NCERT Solutions for Class-XI Chemistry

Chapter-13
NCERT Chemistry Class 11

1. How do you account for the formation of ethane during chlorination of methane?

1. Chlorination of methane proceeds via a free radical chain mechanism. The whole reaction takes place in the given three steps.

Step 1: Initiation: The reaction begins with the homolytic cleavage of Cl â€“ Cl bond as:

$$Cl-Cl\xrightarrow{h\nu}\dot{C}l+\dot{C}$$

Chlorine free radicals

Step 2: Propagation: In the second step, chlorine free radicals attack methane molecules and break down the Câ€“H bond to generate methyl radicals as:

$$\dot{C}H_3+Cl-Cl\longrightarrow \underset{\text{Methyl chloride}}{CH_3-Cl}+\dot{C}l$$

Hence, methyl free radicals and chlorine free radicals set up a chain reaction. While HCl and CH3Cl are the major products formed, other higher halogenated compounds are also formed as:

$$CH_3Cl+\dot{C}l\longrightarrow \dot{C}H_2Cl+HCl$$

$$\dot{C}H_2Cl+Cl-Cl\longrightarrow CH_2Cl_2+\dot{C}l$$

Step 3: Termination: Formation of ethane is a result of the termination of chain reactions taking place as a result of the consumption of reactants as:

$$\dot{C}l+\dot{C}l\longrightarrow Cl-Cl$$

$$H_3\dot{C}+\dot{C}H_3\longrightarrow \underset{\text{(Ethane)}}{H_3C-CH_3}$$

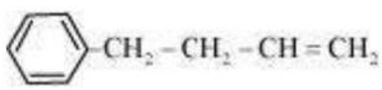
Hence, by this process, ethane is obtained as a by-product of chlorination of methane.

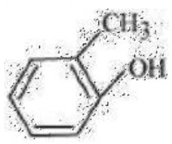
2. Write IUPAC names of the following compounds:

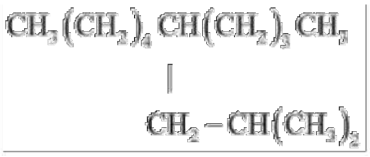
(a) $CH_3CH=C(CH_3)_2$

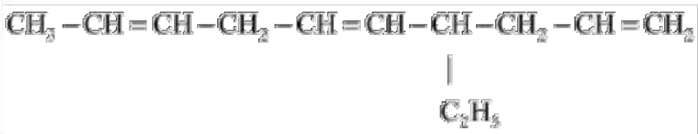
(b) $CH_2=CH-C\equiv C-CH_3$

(c) 

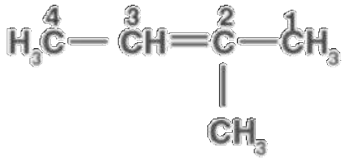
(d) 

(e) 

(f) 

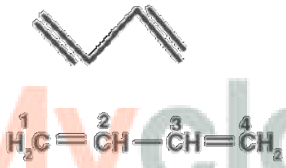
(g) 

2. (a) 2-Methylbut-2-ene is the required IUPAC name

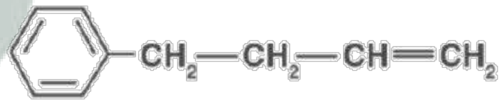


(b) Pen-1-ene-3-yne is the required IUPAC name

(c) 1, 3-Butadiene or Buta-1,3-diene is the required IUPAC name



(d) 4-Phenyl but-1-ene is the required IUPAC name



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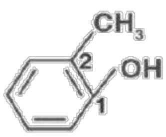
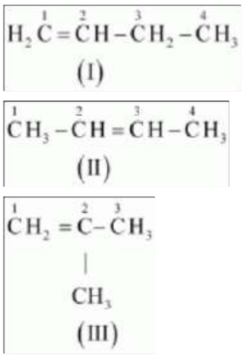


3. For the following compounds, write structural formulas and IUPAC names for all possible isomers having the number of double or triple bond as indicated:

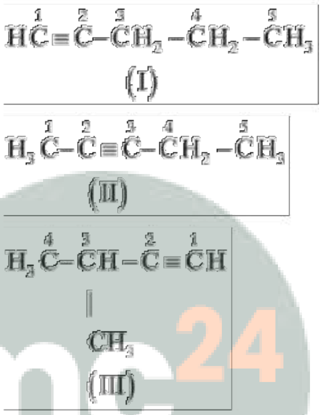
(a) C_4H_8 (one double bond)

(b) C_5H_8 (one triple bond)

3. (a) The following structural isomers are possible for C_4H_8 with one double bond:



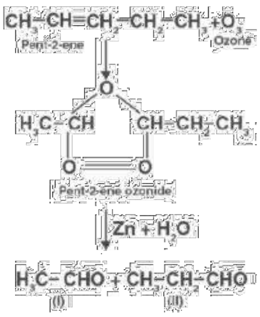
The IUPAC name of
Compound (I) is But-1-ene,
Compound (II) is But-2-ene, and
Compound (III) is 2-Methylprop-1-ene.
(b) The following structural isomers are possible for C5C8 with one triple bond:



The IUPAC name of
Compound (I) is Pent-1-yne,
Compound (II) is Pent-2-yne, and
Compound (III) is 3-Methylbut-1-yne.

