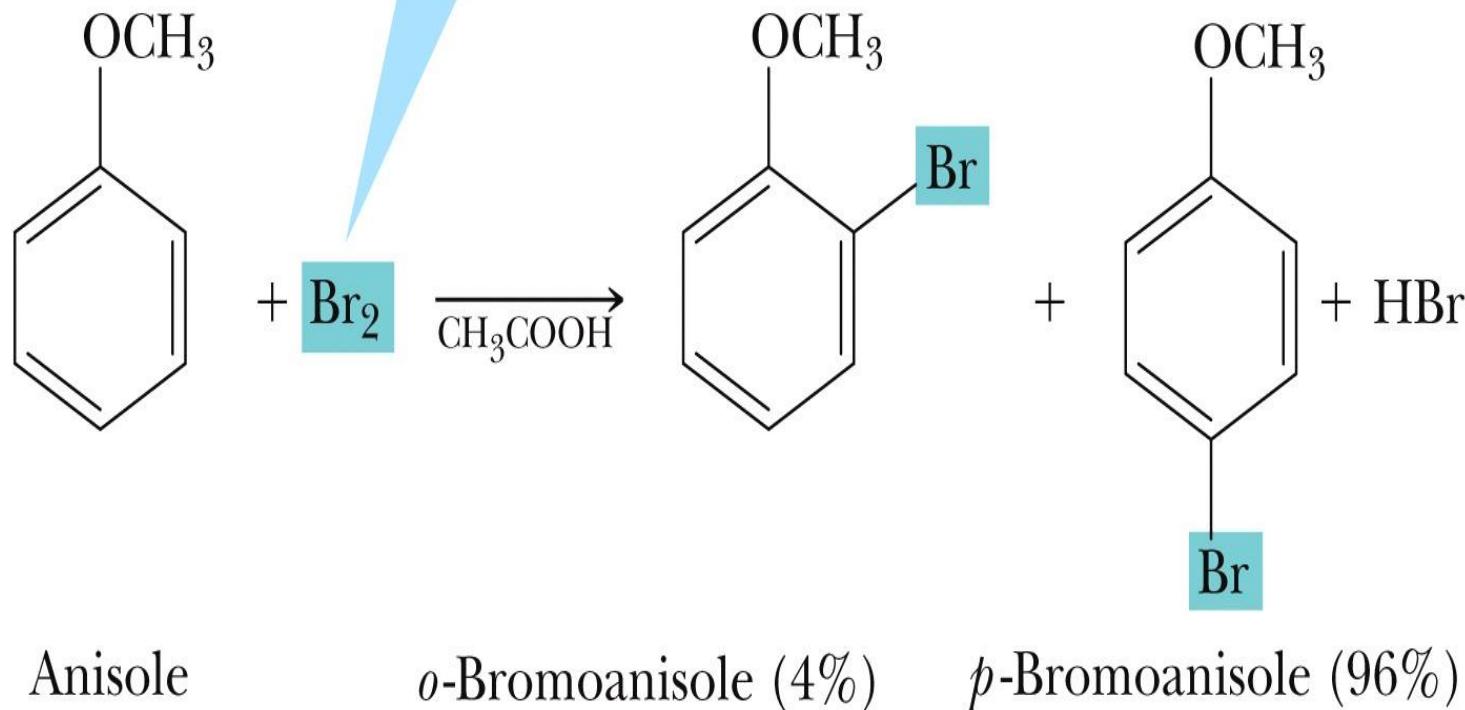
# Directing effects of substituents on benzene ring

## Activating Directors

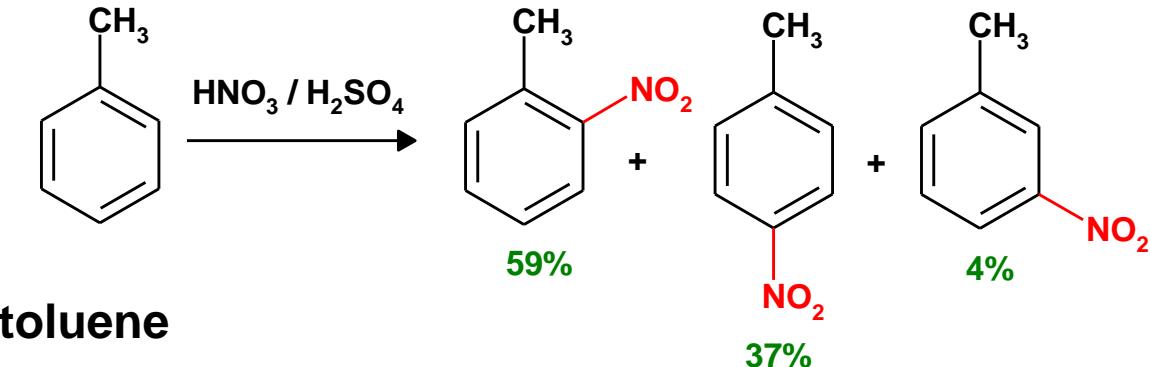
- Any resonance effect for electron-donating groups such as  $\text{-NH}_2$ ,  $\text{-OH}$ , and  $\text{-OR}$ , which delocalizes the positive charge on the cation intermediate, lowers the activation energy for its formation and activates the ring toward further EAS.
- These groups on the benzene ring make electrophilic aromatic substitution faster.
- They direct substitution to the **ortho** and **para** positions.
- For **ortho-para directors**, ortho-para attack forms a more stable cation than meta attack.

