

# WJEC (Eduqas) Chemistry A-level

## Organic Analysis 1.2 - Aromaticity

### Flashcards

This work by [PMT Education](https://www.pmt.education) is licensed under [CC BY-NC-ND 4.0](https://creativecommons.org/licenses/by-nc-nd/4.0/)



Give the molecular and skeletal formula  
of benzene



Give the molecular and skeletal formula of benzene

Molecular formula:  $C_6H_6$

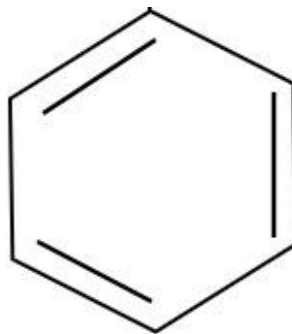
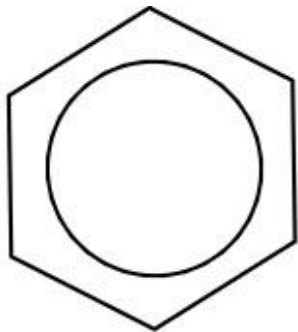
Skeletal formula:



How can the structure of benzene be represented? Which model is more suitable?



How can the structure of benzene be represented?  
Which model is more suitable?



The first model is more suitable because the second model does not demonstrate the delocalised electron system.



# Describe the bonding in benzene



## Describe the bonding in benzene

Benzene has six carbon atoms which each form a single covalent bond to the carbons next to it and to a hydrogen atom. This means each carbon atom has one unpaired electron in the outer p-orbital. These unpaired electrons combine to form a delocalised ring of electrons.



Explain the delocalised electron system of benzene in terms of the types of bonds involved





Explain the delocalised electron system of benzene in terms of the types of bonds involved

The p orbital on each carbon atom in benzene overlaps with the p orbitals either side of them. This series of overlaps produces a pi bond system. These electrons are spread out over the whole carbon ring and therefore are described as being delocalised.



What is the shape and bond angle of benzene?



What is the shape and bond angle of benzene?

Benzene is a planar, regular hexagon and the shape around each carbon atom is trigonal planar. The bond angle is  $120^\circ$ .



What is the general name for compounds containing a benzene ring?

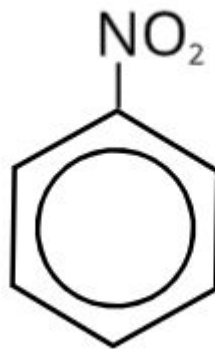


What is the general name for compounds containing a benzene ring?

Arenes or aromatic compounds.



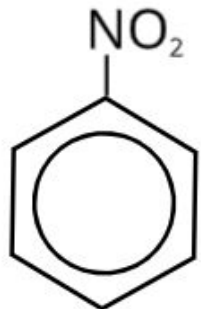
# Name the following arenes



Name the following arenes



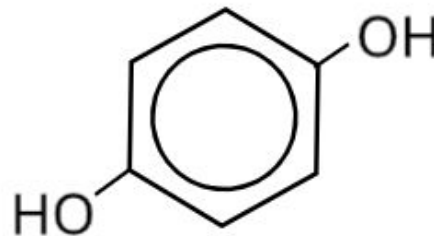
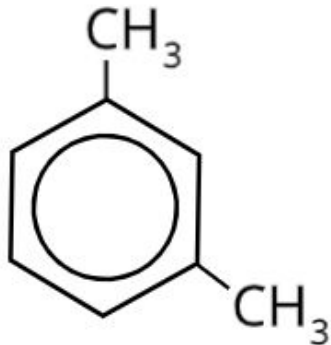
Chlorobenzene



Nitrobenzene

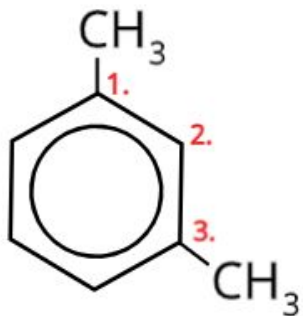


# Name the following arenes

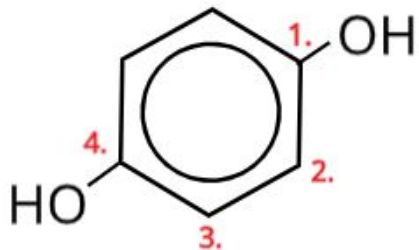




Name the following arenes



1,3-dimethylbenzene



Benzene-1,4-diol



Why does benzene not undergo electrophilic addition reactions?