4. Write IUPAC names of the products obtained by the ozonolysis of the following compounds:
(i) Pent-2-ene
(ii) 3,4-Dimethyl-hept-3-ene
(iii)2-Ethylbut-1-ene
(iv)1-Phenylbut-1-ene

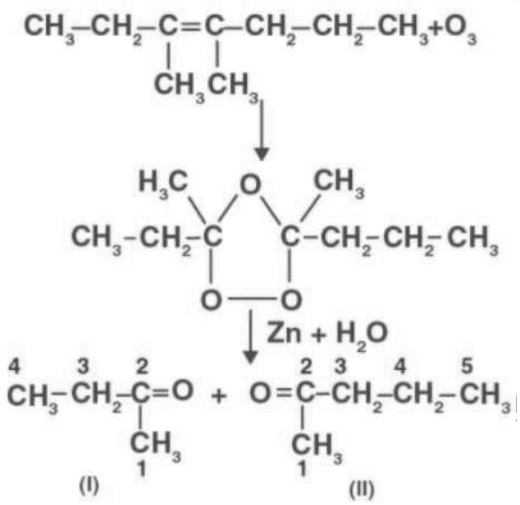
4. (i) Ozonolysis of Pent-2-ene is shown as:



The following Product IUPAC names are:

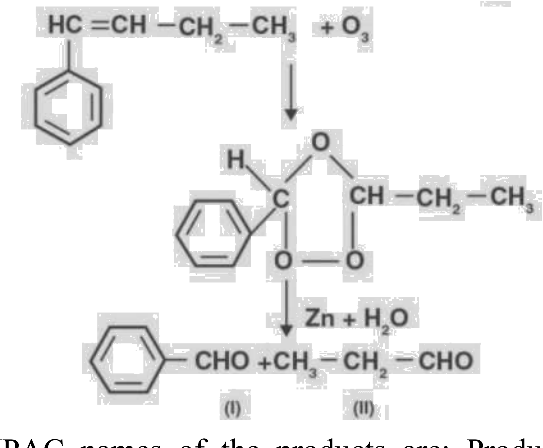
Product (I) ethanal, and Product (II) propanal.

(ii) Ozonolysis of 3, 4-Dimethylhept-3-ene is shown as:



The product names subsequent to IUPAC are: Product (I) butan-2-one, and Product (II) Pentan-2-one (iii) Ozonolysis of 2-Ethylbut-1-ene is shown as:

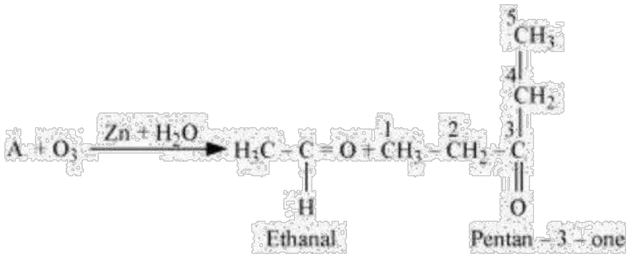
The subsequent IUPAC names of the products are: Product (I) pentan-3-one, and Product (II) methanal (iv) Ozonolysis of 1 – Phenylbut-1-ene is shown as



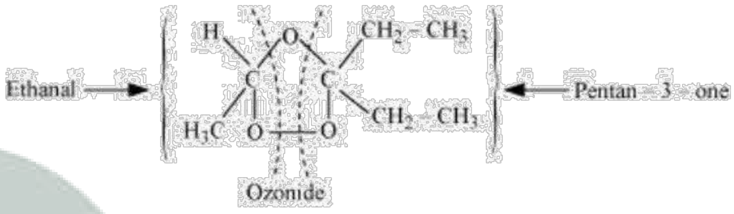
The subsequent IUPAC names of the products are: Product (I) benzaldehyde, and Product (II) propanal

5. An alkene 'A' on ozonolysis gives a mixture of ethanal and pentan-3-one. Write structure and IUPAC name of 'A'.

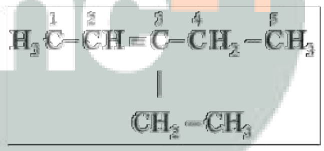
5.



During ozonolysis, an ozonide having a cyclic structure is formed as an intermediate which undergoes cleavage to give the final products. Ethanal and pentan-3-one are obtained from the intermediate ozonide. Hence, the expected structure of the ozonide is:



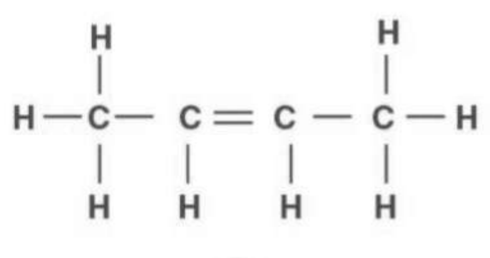
This ozonide is formed as an addition of ozone to 'A'. The desired structure of 'A' can be obtained by the removal of ozone from the ozonide. Hence, the structural formula of 'A' is:



The IUPAC name of 'A' is 3-Ethylpent-2-ene.