## Activating Directors

the bromination of anisole proceeds many times faster than the bromination of benzene. In fact,  $-OCH_3$  is so activating that no catalyst is necessary in this reaction

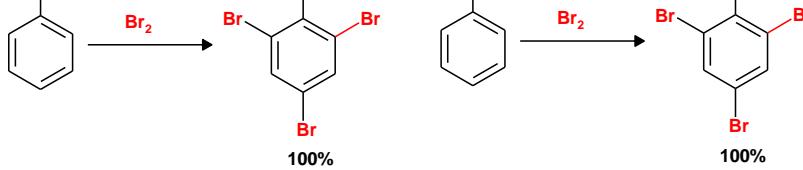


## Activating Directors



○ **R (alkyl) groups are weakly activating and ortho- & para-directing.**

○ Toluene reacts 25 times faster than benzene in nitration



aniline

phenol

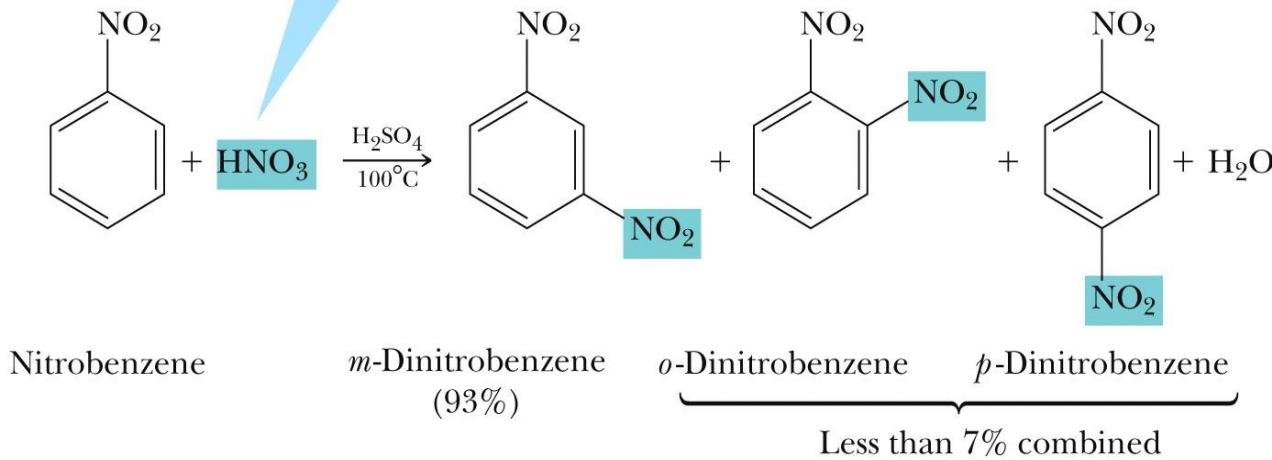
*Note – no catalyst*

-NH<sub>2</sub>, -OH, -OMe, MeCONH- are all *powerful activating groups*  
*Ortho- and para- directing*

# Deactivating Directors

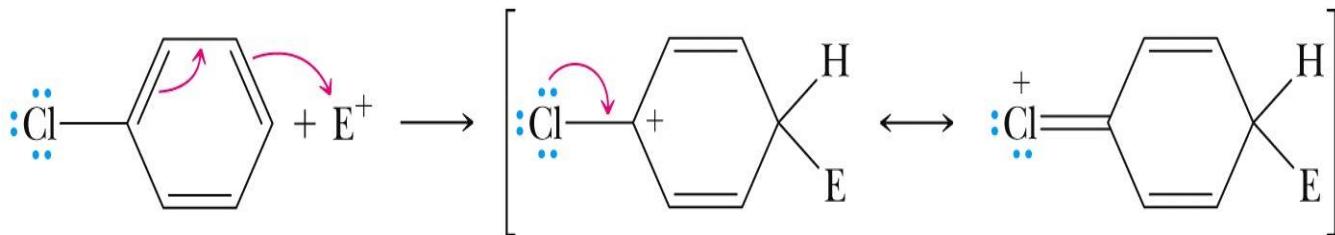
- Any resonance or inductive effect for electron-withdrawing groups such as  $\text{-NO}_2$ ,  $\text{-C=O}$ ,  $\text{-SO}_3\text{H}$ ,  $\text{-NR}_3^+$ ,  $\text{-CCl}_3$ , and  $\text{-CF}_3$ , which decreases electron density on the ring, deactivates the ring toward further EAS.
- These groups on the benzene ring make electrophilic aromatic substitution slower.
- They direct substitution to the **meta** position.
- For **meta directors**, meta attack forms a more stable cation than ortho-para attack.
- Also, meta products
- $\text{-NO}_2$  is meta directing.

