13 Hydrocarbons

LESSON AT A GLANCE

- **Hydrocarbons:** They are compounds of carbon and hydrogen only.
  Open Chain saturated compound—Alkane
  Unsaturated Compound—Alkenes and Alkynes
  Aromatic Compound—Benzene and its derivatives
  Terminal alkynes are weakly acidic in nature.
- **Conformation:** Spatial arrangements obtained by rotation around sigma bonds.
- **Eclipsed Conformation:** It is less stable because of more repulsion between bond pairs of electrons.
- **Staggered:** It is more stable since there is less repulsion between bond pairs of electrons.
- **Geometrical isomerism:** Observed only in compounds containing a double bond.
- **Stability of benzene.** It is explained on the basis of resonance hybrid.
- **Anenes:** It takes part in electrophilic substitution reaction.
  Aromaticity is determined by Huckle's rule (4n + 2) rule.

TEXTBOOK QUESTIONS SOLVED

Q1. *How do you account for the formation of ethane during chlorination of methane?*

Ans. During chlorination of methane, methyl radicals are formed in the chain propagating steps:

$$CH_4 + \dot{Cl} \longrightarrow C\dot{H}_3 + HCl$$

These methyl radicals can combine with each other in chain terminating steps to form a small amount of ethane.

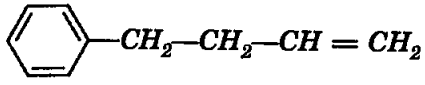
$$\dot{C}H_3 + \dot{C}H_3 \longrightarrow \underset{\text{Ethane}}{H_3C{-}CH_3}$$

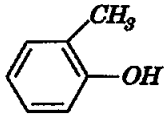
Q2. *Write IUPAC names of the following compounds:*

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

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

(*c*) 

(*d*) 

(*e*) 

(*f*) $CH_3(CH_2)_4\underset{\displaystyle CH_2-CH(CH_3)_2}{\underset{|}{CH}}(CH_2)_3CH_3$

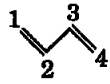
(*g*) $CH_3-CH = CH-CH_2-CH = CH-\underset{\displaystyle C_2H_5}{\underset{|}{CH}}-CH_2-CH = CH_2$

Ans. (*a*) $\overset{4}{C}H_2\overset{3}{C}H=\overset{2}{\underset{\displaystyle CH_3}{\underset{|}{C}}}-\overset{1}{C}H_3$

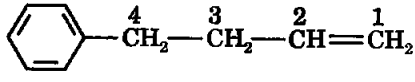
2–Methylbut–2–ene

(*b*) $\overset{1}{C}H_2=\overset{2}{C}H-\overset{3}{C}\equiv\overset{4}{C}-\overset{5}{C}H_3$

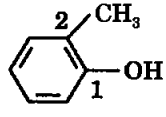
Pen – 1 – ene – 3 – yne

(*c*) 

Buta–1,3–diene

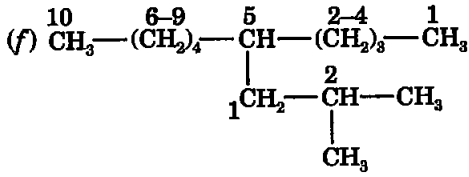
(*d*) 

4 – Phenylbut – 1 – ene

(*e*) 

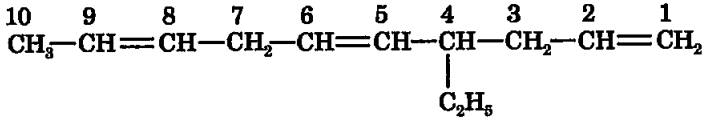
2 – Methylphenol

(*f*)



5–(2– Methylpropyl)decane

(*g*)



4–Ethyldeca – 1, 5, 8 – triene

Q3. *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*)

Ans. (*a*) Three isomers are possible

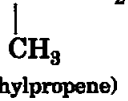
(*i*) $CH_3—CH_2—CH = CH_2$

(But-1-ene)

(*ii*) $CH_3—CH = CH — CH_3$

(But-2-ene)

(*iii*)



(2-Methylpropene)

(*b*) Three isomers are possible

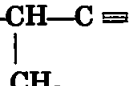
(*i*) $CH_3—CH_2—CH_2—C \equiv CH$

(Pent-1-yne)

(*ii*) $CH_3—CH_2—C \equiv C—CH_3$

(Pent-2-yne)

(*iii*)



(3-Methylbut-1-yne)

Q4. *Write IUPAC names of the products obtained by the ozonolysis of the following compounds:*