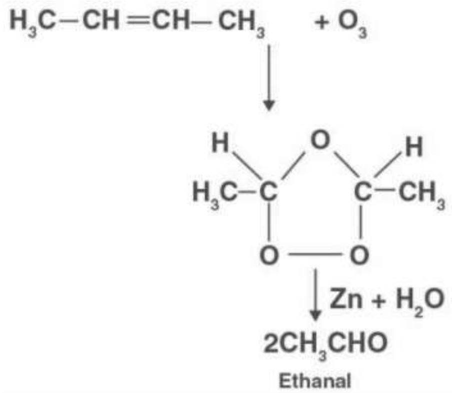
6. An alkene ‘A’ contains three C – C, eight C – H σ bonds and one C – C π bond. ‘A’ on ozonolysis gives two moles of an aldehyde of molar mass 44 u. Write IUPAC name of ‘A’.

6. From the information given it gives two moles of an aldehyde of molar mass 44 u when ‘A’ undergoes ozonolysis. The formation of an aldehyde’s two moles suggests that the presence of similar structural units on both sides of the C-C ÿ bond is present. Consequently, the ‘A’ structure can be represented as shown below: We know, XC = CX Because there are eight C – H σ bonds, 8 hydrogen atoms are present in ‘A. ‘There are also three C – C bonds, so the ‘A’ structure contains four carbon atoms. The combination of all these inferences can represent the structure of ‘A’ as shown below:



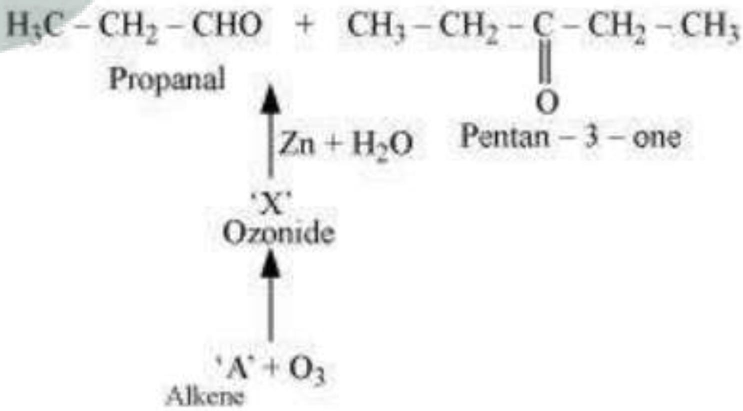
(A)

Since, 'A' has 3 C–C bonds, 8 C–H σ bonds, and one C–C π bond. Therefore, the IUPAC name of 'A' is But-2-ene. After Ozonolysis of 'A' takes place, The end product is ethanol with molecular weight = 44 u

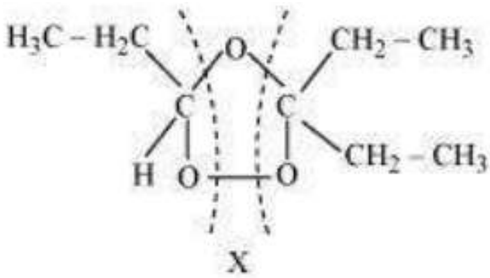


7. Propanal and pentan-3-one are the ozonolysis products of an alkene? What is the structural formula of the alkene?

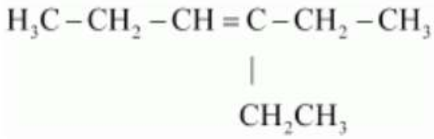
7. As per the given information, propanal and pentan-3-one are the ozonolysis products of an alkene. Let the given alkene be 'A'. Writing the reverse of the ozonolysis reaction, we get:



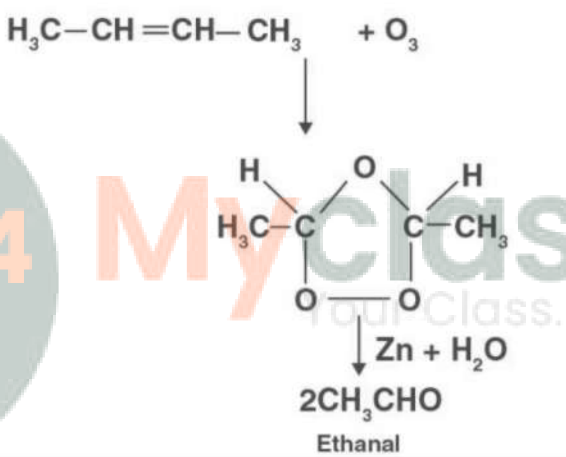
The products are obtained on the cleavage of ozonide 'X'. Hence, 'X' contains both products in the cyclic form. The possible structure of ozonide can be represented as:



Now, 'X' is an addition product of alkene 'A' with ozone. Therefore, the possible structure of alkene 'A' is:



Since, ‘A’ has 3 C–C bonds, 8 C–H σ bonds, and one C–C π bond. Therefore, the IUPAC name of ‘A’ is But-2-ene. After Ozonolysis of ‘A’ takes place, The end product is ethanol with molecular weight = 44 u



8. Write chemical equations for combustion reaction of the following hydrocarbons:

(i) Butane (ii) Pentene

(iii)Hexyne (iv)Toluene

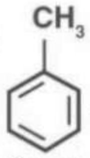
8. Combustion reactions may be defined as an oxygen or oxygen reaction of a compound.