the nitration of nitrobenzene proceeds many times slower than the nitration of benzene



## Deactivating Directors

- **Halogens:** the resonance and inductive effects operate in opposite directions.
- **The inductive effect:** halogens have an electron-withdrawing inductive effect; therefore, aryl halides react more slowly in EAS than benzene.
- **The resonance effect:** a halogen ortho or para to the site of electrophilic attack stabilizes the cation intermediate by delocalizing the positive charge; halogen, therefore, is ortho-para directing.



# Summary

1. Groups which are ortho-para directing.
  - a. Alkyl groups, Phenyl groups and,
  - b. Substituents in which the atom bonded to the ring has an unshared pair of electrons
2. All ortho-para directing groups are activating toward further substitution; except halogens, which are weakly deactivating.
3. All other substituents are meta directing.
4. All meta directing groups carry either a partial or full positive charge on the atom bonded to the ring.

Effects of Substituents on Further Electrophilic Aromatic Substitution						
Ortho-Para Directing	strongly activating	$\text{--NH}_2$	$\text{--NHR}$	$\text{--NR}_2$	$\text{--OH}$	$\text{--OR}$
	moderately activating	$\text{--NHCR}$	$\text{--NHCar}$	$\text{--OCCR}$	$\text{--OCAr}$	
	weakly activating	$\text{--R}$				
	weakly deactivating	$\text{--F:}$	$\text{--Cl:}$	$\text{--Br:}$	$\text{--I:}$	
Meta Directing	moderately deactivating	$\text{--CH}$	$\text{--CR}$	$\text{--COH}$	$\text{--COR}$	$\text{--C(=O)NH}_2$
	strongly deactivating	$\text{--NO}_2$	$\text{--NH}_3^+$	$\text{--CF}_3$	$\text{--CCl}_3$	$\text{--SO}_2\text{O}$

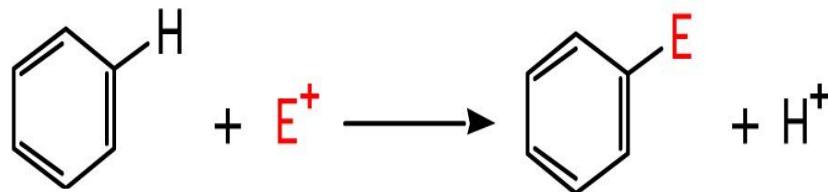
Relative importance in directing further substitution  
relative to benzene

Increasing reactivity  
relative to benzene

Decreasing reactivity  
relative to benzene

# Electrophilic Aromatic Substitution Reactions and their Mechanism

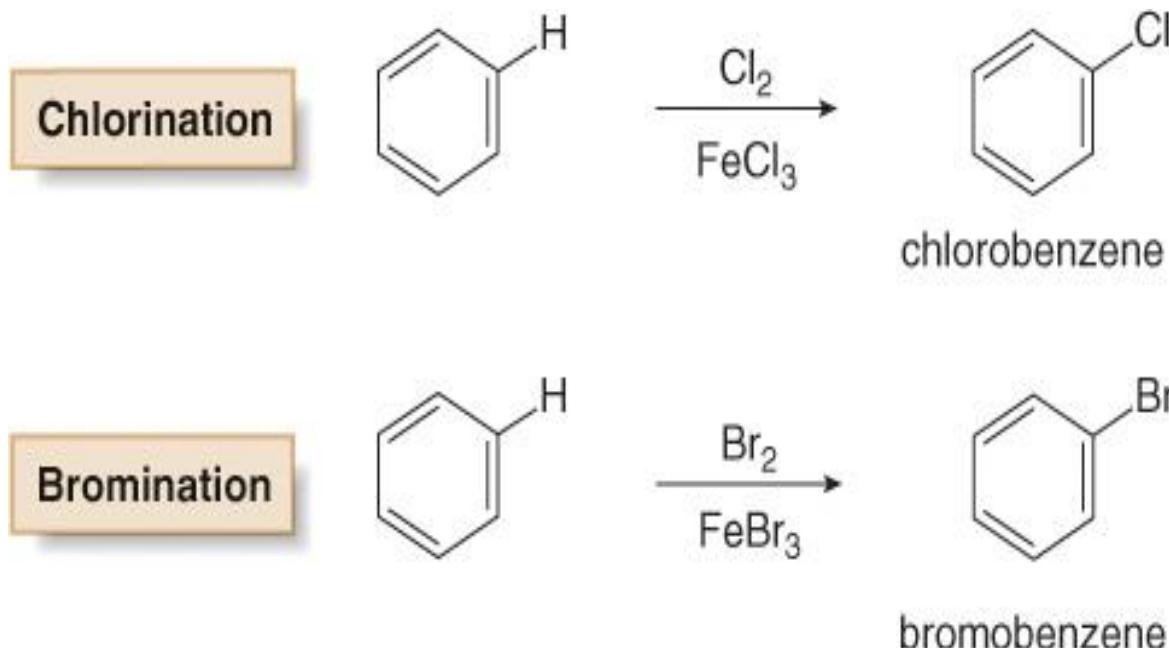
- **Electrophilic Aromatic Substitution (EAS):** A reaction in which an electrophile,  $E^+$ , substitutes for an H on an aromatic ring.