(*i*) *Pent-2-ene*
(*ii*) *3, 4-Dimethylhept-3-ene*
(*iii*) *2-Ethylbut-1-ene*
(*iv*) *1-Phenylbut-1-ene*

Ans. (*i*) $CH_3—CH_2—CH=CH—CH_3 \xrightarrow{\text{ozonolysis}}$
(Pent-2-ene)

$CH_3—CH_2—CHO + CH_3—CHO$
(Propanal) (Ethanal)

(*ii*) $CH_3—CH_2—CH_2—\underset{\displaystyle CH_2}{\overset{|}{C}}=\underset{\displaystyle CH_2}{\overset{|}{C}}—CH_2CH_3 \xrightarrow{\text{ozonolysis}}$
3, 4-Dimethylhept-3-ene

$CH_3—CH_2—CH_2—\overset{\displaystyle O}{\overset{\|}{C}}—CH_3 + CH_3—CH_2—\overset{\displaystyle O}{\overset{\|}{C}}—CH_3$
(Pentan-2-one) (Butanone)

(*iii*) $CH_3—CH_2—\underset{\displaystyle CH_2}{\overset{|}{\underset{\displaystyle CH_3}{\overset{|}{C}}}}=CH_2 \xrightarrow{\text{ozonolysis}}$
(2-Ethylbut-1-ene)

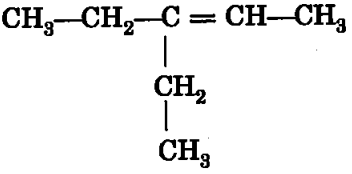
$CH_3—CH_2—\overset{\displaystyle O}{\overset{\|}{C}}—CH_2—CH_3 + H—\overset{\displaystyle O}{\overset{\|}{C}}—H$
(Pentan-3-one) (Methanal)

(*iv*)  $—CH=CH—CH_2—CH_3 \xrightarrow{\text{ozonolysis}}$
(1-Phenylbut-1-ene)

$CH_3—CH_2—CHO + \underset{\displaystyle CHO}{\overset{|}{CHO}} + OHC—\underset{\displaystyle O}{\overset{\|}{C}}—CHO$
Propanal (Ethanedial) (2-Oxopropane-1, 3-dial)

Q5. *An alkene 'A' on ozonolysis gives a mixture of ethanal and pentan-3-one. Write structure and IUPAC name of 'A'.*

Ans.



(3-Ethylpent-2-ene)

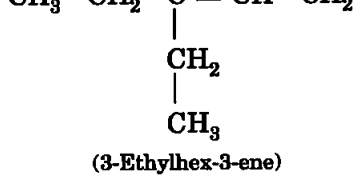
Q6. *An alkene 'A' contains three C—C, eight C—H σ bonds and one C—C π bond. 'A' on ozonolysis gives two moles of an aldehyde of molar mass 44 u. Write IUPAC name of 'A'.*

Ans. Since two moles of the same aldehyde are obtained on ozonolysis, so compound 'A' should have similar groups on either side of the double bond. The aldehyde with molar mass 44 u can be only CH_3CHO. So compound 'A' should be but-2-ene

$$CH_3—CH = CH—CH_3$$

Q7. *Propanal and pentan-3-one are the ozonolysis products of an alkene. What is the structural formula of the alkene?*

Ans.



(3-Ethylhex-3-ene)

Q8. *Write chemical equations for combustion reaction of the following hydrocarbons:*

(*i*) *Butane* (*ii*) *Pentene*

(*iii*) *Hexyne* (*iv*) *Toluene*

Ans. (*i*) $C_4H_{10} + \frac{13}{2}O_2 \longrightarrow 4CO_2 + 5H_2O$

(Butane)

(*ii*) $C_5H_{10} + \frac{15}{2}O_2 \longrightarrow 5CO_2 + 5H_2O$

(Pentene)

(*iii*) $C_6H_{10} + \frac{17}{2}O_2 \longrightarrow 6CO_2 + 5H_2O$

(Hexyne)

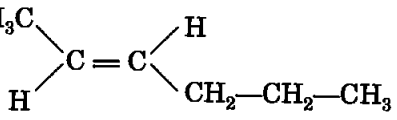
(*iv*) $C_7H_8 + 9O_2 \longrightarrow 7CO_2 + 4H_2O$

(Toluene)

Q9. *Draw the cis and trans structures of hex-2-ene. Which isomer will have higher b.p. and why?*

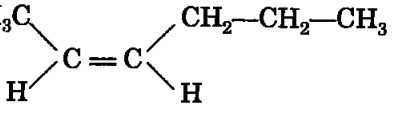
Ans. The two geometrical isomers for hex-2-ene are:

(*i*)



trans-Hex-2-ene

(*ii*)

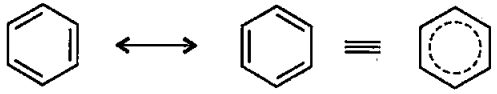


cis-Hex-2-ene

Out of these two, the *cis* isomer is expected to have higher boiling point because it will be more polar (higher value of dipole moment). This higher polarity leads to stronger dipole-dipole interactions.