(i) $2C_4H_{10(g)} + 13O_{2(g)} \rightarrow 8CO_{2(g)} + 10H_2O_{(g)}$ + Heat
Butane

(ii) $2C_5H_{10(g)} + 15O_{2(g)} \rightarrow 10CO_{2(g)} + 10H_2O_{(g)}$ + Heat
Pentene

(ii) $2C_6H_{10(g)} + 17O_{2(g)} \rightarrow 12CO_{2(g)} + 10H_2O_{(g)}$ + Heat
Hexyne

(iv)



$+ 9O_{2(g)} \rightarrow 7CO_{2(g)} + 4H_2O_{(g)}$ + Heat

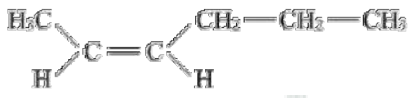
Toluene

9. Draw the cis and trans structures of hex-2-ene. Which isomer will have higher b.p. and why?

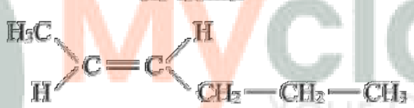
9. Hex-2-ene is represented as:

$CH_3 — CH = CH — CH_2 — CH_2 — CH_3$

Geometrical isomers of hex-2-ene are:



cis-isomer



trans-isomer

The dipole moment of cis-compound is a sum of the dipole moments of Câ€“CH_3 and Câ€“$CH_2CH_2CH_3$ bonds acting in the same direction.

The dipole moment of trans-compound is the resultant of the dipole moments of Câ€“CH_3 and Câ€“$CH_2CH_2CH_3$ bonds acting in opposite directions.

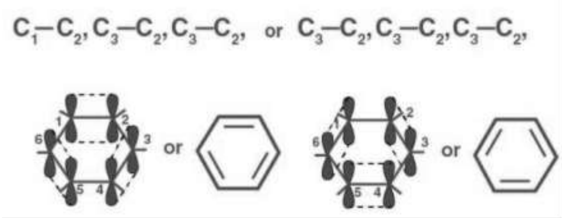
Hence, cis-isomer is more polar than trans-isomer. The higher the polarity, the greater is the intermolecular dipole-dipole interaction and the higher will be the boiling point.

Hence, cis-isomer will have a higher boiling point than trans-isomer.

10. Why is benzene extra ordinarily stable though it contains three doublebonds?

10. Benzene is a hybrid of the resonating structures and it is shown as:

All six carbon atoms in benzene are hybridized to sp_2.In benzene, each carbon atom's two sp_2 hybrid orbital overlaps with its adjacent carbon atoms 'sp_2 hybrid orbital, forming a six-sigma bond in the hexagonal plane. The remaining hybrid orbital sp_2 on each carbon atom overlaps with the hydrogen atom's s-orbital to form six sigma C – H bonds. Now, the rest are unhybridized p-orbital of carbon atoms will have the possibility of forming three C–C π bonds by the lateral overlap of



These six π-bonds are delocalized and can move about the six-carbon nuclei freely. Therefore, due to the delocalization of these π-bonds, benzene is stabilized even after the presence of three C-C π -bonds.

11. What are the necessary conditions for any system to be aromatic?

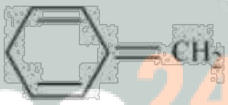
11. A compound is said to be aromatic if it satisfies the following three conditions:

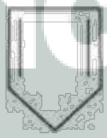
(i) It should have a planar structure.

(ii) The π-electrons of the compound are completely delocalized in the ring.

(iii)The total number of π-electrons present in the ring should be equal to (4n + 2), where n = 0, 1, 2 … etc. This is known as Huckel's rule.

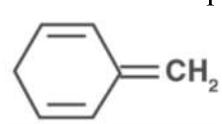
12. Explain why the following systems are not aromatic?

(i) 

(ii) 

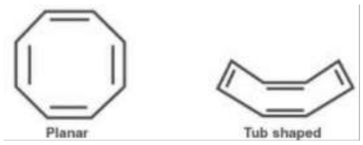
(iii) 

12. (i) Due to the presence of a sp^3-hybridized carbon, the system is not planar. It does contain six n-electrons but the system is not fully conjugated since all the six n-electrons do not form a single cyclic electron cloud that surrounds all the atoms of the ring. Therefore, it is not an aromatic compound.



(ii) Due to the presence of sp^3– hybridized carbon, the system is not planar. Further, it contains only four n-electrons, therefore, the system is not aromatic because it does not contain planar cyclic cloud having (4n + 2) n-electrons.

(iii)Cyclo-octatetraene is not planar but is tub-shaped. It is, therefore, a non-planar system having 8 n-electrons. Therefore, the molecule is not aromatic as it does not contain a planar cyclic cloud having (4n + 2) n-electrons.



