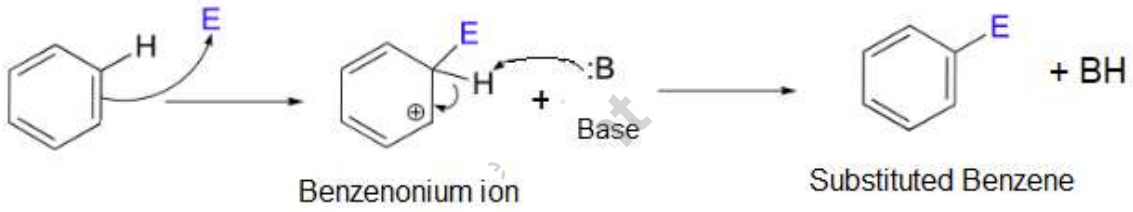
CHEMISTRY CHAPTER 9(XII)
(Aromatic Hydrocarbons)
Short Questions:

1. Write general mechanism of electrophilic substitution reactions in benzene.
OR
Give general pattern of reactivity of benzene towards electrophiles.

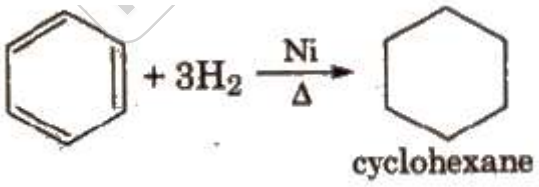
Mechanism of electrophilic substitution reaction:
The general pattern of the chemical reactivity of benzene towards electrophiles can be shown as follows.

i. Pi electrons of benzene ring are donated to the strong electrophile (E^+) and benzenonium ions are formed. Benzenonium ions are unstable.
ii. A proton is released with the help of strong base from benzenonium ion and stability of benzene is retained.

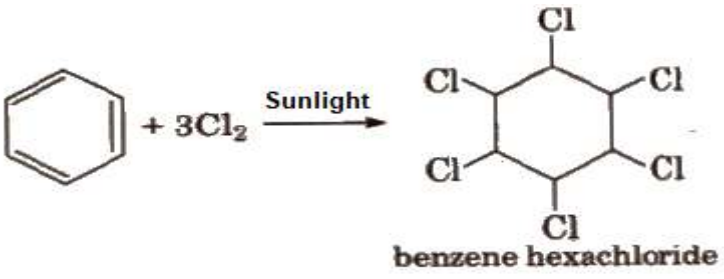


2. Benzene has three pi bonds. Prove it by two points.

i. Benzene adds three hydrogen molecules in the presence of a catalyst. It indicates that it has three pi bonds in it.

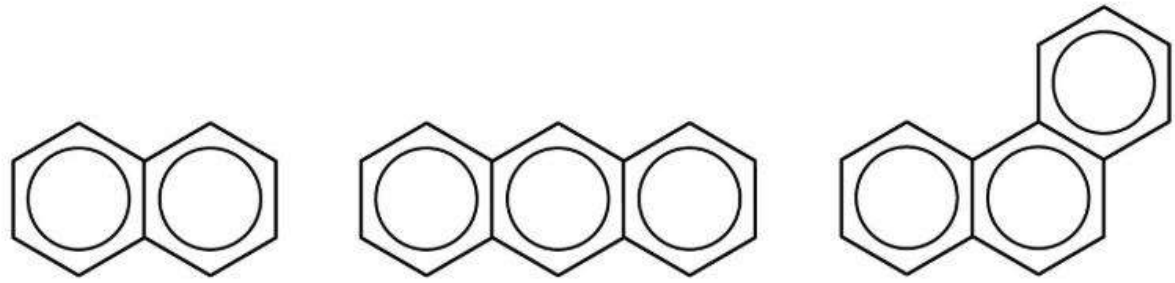


ii. Benzene adds three molecules of chlorine in the presence of sunlight, showing the presence of three pi bonds.