## Why does benzene not undergo electrophilic addition reactions?

Benzene's delocalised ring of electrons is a region of high electron density which attracts electrophiles. However, the ring of electrons is very stable so benzene does not undergo electrophilic addition as this would break up the delocalised ring of electrons.



What are the two common electrophilic substitution mechanisms for benzene?



What are the two common electrophilic substitution mechanisms for benzene?

Friedel-Crafts acylation

Nitration reaction



How is the acyl chloride electrophile  
made stronger for Friedel-Crafts  
acylation?



## How is the acyl chloride electrophile made stronger for Friedel-Crafts acylation?

An acyl chloride is reacted with  $\text{AlCl}_3$ . The  $\text{AlCl}_3$  accepts a lone pair of electrons from the acyl chloride. This increases the polarisation in the acyl chloride and it forms a carbocation. This is a much stronger electrophile so it is able to react with the benzene ring.

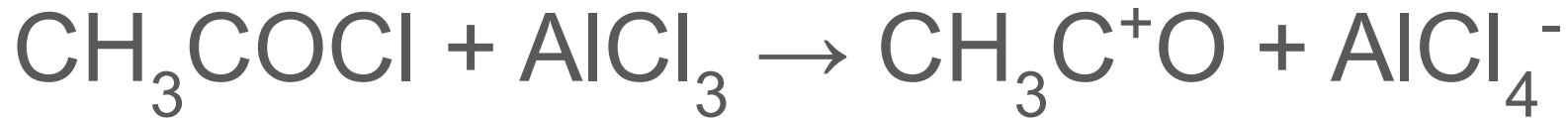


Give the equation for the reaction  
between aluminium chloride and  
ethanoyl chloride





Give the equation for the reaction between aluminium chloride and ethanoyl chloride



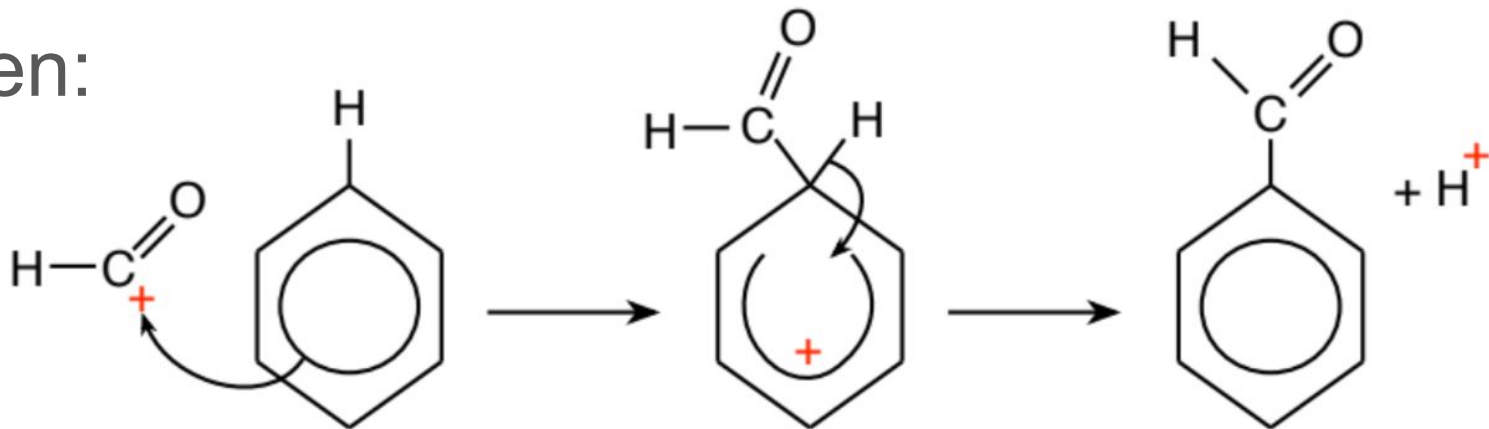
Draw the electrophilic substitution mechanism for the reaction between benzene and methanoyl chloride



