

ANSWERS TO THE SHORT QUESTIONS

GENERAL FEATURES OF AROMATIC COMPOUNDS

Q.1 What do you mean by term "aromatic"?

Ans. Benzene and many derivatives of benzene had "aroma" type smell. The word "aroma" means "fragrant". So all these compounds were called aromatic by Kekule. This thing enabled the scientists to distinguish between derivatives of benzene from aliphatic compounds.

Q.2 What are nonbenzoid aromatic compounds?

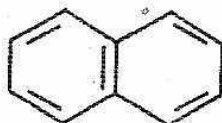
Ans. Those aromatic compounds, whose stabilities are just like benzene or derivatives of benzene but they do not have the benzene ring in them. The best examples are pyridine, pyrrol, furan, thiophene and their derivatives.

Q.3 What are the characteristics of aromatic compounds?

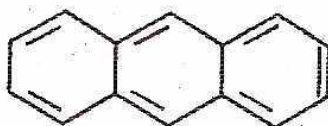
Ans. They are cyclic in nature, planar, unsaturated, give substitution reactions rather than addition and they have low heat of hydrogenations and heat of combustions.

Q.4 Give three examples of condensed aromatic hydrocarbons and give their names? (Lahore 2009, Sargodha 2009, Mirpur 2009, Rwp. 2010, Lahore 2011, Multan 2012, Guj. 2012, Multan 2012)

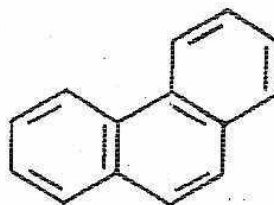
Ans. Following are three examples:



Naphthalene



Anthracene



Phenanthrene

STRUCTURE OF BENZENE

Q.5 Write the reactions which give the evidence for the ring structure of benzene. (Guj. 2012, Lahore 2013)

Ans. When H_2 and Cl_2 react separately with benzene, cyclohexane and benzene hexachloride are produced, which are cyclic compounds. We get only one mono-substituted derivative and three di-substituted derivatives of benzene.

Q.6 What informations do we get from x-ray analysis of benzene?

(Lahore 2008, Rwp. 2010, Guj. 2012, Lahore 2013)

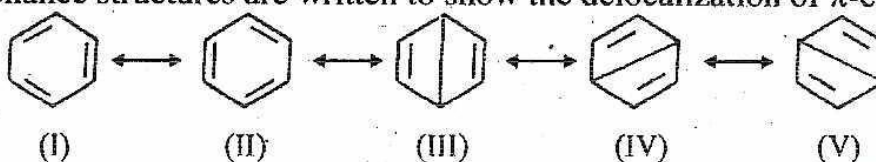
Ans. It shows that benzene is six membered planar molecule. All the bond lengths of C-C and C-H are all equal with the values of 139 pm and 109 pm respectively.

Q.7 There are three alternate double bonds in the benzene ring, but why all the carbon-carbon bonds are of equal length? (Guj. 2012)

Ans. Since, there is conjugated system of double bonds, so resonance starts and six π -electrons are completely delocalized. In this way, the status of all the C-C bonds become equal and they are 139 pm in length.

Q.8 Which orbitals in benzene give stability to benzene, but not to alkenes?
(Mirpur 2009, D.G.K 2009, B.Pur 2009, Sarg. 2010)

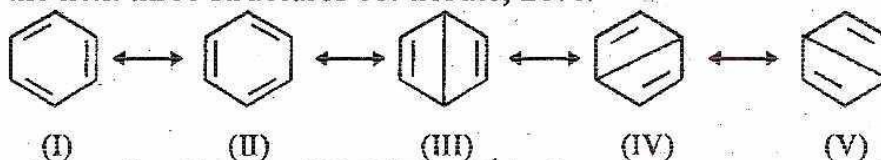
Ans. Six p-orbitals in benzene having one electron each are completely delocalized. This delocalization gives stability to benzene. For this reason, benzene undergoes substitution reactions rather than addition reactions. Five resonance structures are written to show the delocalization of π -electrons.



Q.9 Write down the resonance structures of benzene and indicate their relative contributions towards the actual structure of benzene.

(Lahore 2013, D.G. Khan 2013)

Ans. Benzene has five resonance structures. First two structures contribute 80% and the next three structures contribute, 20%.