13. How will you convert benzene into

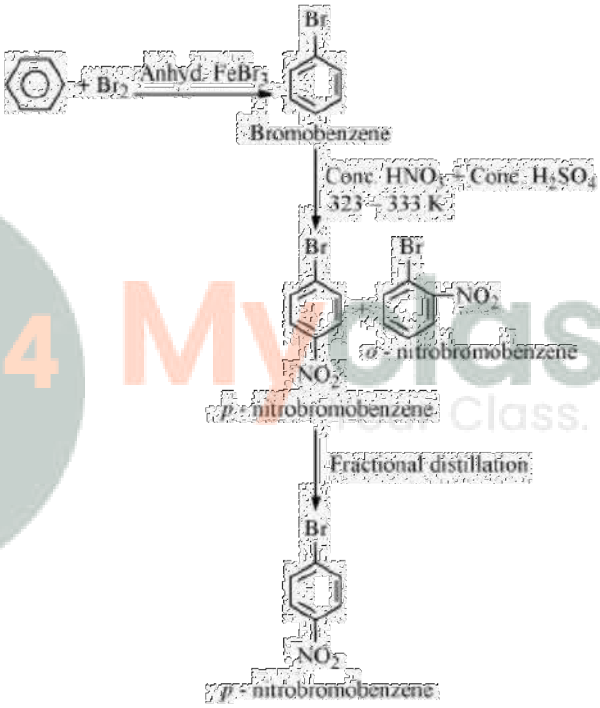
(i) p-nitrobromobenzene

(ii) m-nitrochlorobenzene

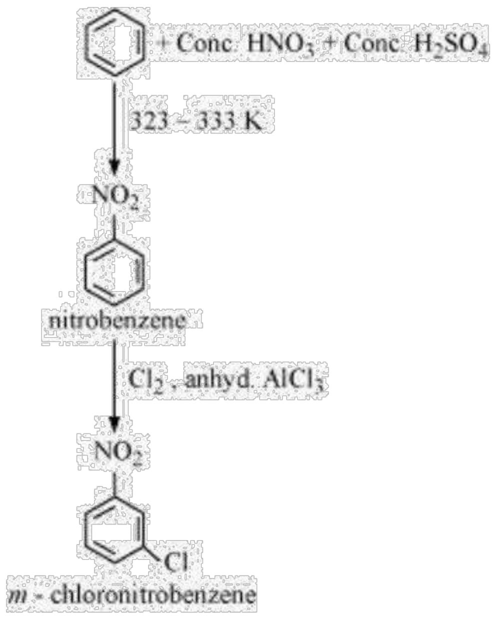
(iii)p -nitrotoluene

(iv)acetophenone

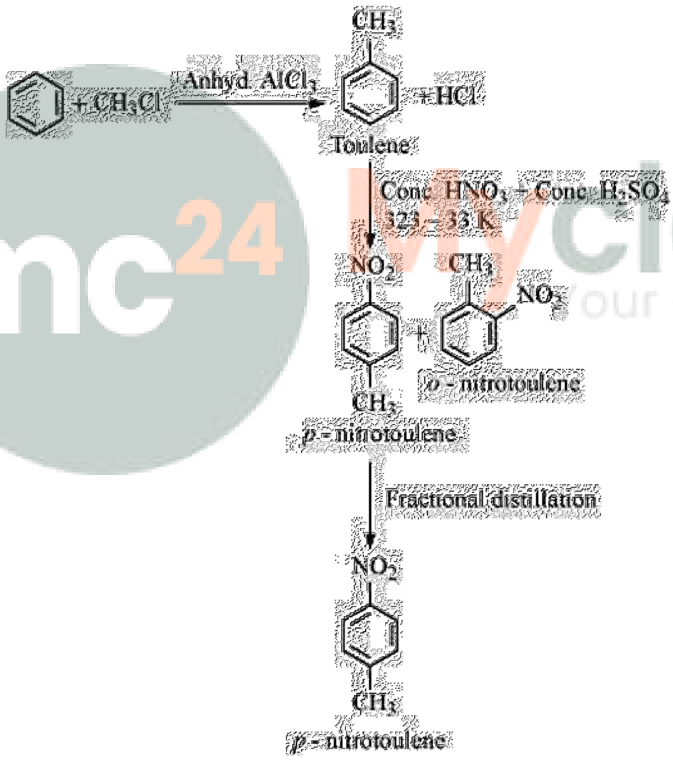
13. (i) Benzene can be converted into p-nitrobromobenzene as:



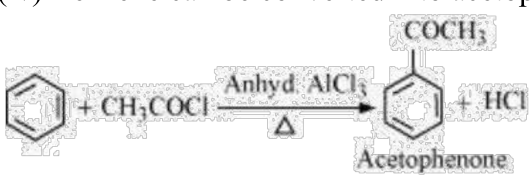
(ii) Benzene can be converted into m-nitrochlorobenzene as:



(iii)Benzene can be converted into p-nitrotoulene as:

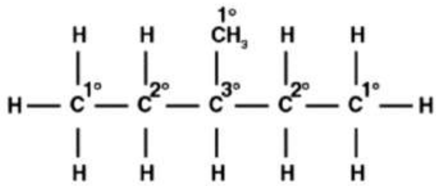


(iv) Benzene can be converted into acetophenone as:



14. In the alkane $H_3C\text{-}CH_2\text{-}C(CH3)_2\text{-}CH_2\text{-}CH(CH_3)_2$, identify 1°,2°,3° carbon atoms and give the number of H atoms bonded to each one of these.