Q10. *Why is benzene extra ordinarily stable though it contains three double bonds?*

Ans. Benzene is more stable due to the resonance between two canonical structures. According to MO theory, the benzene ring becomes more stable due to delocalisation of six π-electrons.



Q11. *What are the necessary conditions for any system to be aromatic?*

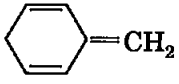
Ans. According to Huckel, there are three necessary conditions for a compound to be aromatic:

(*i*) It should be a planar cyclic compound.

(*ii*) It should have $(4n + 2)$ π-electrons.

(*iii*) These electrons should be in conjugation.

Q12. *Explain why the following systems are not aromatic?*

(*i*)  (*ii*)  (*iii*) 

Ans. All these three compounds are not aromatic because they do not have six π-electrons in conjugation in the ring.

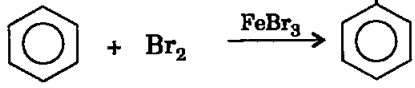
Q13. *How will you convert benzene into*

(*i*) *p-nitrobromobenzene*

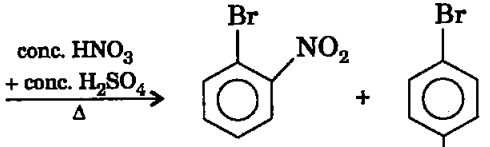
(*ii*) *m-nitrochlorobenzene*

(iii) *p-nitrotoluene*
(iv) *acetophenone*

Ans. (i)



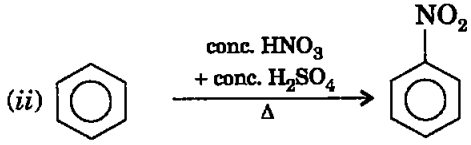
(*p*-Nitrobromobenzene can be separated from *o*-isomer by distillation)

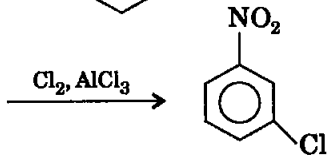


(*o*-Nitrobromobenzene)

(*p*-nitrobromobenzene)

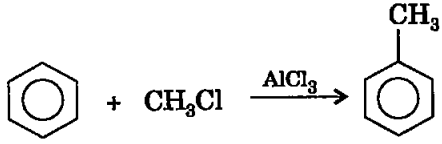
(ii)

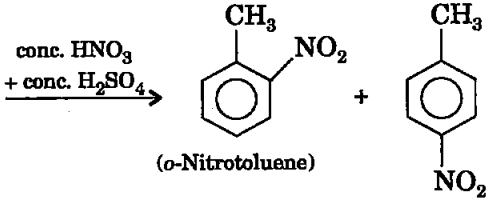




(*m*-Nitrochlorobenzene)

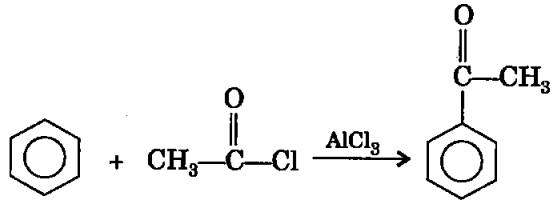
(iii)





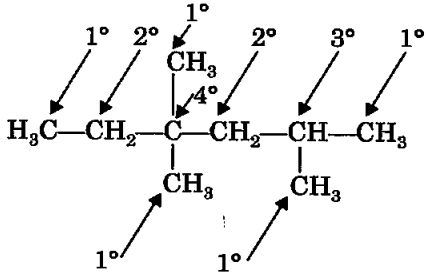
(*o*-Nitrotoluene)

(*p*-Nitrotoluene)

(iv) 

(Acetophenone)

Q14. *In the alkane $H_3C—CH_2—C(CH_3)_2—CH_2—CH(CH_3)_2$, identify 1°, 2°, 3° carbon atoms and give the number of H atoms bonded to each one of these.*

Ans. 