3. What are fused ring aromatic compounds? Give examples.

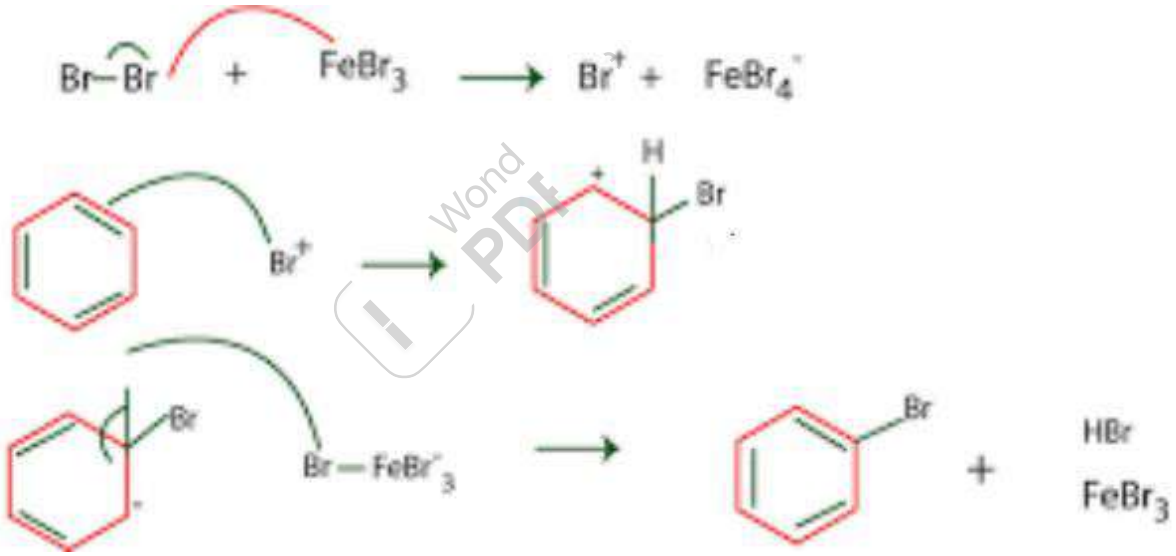
Fused ring aromatic compounds
The compounds in which the benzene rings are fused together so that the adjacent rings have a common carbon to carbon bonds are called fused ring aromatic compounds. For e.



Naphthalene Anthracene Phenanthrene

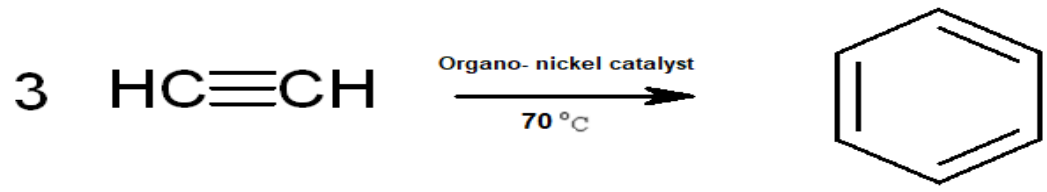
4. Predict major product of the bromination of benzene. Also give equation.

Bromination of benzene ring:
If hydrogen atom of benzene ring is substituted by bromine atom, it is called Bromination.

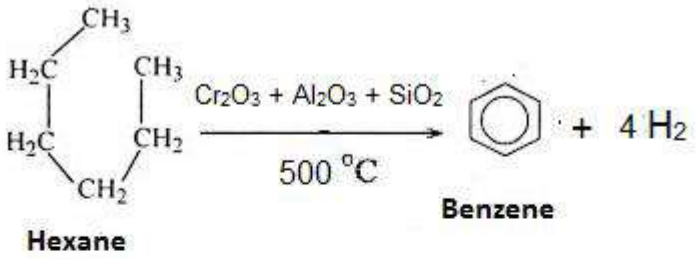


5. Benzene can be prepared commercially from acetylene. Give reaction with Conditions.

Benzene is formed by passing acetylene under pressure over an organo-nickel catalystat 70°C.