Draw the electrophilic substitution mechanism for the reaction between benzene and methanoyl chloride



Then:



Explain how  $\text{AlCl}_3$  behaves as a catalyst in the Friedel-Crafts acylation of benzene



## Explain how $\text{AlCl}_3$ behaves as a catalyst in the Friedel-Crafts acylation of benzene

$\text{AlCl}_3$  initially reacts with an acyl chloride to produce a reactive carbocation intermediate and  $\text{AlCl}_4^-$ . At the end of the mechanism a hydrogen ion is released from the benzene ring. This reacts with the  $\text{AlCl}_4^-$  to produce  $\text{HCl}$  and  $\text{AlCl}_3$ . Therefore  $\text{AlCl}_3$  does not get used up during the reaction and so acts as a catalyst.



What conditions are required for Friedel-Crafts acylation reactions?



What conditions are required for Friedel-Crafts acylation reactions?

The reactants should be heated under reflux in a non-aqueous solvent.



# Why are electrophiles attracted to benzene?





## Why are electrophiles attracted to benzene?

Electrophiles are electron pair acceptors so are attracted to areas of high electron density. Benzene has a ring of delocalised electrons. This is an area of high electron density so it attracts electrophiles.



Give the reactants and catalyst required  
for the nitration of benzene



Give the reactants and catalyst required for the nitration of benzene

Reactants: Benzene

Concentrated nitric acid

Catalyst: Concentrated sulfuric acid



How is the electrophile,  $\text{NO}_2^+$ , produced for the nitration of benzene?



How is the electrophile,  $\text{NO}_2^+$ , produced for the nitration of benzene?

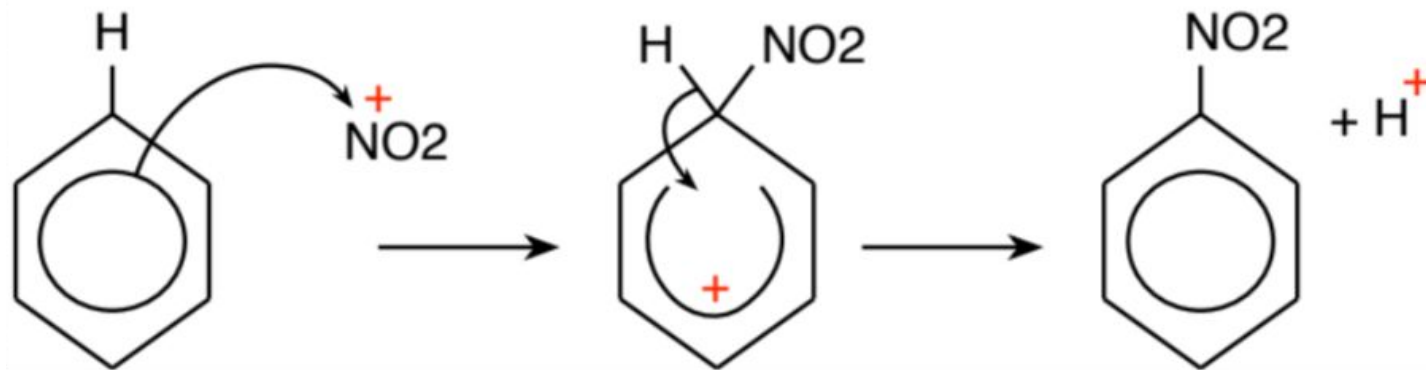
Concentrated nitric and sulfuric acid react to form the  $\text{NO}_2^+$  intermediate:



Draw the electrophilic substitution mechanism for the nitration of benzene



# Draw the electrophilic substitution mechanism for the nitration of benzene



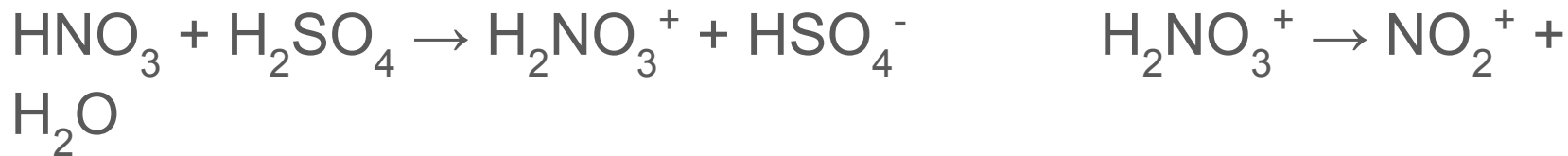
How does sulfuric acid act as a catalyst  
in the nitration of benzene?





## How does sulfuric acid act as a catalyst in the nitration of benzene?

Initially sulfuric acid reacts to produce the  $\text{NO}_2^+$  electrophile:



At the end of the mechanism a hydrogen ion is released from benzene. This reacts with the  $\text{HSO}_4^-$  ion to reproduce  $\text{H}_2\text{SO}_4$ . Therefore  $\text{H}_2\text{SO}_4$  does not get used up and so acts as a catalyst.

What condition ensures mononitration will occur in the nitration of benzene?



What condition ensures mononitration will occur in the nitration of benzene?

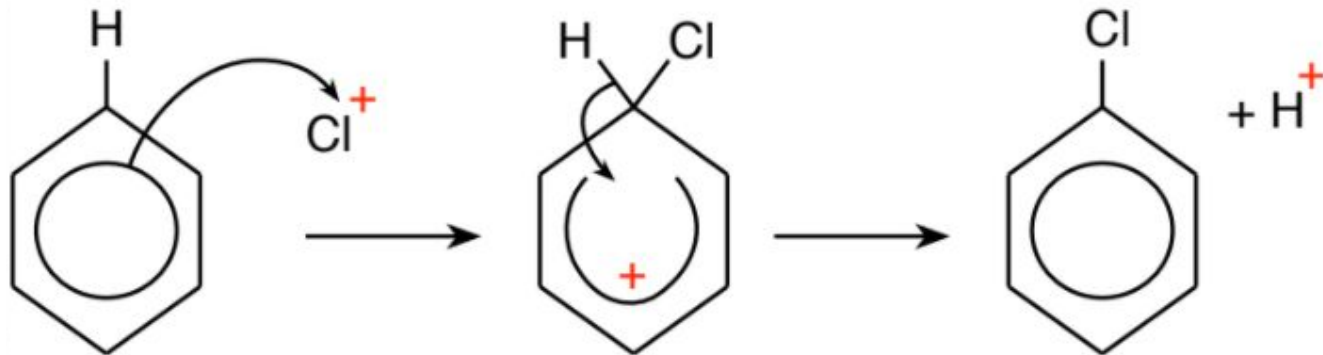
Mononitration is when only one  $\text{NO}_2$  group is added to benzene. This occurs if the temperature is kept below  $55^\circ\text{C}$ .



Draw the electrophilic substitution mechanism for the reaction between benzene and chlorine



Draw the electrophilic substitution mechanism for the reaction between benzene and chlorine



Why is the C-Cl bond stronger in benzene than in a chloroalkane?



Why is the C-Cl bond stronger in benzene than in a chloroalkane?

The lone pair of electrons on the chlorine atom is delocalised over the benzene ring which strengthens the carbon-chlorine bond.



Why is chlorobenzene unreactive towards nucleophiles?





Why is chlorobenzene unreactive towards nucleophiles?

The C-Cl bond in benzene is stronger than in halogenoalkanes. This makes it harder to break and so is not easily attacked by nucleophiles.

