

# Friedel-Crafts alkylation

Answer all the questions below as fully as you can then check your answers

1. What is an electrophile?
2. What is a Lewis acid?
3. What role does the Lewis acid play in a Friedel-Crafts alkylation reaction?
4. What do Friedel-Crafts reactions produce?
  - a. What are the typical reagents needed in a Friedel-Crafts reaction?
  - b. Write an equation to show how a typical Friedel-Crafts reaction occurs using benzene and an alkyl chloride as the starting reagents.
5. What type of reaction will aromatic rings undergo?
6. Write an equation to show how methylbenzene (Toluene) can be prepared from benzene in a Friedel-Crafts reaction.
  - a. Why is this method not particularly effective in producing toluene?
  - b. Draw the structure of at least two other likely products of this reaction other than toluene.
7. Draw the structure of phenylethene or styrene and ethylbenzene.
  - a. What is the main use of styrene?
  - b. Ethylbenzene is often prepared industrially by the alkylation of benzene in the presence of HCl and the Lewis acid aluminium chloride.
    - i. Write an equation to show how ethane reacts with hydrogen chloride to form the intermediate carbocation ion  $\text{CH}_3\text{CH}_2^+\text{Cl}^-$ .

- ii. The Lewis acid reacts with the  $\text{Cl}^-$ . Write an equation for this reaction.
- iii. Write an equation to show how the intermediate carbocation reacts with benzene to form ethylbenzene.
- iv. Write an equation to show how styrene is formed from ethylbenzene.
- 8. Discuss the major limitations of Friedel-Crafts reactions.

## Answers

1. What is an electrophile?

An electron deficient species.

2. What is a Lewis acid?

An electron pair acceptor. Lewis acids have vacant or empty orbitals that are able to accept a pair of electrons. Lewis acids are normally molecules which do not have an octet of electrons, such as  $\text{AlCl}_3$ . Here for example the aluminium atom only has 6 electrons in its outer valency shell.

3. What role does the Lewis acid play in a Friedel-Crafts alkylation reaction?

They help to polarise the halogenalkane molecule or even produce a positively charged alkyl cation.

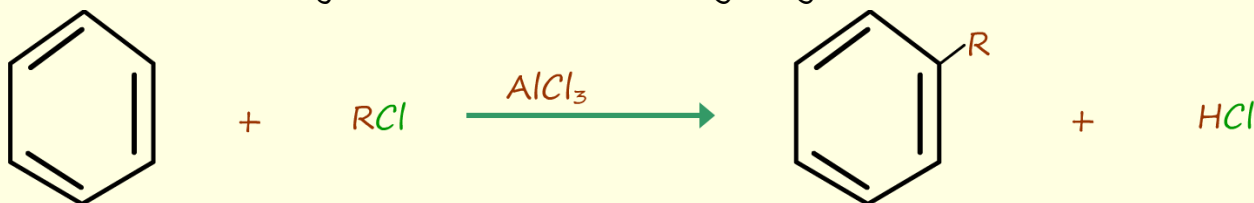
4. What do Friedel-Crafts reactions produce?

Alkylated aromatic rings.

a. What are the typical reagents needed in a Friedel-Crafts reaction? Reagents are shown in bold and underlined.

Lewis acid to help to polarise or ionise the halogenalkane which will then form the carbocation which will act as the electrophile and add to the aromatic compound.

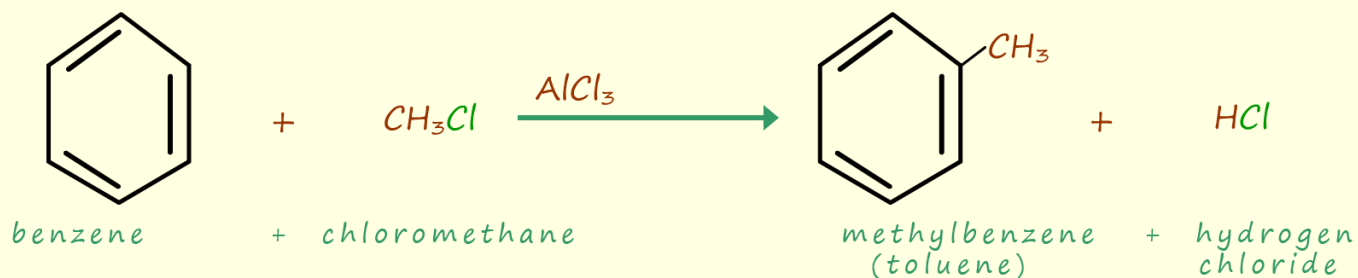
b. Write an equation to show how a typical Friedel-Crafts reaction occurs using benzene and a alkyl chloride as the starting reagents.