14.



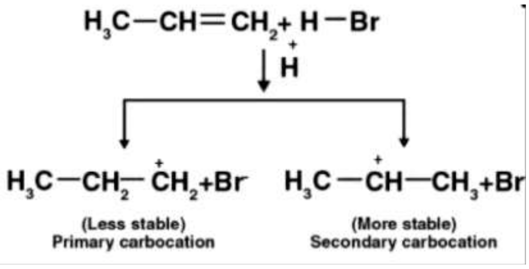
Primary carbon atoms (1o): Carbon atoms bonded to a single atom of carbon are called primary atoms of carbon. The arrangement given has corresponding five 1o carbon atoms and fifteen H atoms. Secondary carbon atoms (2o): The secondary carbon atom is called carbon atom bonded to double carbon atom. The arrangement given has two corresponding 2o carbon atoms, and four H atoms. Tertiary carbon atoms (3o): The term tertiary carbon atom is used to refer to carbon atoms bonded to three carbon atoms. The arrangement given has one corresponding 3 degree carbon atom and single H atom.

15. What effect does branching of an alkane chain has on its boiling point?

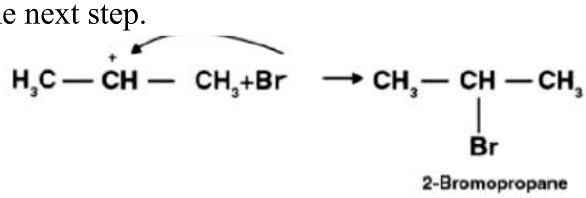
15. Alkanes experience inter-molecular Van der Waals forces. The stronger the force, the greater will be the boiling point of the alkane.
As branching increases, the surface area of the molecule decreases which results in a small area of contact. As a result, the Van der Waals force also decreases which can be overcome at a relatively lower temperature. Hence, the boiling point of an alkane chain decreases with an increase in branching.

16. Addition of HBr to propene yields 2-bromopropane, while in the presence of benzoyl peroxide, the same reaction yields 1-bromopropane. Explain and give mechanism.

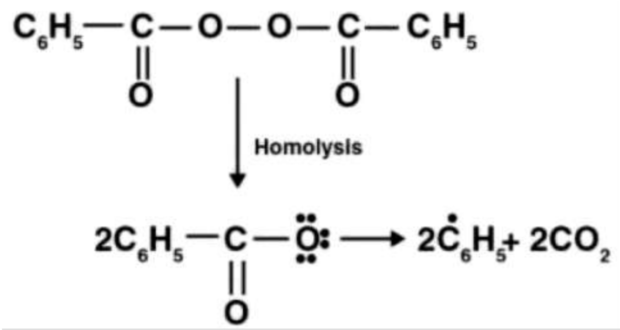
16. The addition of HBr to propene is an example of an electrophilic substitution reaction Being an acid, the hydrogen bromide provides an electrophile, H+. This electrophile attacks the propene double bond to form carbocations of 1 ° and 2 °, as shown below:

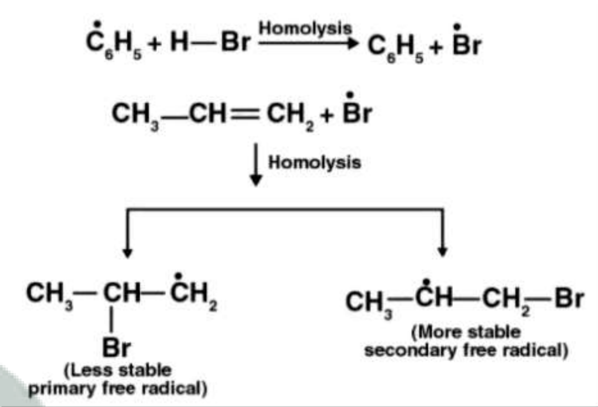


Secondary carbocations are stable in comparison with primary carbocations. The secondary carbocations therefore predominate, as they form at a faster rate than primary carbocations. Thus, Br– attacks the primary carbocation to form 2-bromopropane as the main product in the next step.