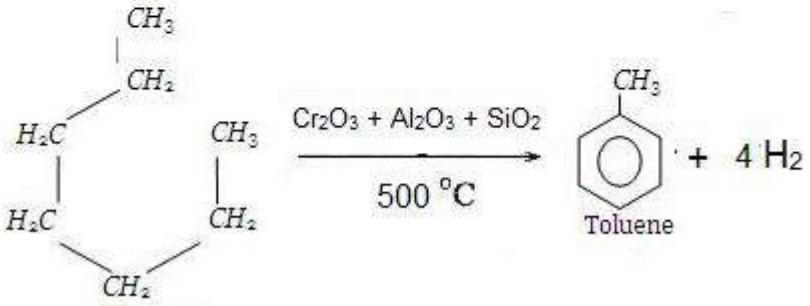


6. How Hexane and Heptane can give Benzene and Toluene respectively?



Hexane

Benzene

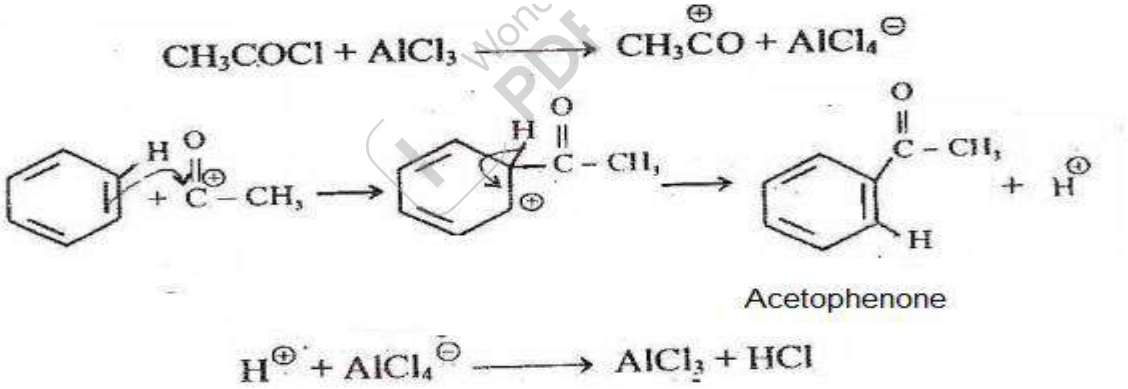


n-Heptane

Toluene

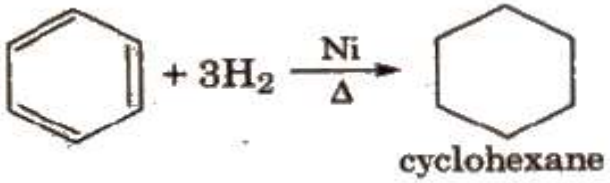
7. How Benzene can be converted to Acetophenone? Give mechanism.

Benzene can be converted to Acetophenone by Friedel Craft Acylation. The mechanism of reaction is given below.

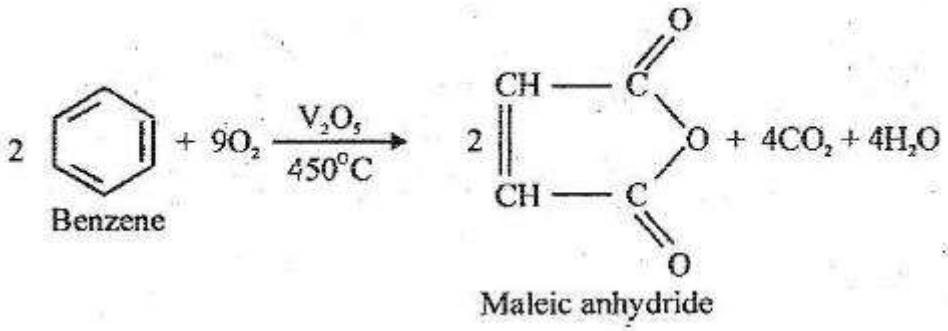


Acetophenone

8. Convert benzene into:
i. Cyclohexane ii. Maleic anhydride



cyclohexane



9. Give two reasons that rule out straight chain structures of benzene.

i. Considering a straight chain structure for benzene and further assuming that each carbon carries one H-atom, it should be capable of forming three mono substitution products. But benzene only gives one mono substituted product. Which shows it does not have straight chain structure.

ii. The molecular formula of benzene is C_6H_6. This formula does not correspond to any aliphatic hydrocarbon like Alkane C_nH_{2n+2}, Alkene C_nH_{2n} or Alkyne C_nH_{2n-2}.