5. What type of reaction will aromatic rings undergo?

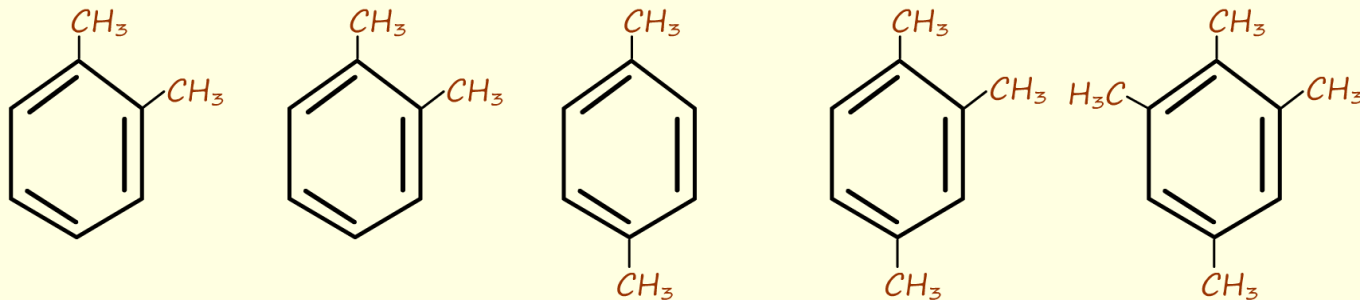
Electrophilic substitution

6. Write an equation to show how methylbenzene (Toluene) can be prepared from benzene in a Friedel-Crafts reaction.

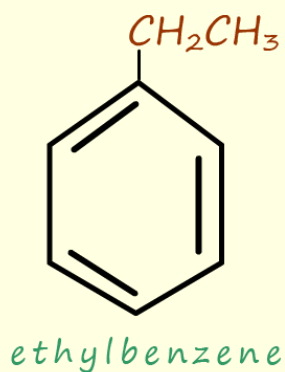
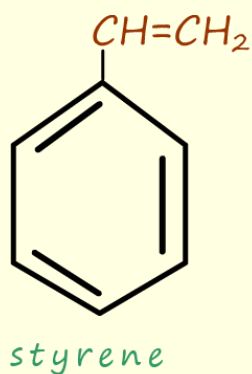


- a. Why is this method not particularly effective in producing toluene?  
The aromatic ring in toluene is more reactive than the aromatic ring in benzene to electrophilic substitution, this means that polyalkylation of methylbenzene is likely which will lead to a mixture of products.
- b. Draw the structure of at least two other likely products of this reaction other than toluene.

Possible structures could be:



7. Draw the structure of phenylethene or styrene and ethylbenzene.

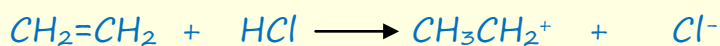


a. What is the main use of styrene?

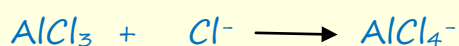
Used as the monomer in production of the addition polymer polystyrene.

b. Ethylbenzene is often prepared industrially by the alkylation of benzene in the presence of HCl and the Lewis acid aluminium chloride.

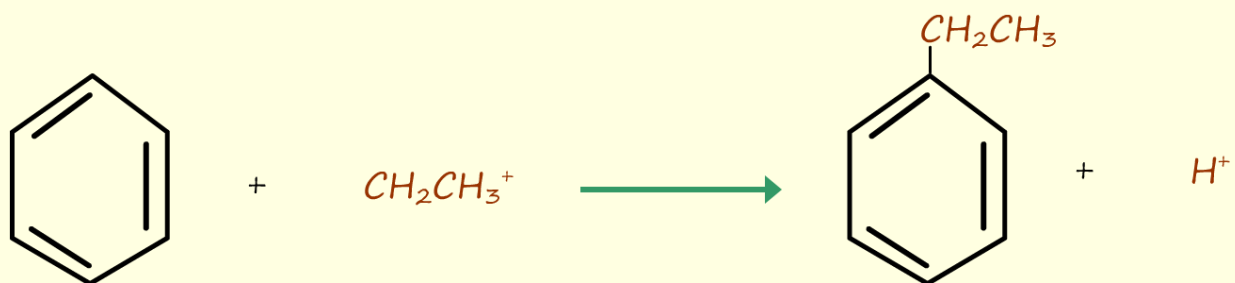
i. Write an equation to show how ethane reacts with hydrogen chloride to form the intermediate carbocation ion  $\text{CH}_3\text{CH}_2^+\text{Cl}^-$ .



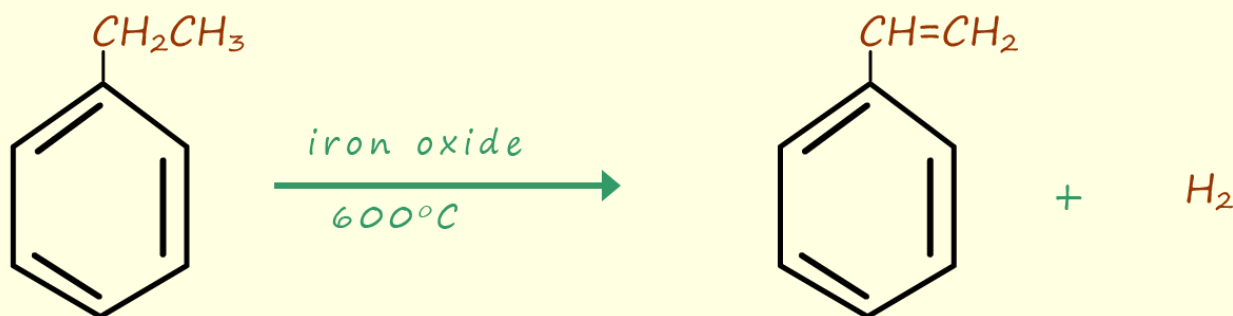
ii. The Lewis acid reacts with the  $\text{Cl}^-$ . Write an equation for this reaction.



iii. Write an equation to show how the intermediate carbocation reacts with benzene to form ethylbenzene.



iv. Write an equation to show how styrene is formed from ethylbenzene.



8. Discuss the major limitations of Friedel-Crafts reactions.
- Polyalkylation is the major drawback with Friedel-Crafts reactions.
  - Reaction does not work on aromatic rings with basic groups attached.
  - Reaction fails on strongly deactivated aromatic rings.
  - Reaction fails with aryl halides and vinylic halides.