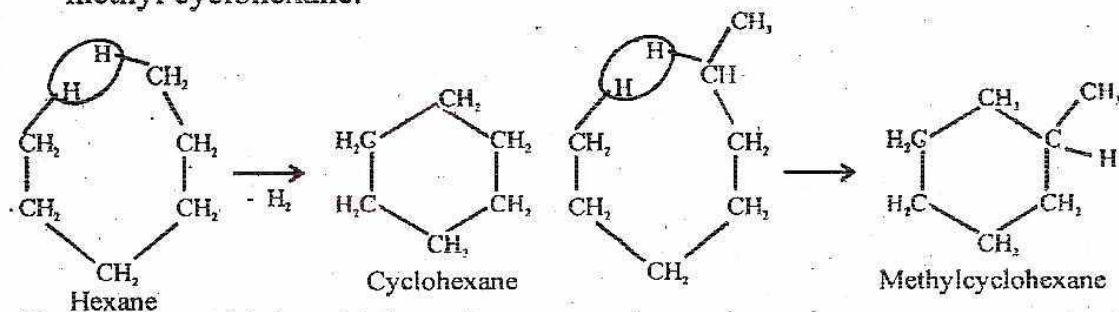
Q.10 How do you justify that $150.5 \text{ kJ mol}^{-1}$ is the resonance energy of benzene?
(Multan 2011)

Ans. If each double bond of benzene ring behaves independently, benzene should have been $358.5 \text{ kJ mol}^{-1}$ more unstable than cyclohexane. Experimentally it is 208 kJ mol^{-1} more unstable. The difference of these two values is $150.5 \text{ kJ mol}^{-1}$, which is the amount of energy evolved due to stability of the benzene.

PREPARATION OF BENZENE

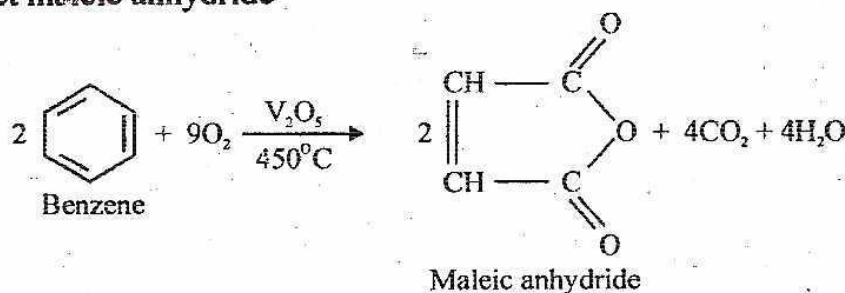
Q.11 How hexane and heptane can give benzene and toluene respectively?
(Lahore 2008, 2010, Lahore 2012, Multan 2013)

Ans. When hexane and heptane are treated with $\text{Cr}_2\text{O}_3 + \text{Al}_2\text{O}_3 + \text{SiO}_2$ at 500°C , the required products are obtained through the formation of cyclohexane and methyl cyclohexane.

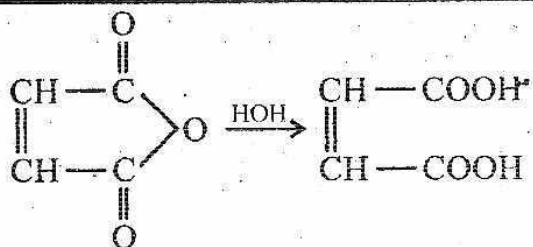


Q.12 Prepare maleic acid from benzene. (Rwp. 2010, F. Abad 2012, Lahore 2012)

Ans. When benzene is oxidized with air in the presence of V_2O_5 at 450°C , then we get maleic anhydride



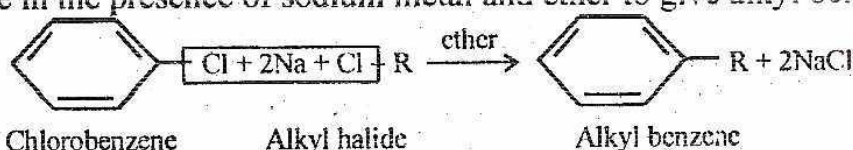
This is commercial method for the preparation of maleic anhydride. Maleic anhydride is hydrolyzed to give maleic acid. Benzene is not oxidized by KMnO_4 or $\text{K}_2\text{Cr}_2\text{O}_7$.



Q.12A What is Wurtz-Fitting reaction?