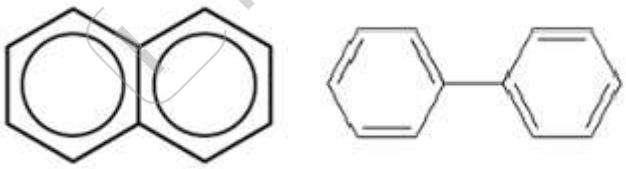
All above points indicate that benzene does not belong to open chain hydrocarbons and has cyclic structure.

10. What are polycyclic aromatic hydrocarbons? Give examples.

Polycyclic aromatic hydrocarbons:

Aromatic compounds containing two or more benzene rings in their molecules are called polycyclic aromatic hydrocarbons.

The benzene rings present in polycyclic aromatic hydrocarbons can be isolated (e.g. Biphenyl) or they may be fused together (e.g. Naphthalene).



11. Briefly describe X-rays studies of benzene.

X-rays studies of benzene:

i. The X-ray studies have confirmed the hexagonal structure for it.

ii. The studies have also revealed that all the carbon and hydrogen atoms are in the same plane. All the angles are of 120°.

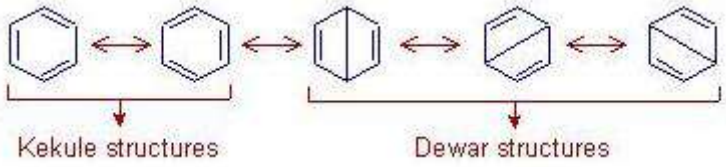
iii. All C-C and C-H bond lengths are 1.397 A° and 1.09 A°, respectively.

12. Define Resonance and write down resonance structures of benzene.

Resonance:

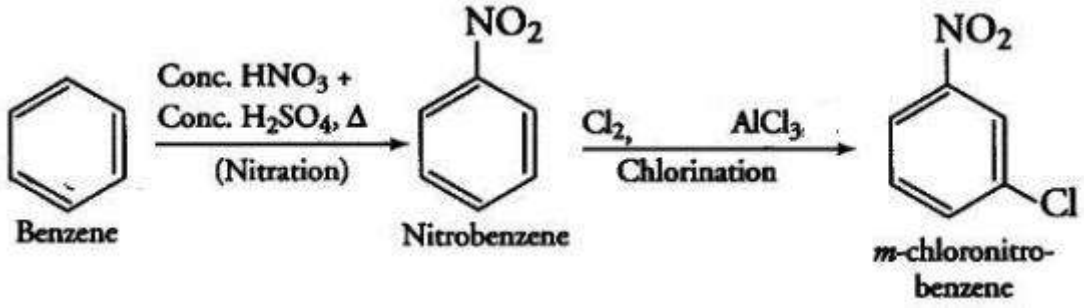
The possibility of different pairing schemes of valence electrons of atoms in a molecule is called resonance, and the different structures thus arranged are called resonance structures.

Resonance structures of benzene:

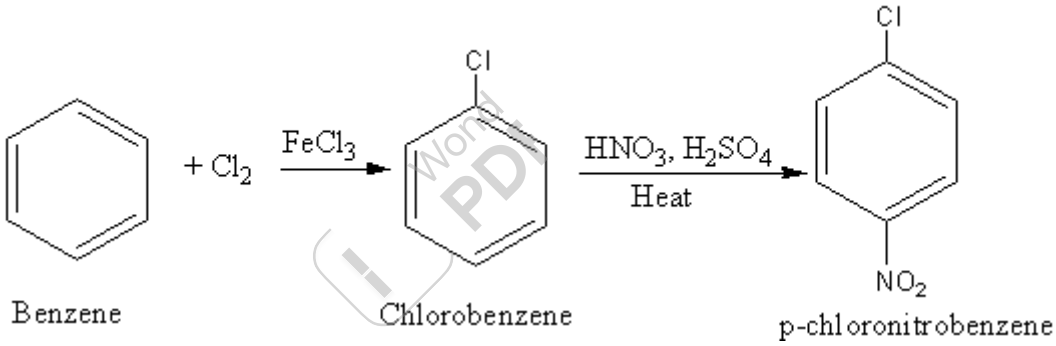


13. How will you prepare following compounds from benzene in two steps?
i. m-Chloronitrobenzene ii. P-Chloronitrobenzene

Conversion of benzene to m-Chloronitrobenzene



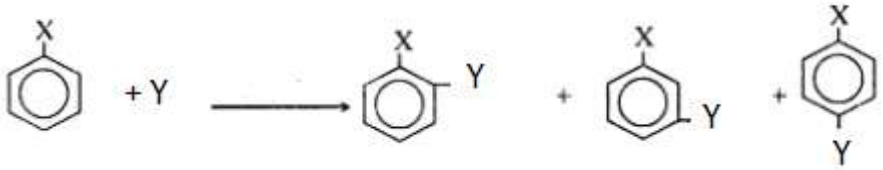
Conversion of benzene to P-Chloronitrobenzene



14. Prove that Benzene has cyclic structure.

i. Benzene gives only one mono substituted product.

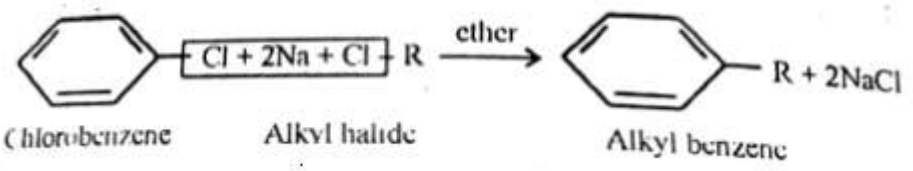
ii. Benzene gives only three di substituted products.



These points confirm the regular hexagonal structure for benzene in which all the carbon atoms are occupying identical positions in the molecule. So, we can say that benzene has a cyclic structure, therefore benzene forms only one toluene, one phenol and one nitrobenzene.

15. What is Wurtz-Fittig reaction? Give an example.

Wurtz-Fittig reaction:
The Wurtz reaction for the synthesis of alkanes was extended by Fittig in 1864 to the synthesis of alkyl aromatic hydrocarbons.
When a mixture of alkyl halide and an aryl halide is treated with sodium metal in dry ether, the sodium preferentially attack the alkyl halide to form alkylated aromatic compound. Thus mixed Wurtz reaction is called Wurtz –Fittig reaction.
Example:



16. What are aromatic hydrocarbons? Give two examples.

Aromatic hydrocarbons:
The aromatic hydrocarbons are closed-chain hydrocarbons containing a benzene ring or its derivatives.
Examples:

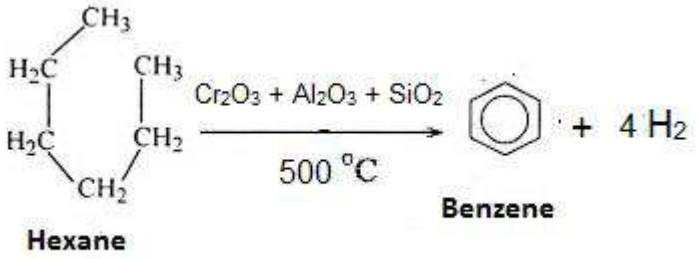
17. Define resonance energy. Give resonance energy of benzene.

Resonance energy:
The difference in energy between hypothetical structure (1,3,5-cyclohexatriene) and actual structure (benzene) is called resonance energy.
Resonance energy of benzene:
The resonance energy of benzene is 150.5 kJ/mol, which shows that it is more stable than 1,3,5-cyclohexatriene by 150.5kJ/mol.

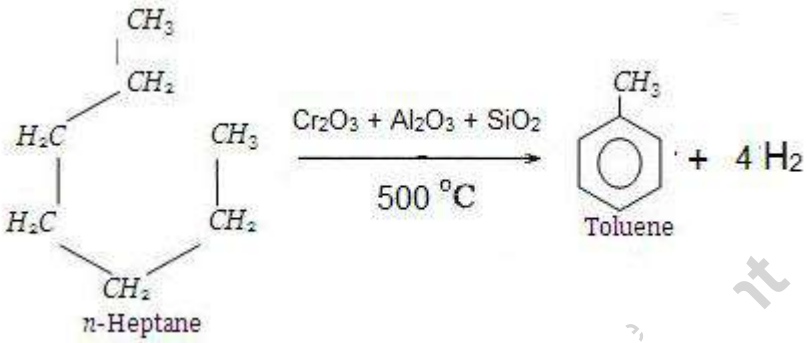
18. What is aromatization?