- Aromatic compounds undergo five electrophilic substitution reaction
  - ✓ Halogenation
  - ✓ Nitration
  - ✓ Sulfonation
  - ✓ Friedel craft alkylation
  - ✓ Friedel acylation

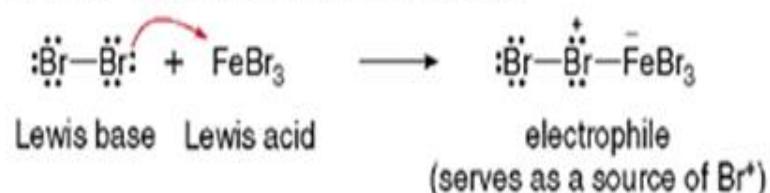
# Halogenation

- In **halogenation**, benzene reacts with  $\text{Cl}_2$  or  $\text{Br}_2$  in the presence of a Lewis acid catalyst, such as  $\text{FeCl}_3$  or  $\text{FeBr}_3$ , to give the aryl halides chlorobenzene or bromobenzene respectively.
- Analogous reactions with  $\text{I}_2$  and  $\text{F}_2$  are not synthetically useful because  $\text{I}_2$  is too unreactive and  $\text{F}_2$  reacts too violently.



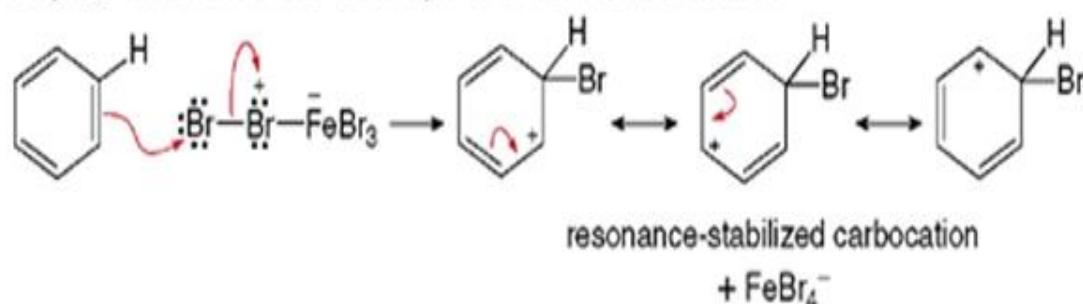
## Bromination of Benzene

### Step [1] Generation of the electrophile



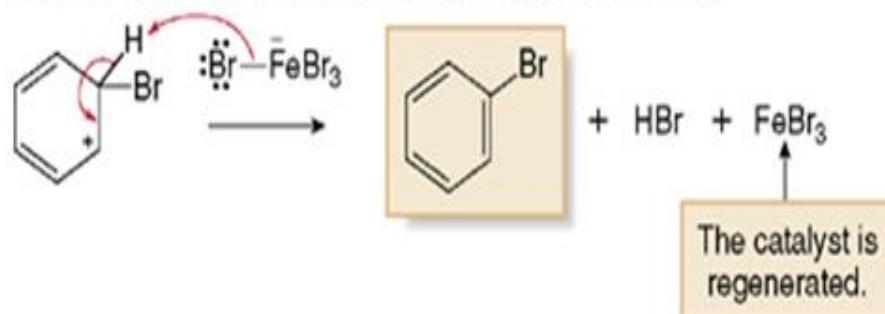
- Lewis acid-base reaction of Br<sub>2</sub> with FeBr<sub>3</sub> forms a species with a weakened and polarized Br–Br bond. This adduct serves as a source of Br<sup>+</sup> in the next step.