(Guj. 2013, D.G. Khan 2013)

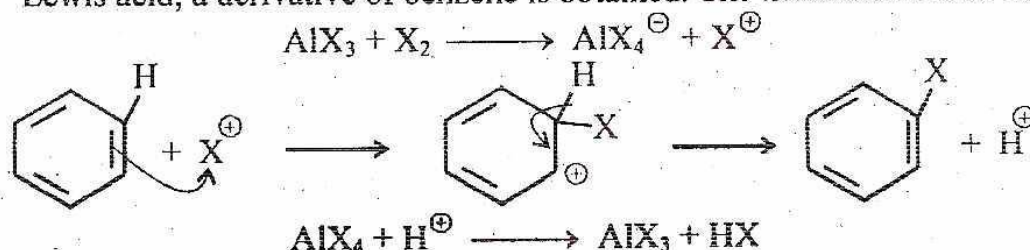
Ans. In this reaction, the haloderivatives of benzene are reacted with an alkyl halide in the presence of sodium metal and ether to give alkyl benzene.



Q.13 What do you mean by electrophilic substitution reactions of benzene? Give general mechanism.

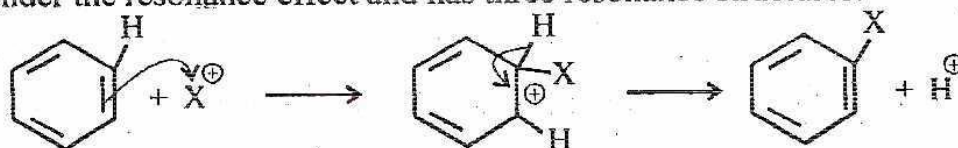
(Sargodha 2008, Lhr. 2010, Faisalabad 2010, Sarg. 2010, Lahore 2012)

Ans. When an electrophile substitutes the electrophile $\text{H}^\oplus$ in the presence of Lewis acid, a derivative of benzene is obtained. The mechanism is as follows:



Q.14 What is sigma complex and how does it get the stability?

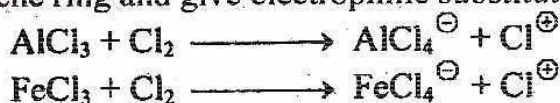
Ans. When an electrophile attacks the benzene ring, positively charged cyclic ring, which is called sigma complex is produced. It is called so because π -bonds of the benzene ring are broken to give sigma bond. It is stabilized under the resonance effect and has three resonance structures.



Q.15 What is the role of FeCl_3 and AlCl_3 in electrophilic substitution reaction of benzene?

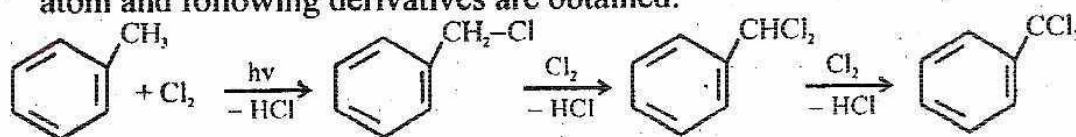
(D.G.K 2009, Guj. 2010)

Ans. FeCl_3 and AlCl_3 are Lewis acids. They generate the electrophiles which can attack the benzene ring and give electrophilic substitution reactions.



Q.16 What are the major products when chlorine reacts with toluene in the presence of sunlight?

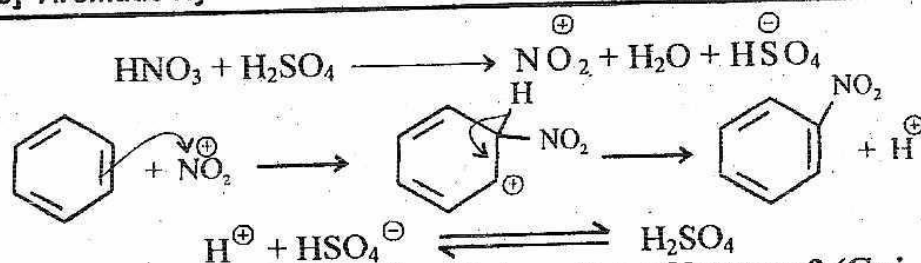
Ans. The hydrogen atoms of CH_3 group in toluene are substituted by chlorine atom and following derivatives are obtained:



Q.17 Give the mechanism of nitration of benzene.

(Multan 2008, Sarg 2009, Guj. 2010)

Ans. $\text{NO}_2^\oplus$ obtained from nitrating mixture, attacks the benzene ring as follows.