Aromatization:

Aromatization is the conversion of a nonaromatic hydrocarbon to an aromatic hydrocarbon. Benzene and toluene can be formed by aromatization of n-hexane and n-heptane as follows.



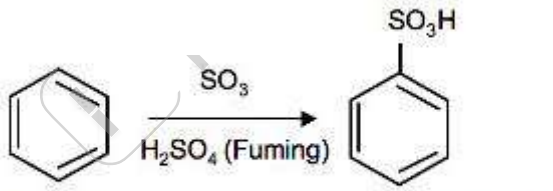
Hexane Benzene



n-Heptane

19. Give reaction of benzene with SO_3.

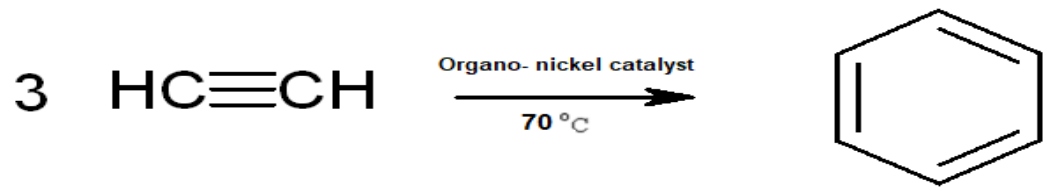
Benzene reacts with sulphur trioxide in the presence of concentrated sulphuric acid to produce Benzene sulfonic acid.



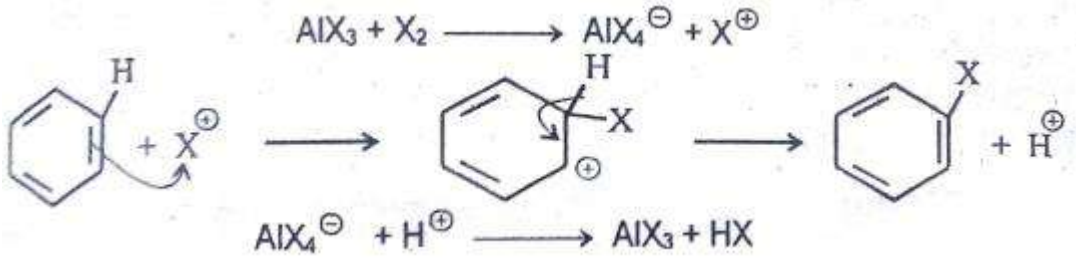
Benzene Benzenesulfonic acid

20. How will you synthesize benzene from Ethyne?

Benzene is formed by passing ethyne under pressure over an organo-nickel catalystat 70°C.