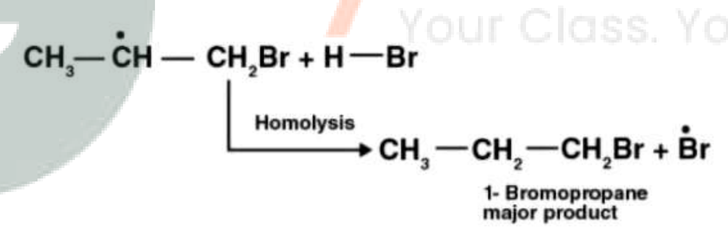


This reaction follows the rule of Markovnikov, in which the negative part of the addendum is attached to the carbon atom with fewer hydrogen atoms than other carbon atoms present in the compound. While, in the presence of benzoyl peroxide, an addition reaction takes place anti to Markovnikov's rule. The reaction follows a free radical chain mechanism as shown below:





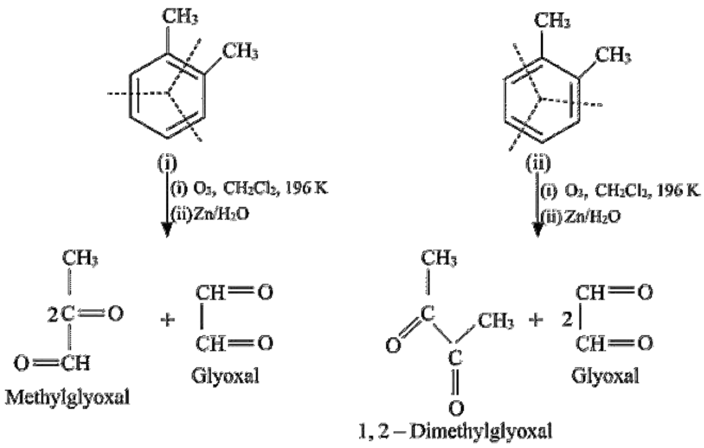
Secondary free radicals are stable in comparison with primary radicals. The secondary radical therefore predominates, for it forms at a faster rate than the primary radical. Therefore 1 – bromopropane is obtained as the main product.



Br acts as an electrophile in the presence of peroxide, as a free radical. Thus, in the presence and absence of peroxide, two different products are obtained on addition of HBr to propene.

17. Write down the products of ozonolysis of 1,2-dimethylbenzene (o-xylene). How does the result support Kekulé structure for benzene?

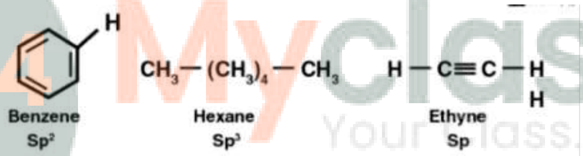
17. o-xylene has two resonance structures:



All three products, i.e., methyl glyoxal, 1, 2-dimethylglyoxal, and glyoxal are obtained from two Kekule structures. Since all three products cannot be obtained from any one of the two structures, this proves that o-xylene is a resonance hybrid of two Kekule structures (I and II).

18. Arrange benzene, n-hexane and ethyne in decreasing order of acidic behaviour. Also give reason for this behaviour.

18. Acidic character of a species is defined on the basis of the ease with which it can lose its H– atoms. The hybridization state of carbon in the given compound is:



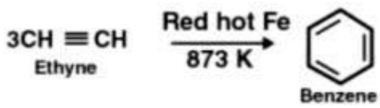
As the s – character decreases, carbon electronegativity decreases and C – H bond pair electrons lie away from the carbon atom. As a result, H– atom partially positive charge increases, and H+ ions are set free.
The s–character decreases in the order: $sp > sp^2 > sp^3$ Hence, the increasing order of acidic behavior is Hexane < Benzene < Ethyne.

19. Why does benzene undergo electrophilic substitution reactions easily and nucleophilic substitutions with difficulty?

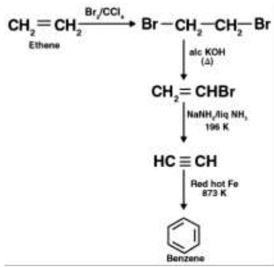
19. Benzene is a planar molecule having delocalized electrons above and below the plane of ring. Hence, it is electron-rich. As a result, it is highly attractive to electron deficient species i.e., electrophiles. Therefore, it undergoes electrophilic substitution reactions very easily. Nucleophiles are electron-rich. Hence, they are repelled by benzene. Hence, benzene undergoes nucleophilic substitutions with difficulty.

20. How would you convert the following compounds into benzene?
(i) Ethyne
(ii) Ethene
(iii) Hexane

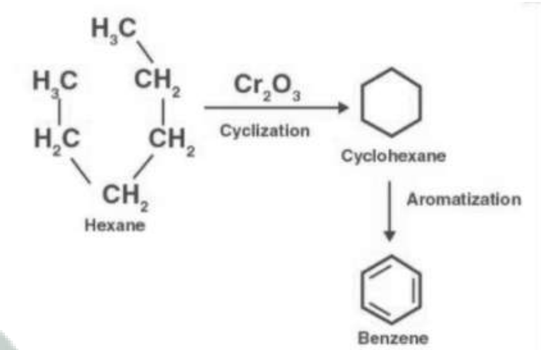
20. (i) Benzene from Ethyne:



(ii) Benzene from Ethene:

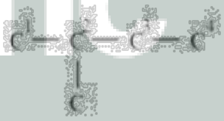


(iii) Hexane to Benzene



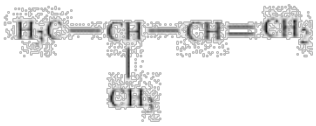
21. Write structures of all the alkenes which on hydrogenation give 2-methylbutane.