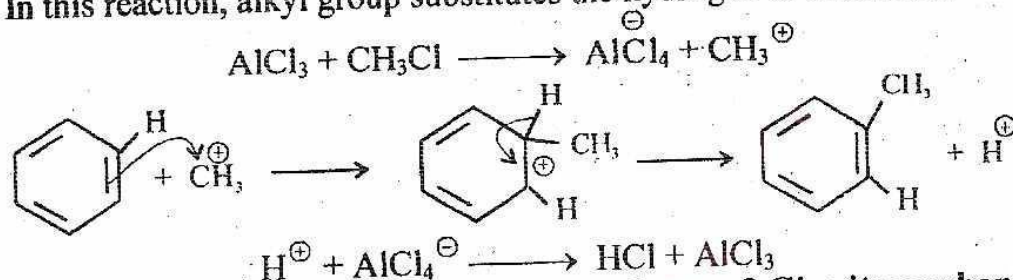


Q.18 Why oleum is required for the sulphonation of benzene? (Guj. 2006)

Ans. Oleum is consisted of $\text{H}_2\text{S}_2\text{O}_7$ in which SO_3 gas is dissolved in H_2SO_4 . SO_3 , after protonation, becomes strong electrophile and attacks the benzene ring to give electrophilic substitution reaction.

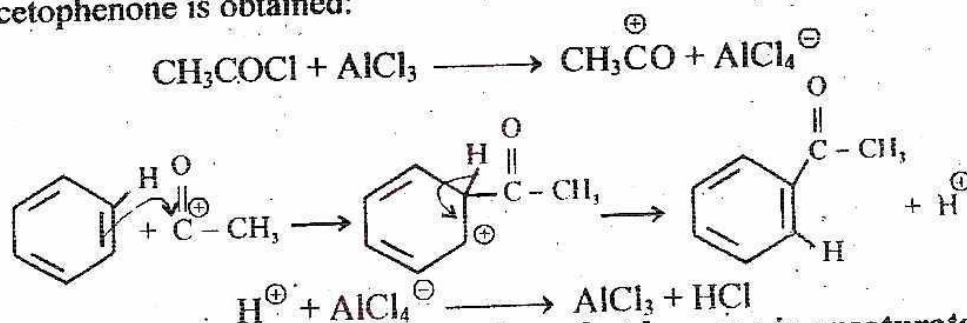
Q.19 Give the general mechanism of Friedal Craft's alkylation: (Lahore Board 2007, Sargodha 2011)

Ans. In this reaction, alkyl group substitutes the hydrogen of benzene as follows:



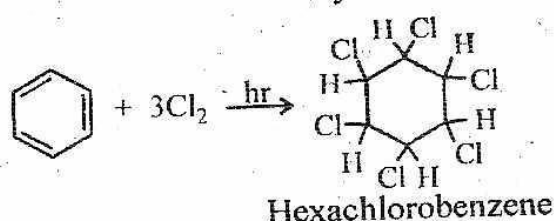
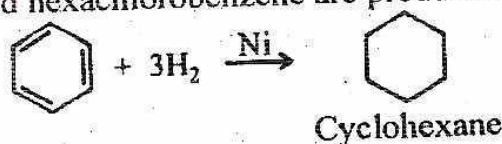
Q.20 How benzene can be converted to acetophenone? Give its mechanism: (Bahawalpur 2011, Lahore 2012, Multan 2012, Multan 2013)

Ans. When CH_3COCl is reacted with benzene in the presence of AlCl_3 , acetophenone is obtained:



Q.21 What are those reactions which show that benzene is unsaturated hydrocarbon?

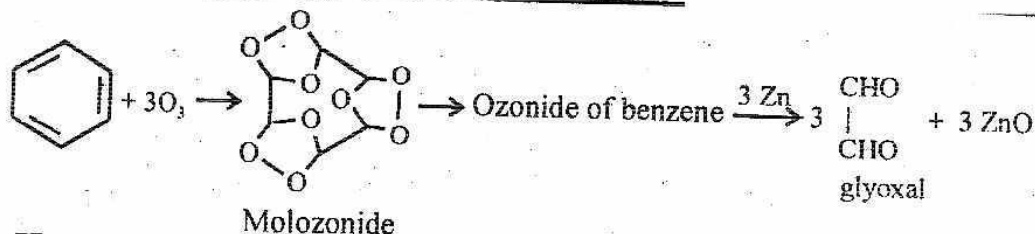
Ans. Benzene adds three H_2 molecules and three Cl_2 molecules at its ring to give cyclic saturated compounds. It means that it has three double bonds. Cyclohexane and hexachlorobenzene are produced.