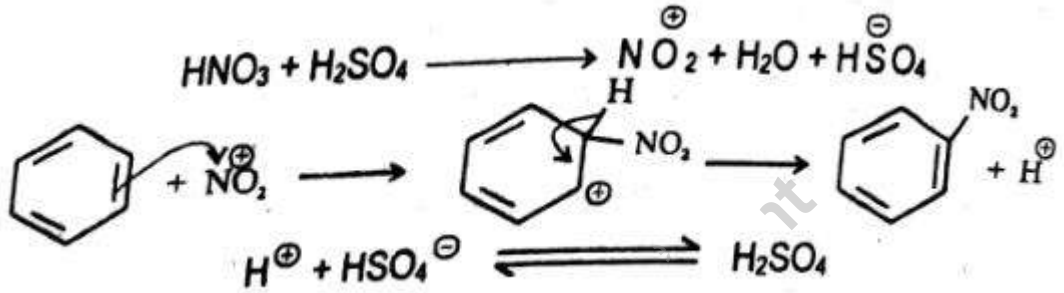


21. Write down mechanism for Halogenation of benzene.

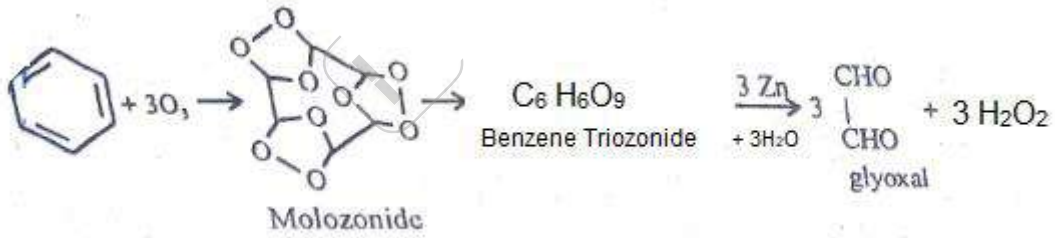


22. Give mechanism for nitration of benzene. **OR** What is meant by nitration of benzene?

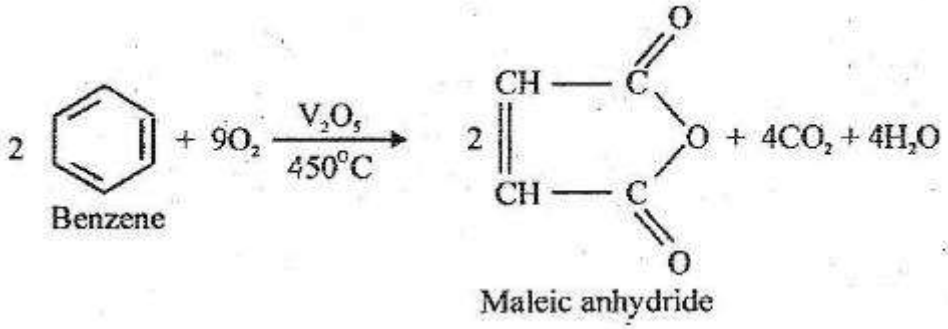
Nitration of benzene:
Introduction of nitro group in the benzene ring is called nitration of benzene. It takes place when benzene is heated with conc. HNO_3 and conc. H_2SO_4 at 50°C.
Mechanism:

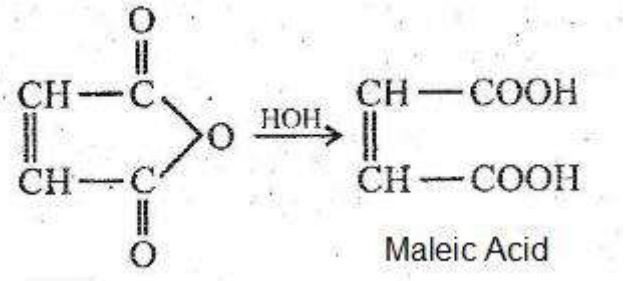


23. Give reaction of benzene with ozone.



24. How benzene is converted into Maleic acid by catalytic oxidation?





25. What happens when benzene is burnt in free supply air? Give equation.

When benzene is burnt in free supply of air, it is completely oxidized to CO_2 and H_20.

$$2C_6H_6 + 15O_2 \text{ --------> } 12CO_2 + 6H_2O$$

LONG QUESTIONS:

1. Write three methods of preparation of benzene.
2. What is meant by orientation in Benzene? Why certain substituents are ortho-para directive and others meta directive? Give one example of each.
3. Describe the structure of Benzene on the basis of resonance method.
4. Write a note on Friedal-crafts reactions.
5. What happens when toluene is reacted with **i.** Cl_2 in sunlight **ii.** $KMnO_4$ in presence of H_2SO_4.
6. Convert benzene into:
i. Cyclohexane **ii.** Maleic acid **iii**. Glyoxal **iv**. Benzene sulphonic acid
7. Give reaction of benzene with respect to i. Nitration ii. Sulphonation
8. Write down four chemical methods for the preparation of benzene.
9. Write down the classification of aromatic hydrocarbons giving one example in each.
10. Write down two reactions in which benzene behaves as saturated hydrocarbon and two reactions in which as unsaturated hydrocarbon.ive equation.