### Step [2] Addition of the electrophile to form a carbocation



- Addition of the electrophile forms a new C–Br bond and generates a carbocation. This carbocation intermediate is resonance stabilized—**three resonance structures can be drawn**.
- The FeBr<sub>4</sub><sup>-</sup> also formed in this reaction is the base used in Step [3].

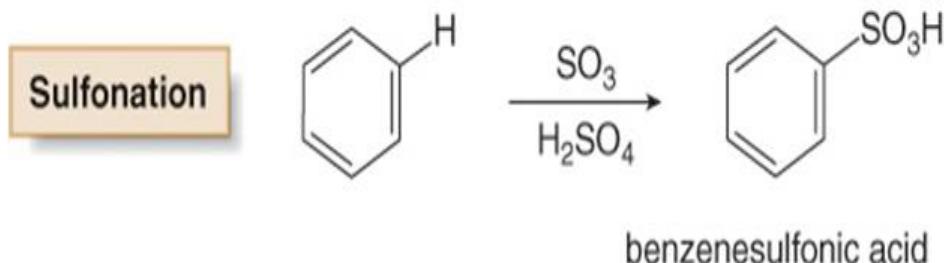
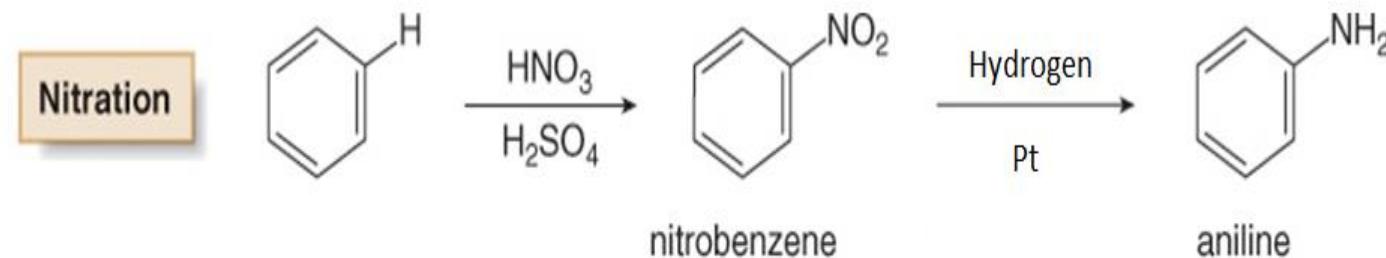
### Step [3] Loss of a proton to re-form the aromatic ring



- FeBr<sub>4</sub><sup>-</sup> removes the proton from the carbon bearing the Br, thus re-forming the aromatic ring.
- FeBr<sub>3</sub>, a catalyst, is also regenerated for another reaction cycle.

# Nitration and Sulfonation

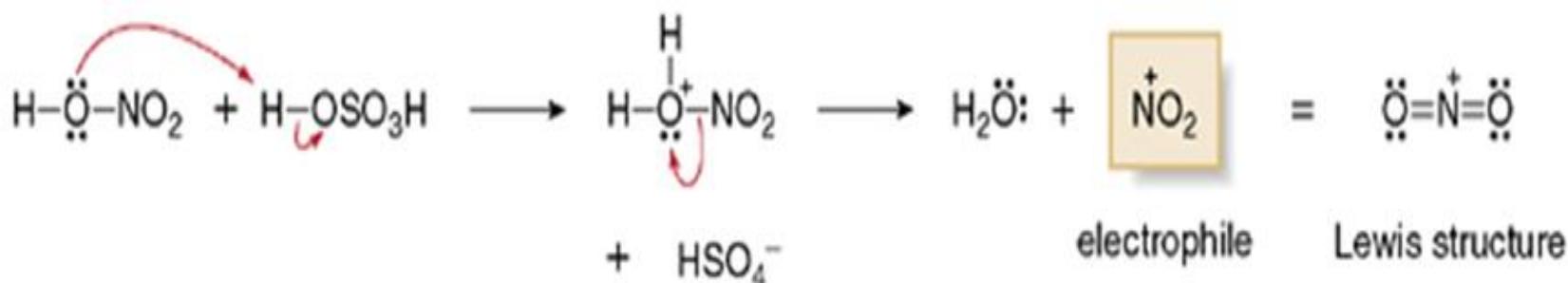
- Nitration and sulfonation introduce two different functional groups into the aromatic ring.
- Nitration is especially useful because the nitro group can be reduced to an  $\text{NH}_2$  group.