21. The basic skeleton of 2-methylbutane is shown below:

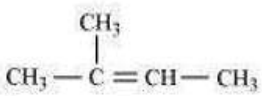


On the basis of this structure, various alkenes that will give 2-methylbutane on hydrogenation are:

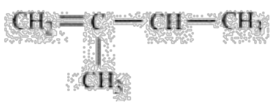
(a)



(b)



(c)



22. Arrange the following set of compounds in order of their decreasing relative reactivity with an electrophile, E^+

(a) Chlorobenzene, 2,4-dinitrochlorobenzene, p-nitrochlorobenzene

(b) Toluene, p-H_3C-C_6H_4-NO_2, p-O_2N-C_6H_4-NO_2.

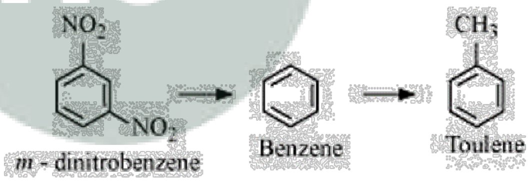
22. Electrophiles are reagents that participate in a reaction by accepting a pair of electrons to bind to nucleophiles. The higher the density of electrons on a benzene ring, the more reactive the compound is to an electrophile, E^+ (Electrophilic reaction).

(a) The electron density of the aromatic ring decreases due to the presence of an electron-withdrawing group (i.e., NO_2 – and Cl –) which deactivates the aromatic ring. Since, Cl – group is less electron-withdrawing (due to the inductive effect) than NO_2 –group (due to resonance effect), the increasing order of reactivity is as follows: 2, 4 – dinitrochlorobenzene < p – nitrochlorobenzene < Chlorobenzene

(b) While NO_2– group is electron-withdrawing, CH_3– is an electron-donating group. Toluene therefore has the maximum density of electrons, and is most easily attacked by E^+. Since NO_2– is an electron-removing group. Therefore, when the number of NO_2 substitutes is higher, the order is the following.: p-O_2N – C_6H_4 – NO_2 < p – H_3C – C6H4 – NO_2 < Toluene.

23. Out of benzene, m-dinitrobenzene and toluene which will undergo nitration most easily and why?

23. The ease of nitration depends on the presence of electron density on the compound to form nitrates. Nitration reactions are examples of electrophilic substitution reactions where an electron-rich species is attacked by a nitronium ion (NO_2-).
Now, CH_3- group is electron donating and NO_2- is electron withdrawing. Therefore, toluene will have the maximum electron density among the three compounds followed by benzene. On the other hand, m- Dinitrobenzene will have the least electron density. Hence, it will undergo nitration with difficulty. Hence, the increasing order of nitration is as follows:

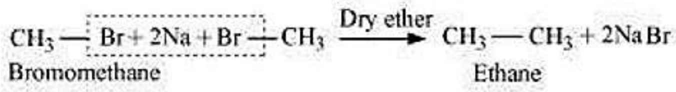


24. Suggest the name of a Lewis acid other than anhydrous aluminium chloride which can be used during ethylation of benzene.

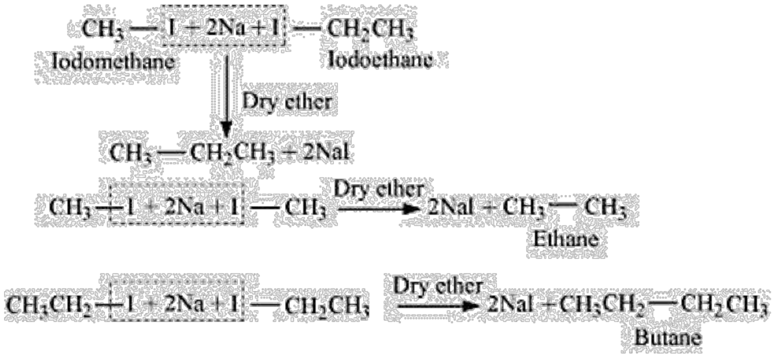
24. The reaction of benzene to the presence of Lewis acids (AlCl3) with an acyl halide or acid anhydride yields acyl benzene (or benzene ring). A Friedel-Craft alkylation reaction is called such a reaction. The reaction occurs in the presence of a Lewis acid. In the Friedel-Craft alkylation reaction, any Lewis acid such as anhydrous $AlCl_3$, $FeCl_3$, $SnCl_4$, BF_3 etc. may be used during the ethylation of benzene.

25. Why is Wurtz reaction not preferred for the preparation of alkanes containing odd number of carbon atoms? Illustrate your answer by taking one example.

25. Wurtz reaction is limited for the synthesis of symmetrical alkanes (alkanes with an even number of carbon atoms) In the reaction, two similar alkyl halides are taken as reactants and an alkane, containing double the number of carbon atoms, are formed. Example:



Wurtz reaction cannot be used for the preparation of unsymmetrical alkanes because if two dissimilar alkyl halides are taken as the reactants, then a mixture of alkanes is obtained as the products. Since the reaction involves free radical species, a side reaction also occurs to produce an alkene. For example, the reaction of bromomethane and iodoethane gives a mixture of alkanes.



The boiling points of alkanes (obtained in the mixture) are very close. Hence, it becomes difficult to separate them.