Q.22 How does ozone affect benzene to give glyoxal?

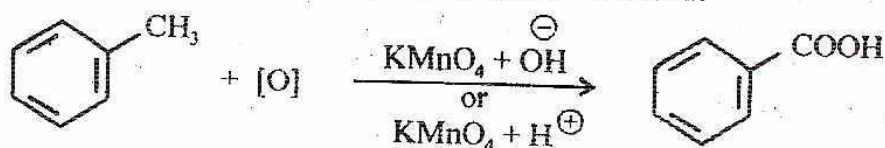
(Sargodha 2008, Multan 2008, Sarg. 2010)

Ans. Benzene adds three molecules of ozone to give triozone which upon reaction with zinc dust, gives three molecules of glyoxal.



Q.23 How toluene can be converted to benzoic acid? (D.G. Khan 2013)

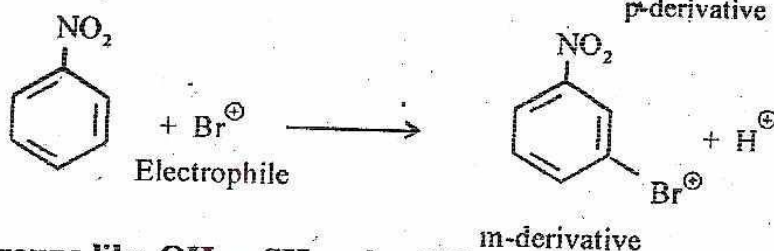
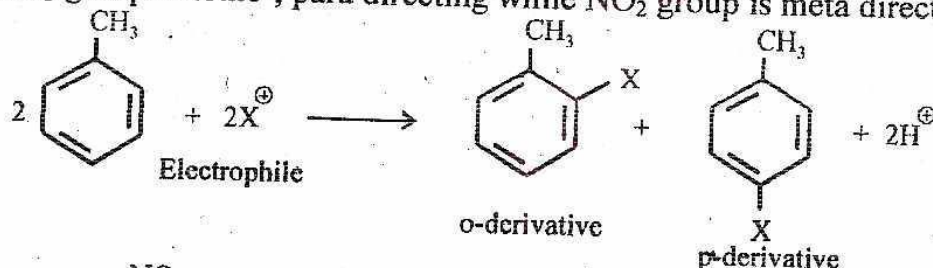
Ans. When toluene or alkyl derivatives of benzene are reacted with alkaline KMnO_4 and acidified KMnO_4 , side chain is oxidized.



ORIENTATION AND REACTIVITY OF BENZENE

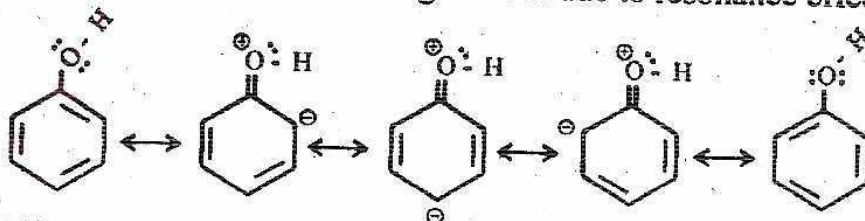
Q.24 Nitration of toluene gives ortho and para nitrotoluene, while the bromination of nitrobenzene gives m-bromonitro benzene. Give reasons?

Ans. $-\text{CH}_3$ group is ortho-, para directing while NO_2 group is meta directing. (Lahore 2011)



Q.25 If the groups like $-\text{OH}$, $-\text{SH}$ and $-\text{NH}_2$ are present on the benzene ring, the ring is activated and ortho, para products are obtained. Give reasons:

Ans. All those groups which have lone pairs in them and these lone pairs are in conjugation with the benzene ring, the groups become ortho, para directing with the activation of benzene ring. This is due to resonance effect:



Q.26 If $-\text{COOH}$ or $-\text{CN}$ groups are present on the benzene ring, they deactivate the ring and meta products are obtained. Give reasons.

Ans. Both these groups are meta-directing with deactivation of the benzene ring. Both these groups have multiple bonds in them which are in conjugation with the benzene ring. The conjugated multiple bonds create electron deficiencies at o- and p-positions, and the ring becomes overall inactive. (F. Abad 2013)