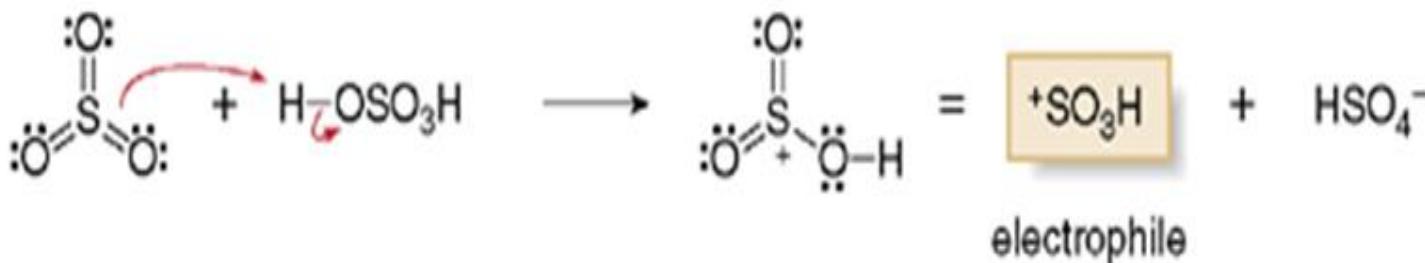
# Nitration and Sulfonation

- Generation of the electrophile in nitration and sulfonation requires strong acid.

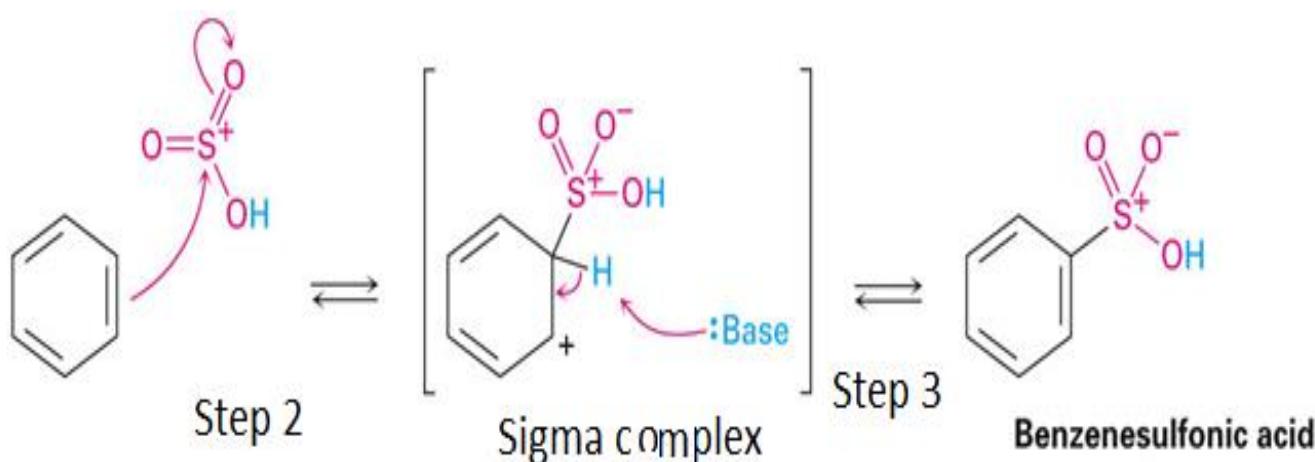
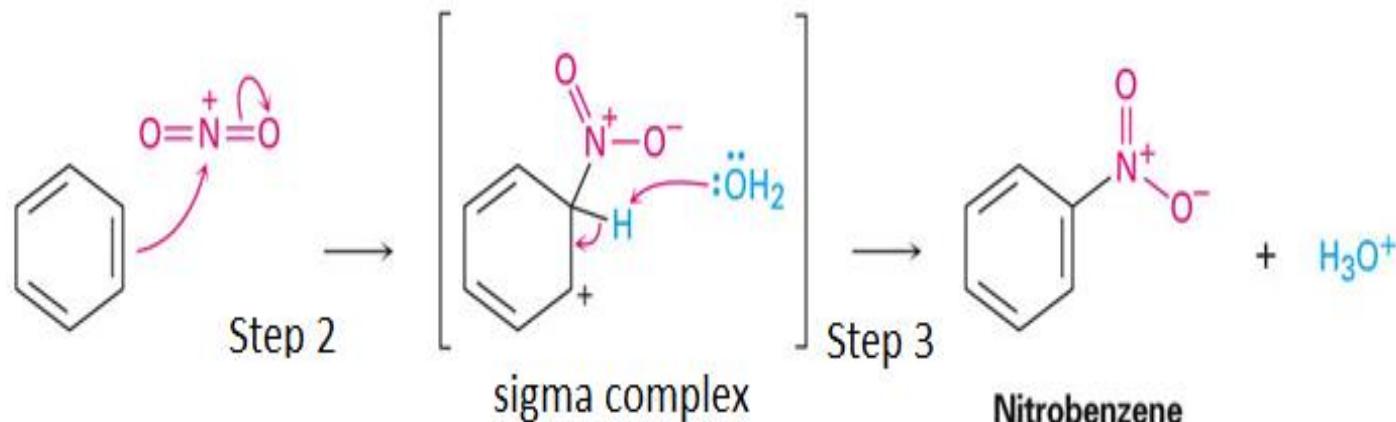
## Formation of the Nitronium Ion ( $^+NO_2$ ) for Nitration



## Formation of the Electrophile $^+\text{SO}_3\text{H}$ for Sulfonation



# Nitration and Sulfonation



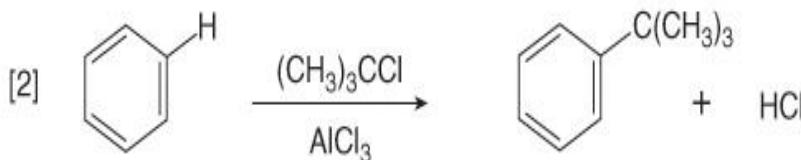
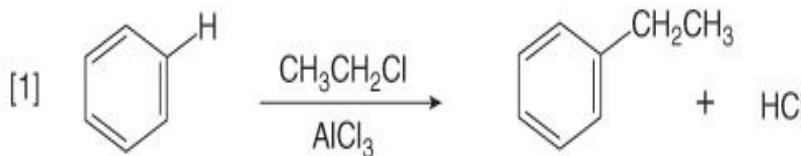
# Friedel-Crafts Alkylation

- In Friedel-Crafts alkylation, treatment of benzene with an alkyl halide and a Lewis acid ( $\text{AlCl}_3$ ) forms an alkyl benzene.

Friedel-Crafts alkylation—  
General reaction

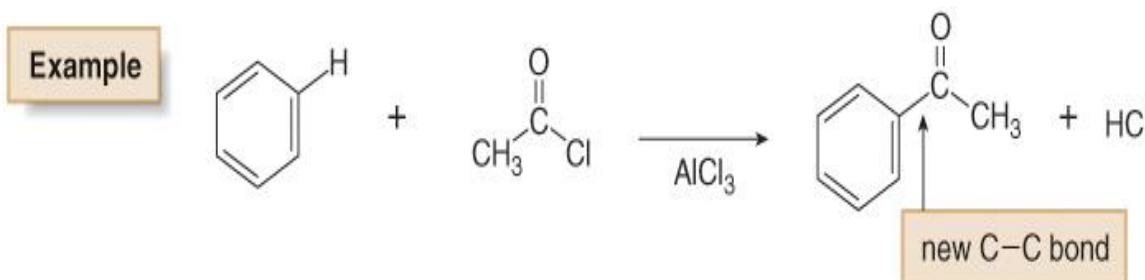
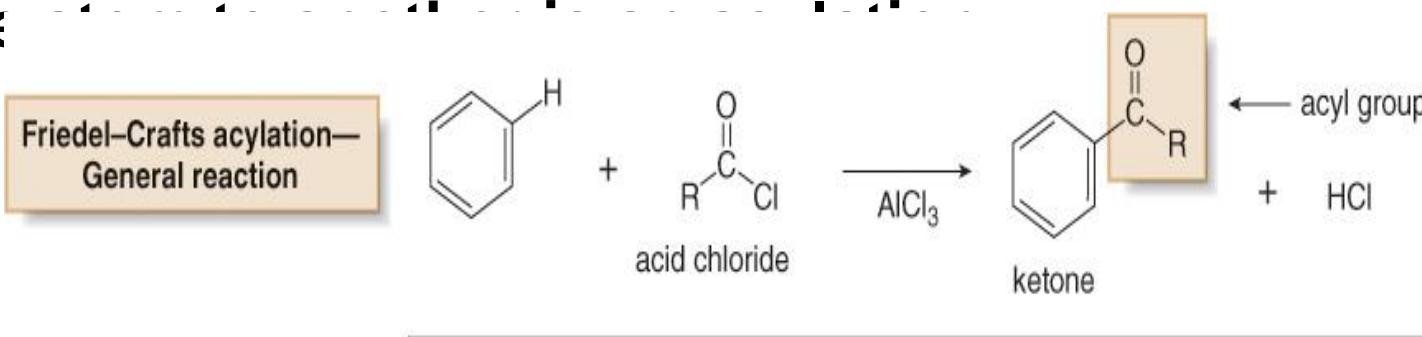


Examples

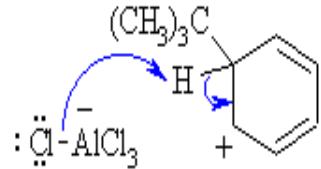
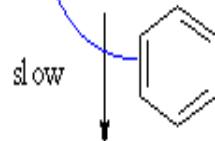
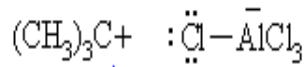
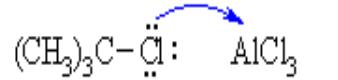


# Friedel-Crafts Acylation

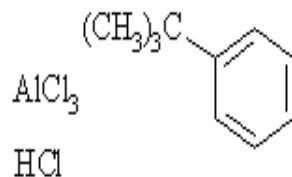
- In Friedel-Crafts acylation, a benzene ring is treated with an acid chloride ( $\text{RCOCl}$ ) and  $\text{AlCl}_3$  to form a ketone.
- Because the new group bonded to the benzene ring is called an acyl group, the transfer of an acyl group from one



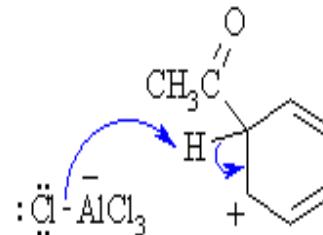
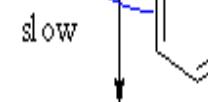
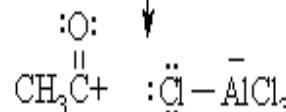
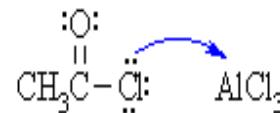
## Mechanism for Alkylation



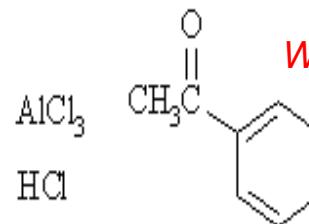
fast



## Mechanism for Acylation

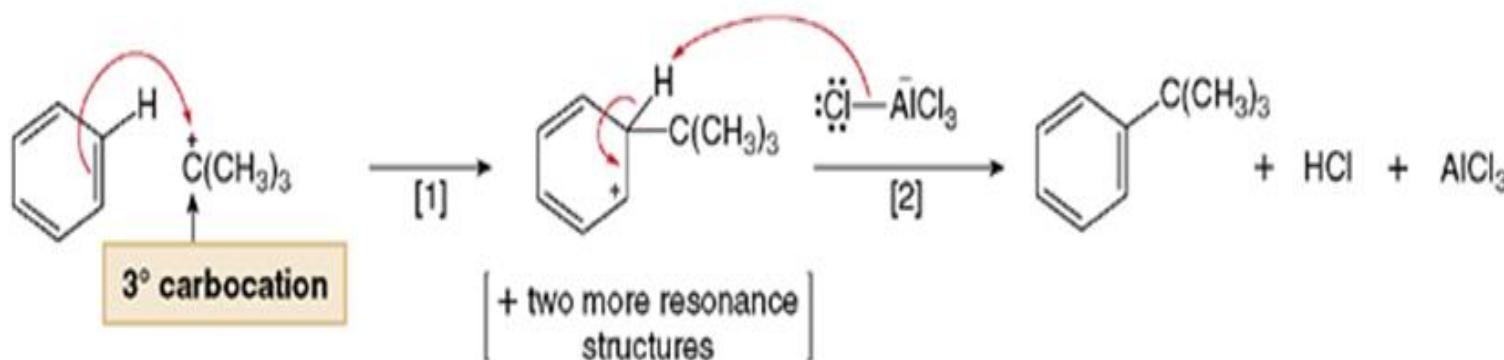


fast



# Friedel-Crafts Alkylation

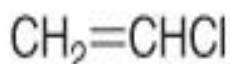
## Friedel-Crafts Alkylation Using a 3° Carbocation



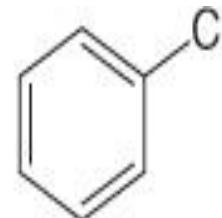
- Addition of the electrophile (a 3° carbocation) forms a new carbon–carbon bond in Step [1].
- $\text{AlCl}_4^-$  removes a proton on the carbon bearing the new substituent, thus re-forming the aromatic ring in Step [2].

Vinyl halides and aryl halides do not react in Friedel-Crafts

Unreactive halides in the Friedel–Crafts alkylation



vinyl halide



aryl halide

# Friedel-Crafts Acylation

- In Friedel-Crafts acylation, the Lewis acid  $\text{AlCl}_3$  ionizes the carbon-halogen bond of the acid chloride, thus forming a positively charged carbon electrophile called an **acylium ion**, which is resonance stabilized.
- The positively charged carbon atom of the acylium ion then goes on to react with benzene in the two step mechanism of

## Formation of the Electrophile in Friedel-Crafts Acylation