Total number of hydrogen atoms attached to

1° carbon = 15

2° carbon = 4

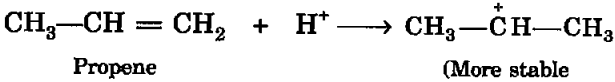
3° carbon = 1

Q15. *What effect does branching of an alkane chain have on its boiling point?*

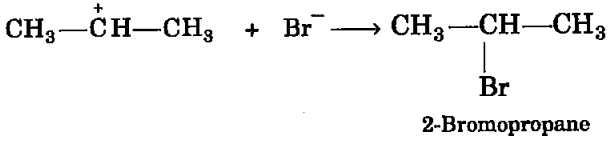
Ans. Generally, the boiling point of alkane decreases with increase in branching. It is due to the fact that due to branching, the molecule becomes more spherical that leads to decrease in intermolecular forces.

Q16. *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.*

Ans. Addition of HBr to propene is an electrophilic addition reaction and proceeds according to Markovnikov's rule, so 2-bromopropane is obtained. The mechanism of the reaction can be shown in the following steps:

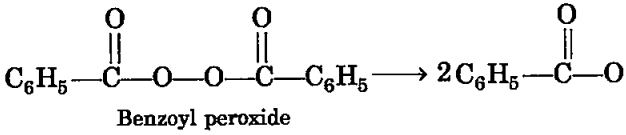


Propene (More stable 2° carbocation)

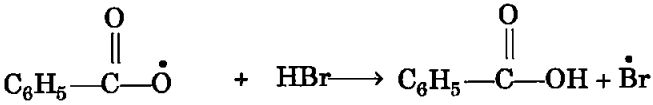


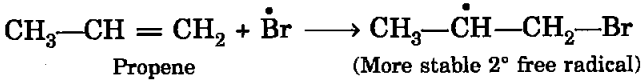
2-Bromopropane

In the presence of benzoyl peroxide, the addition of HBr is reversed and 1-bromopropane is obtained. In presence of peroxide, this reaction follows a free radical mechanism as shown below:

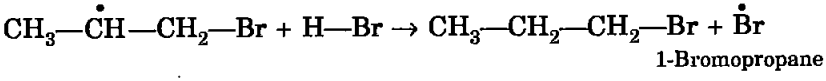


Benzoyl peroxide





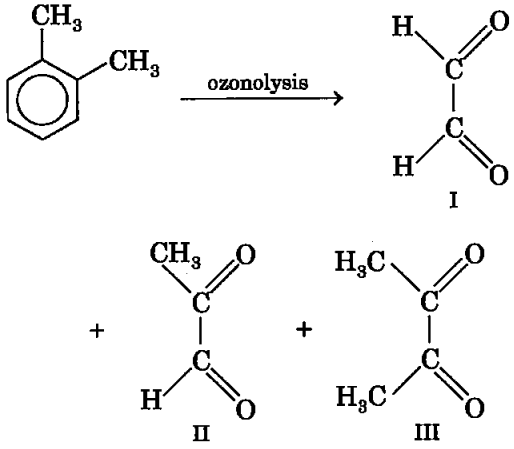
Propene (More stable 2° free radical)



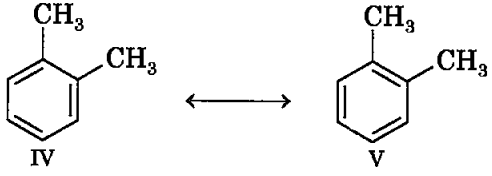
1-Bromopropane

Q17. *Write down the products of ozonolysis of 1,2-dimethylbenzene (o-xylene). How does the result support Kekule structure for benzene?*

Ans. 1,2-Dimethylbenzene gives the following products on ozonolysis.



Formation of these three products on ozonolysis supports the Kekule structure for benzene and other substituted compounds. It shows that double bond present between the two carbon atoms carrying methyl groups which is supported by the formation of II. It also shows that double bond is not present between two carbon atoms carrying methyl groups which is supported by the formation of III. It shows that *o*-xylene is the resonance hybrid of two Kekule structures, IV and V.



IV V

Same arguments are true for benzene and other aromatic compounds also.

Q18. *Arrange benzene, n-hexane and ethyne in decreasing order of acidic behaviour. Also give reason for this behaviour.*

Ans. In hydrocarbons, acidity of the hydrogen atoms attached to the carbon depends on the state of hybridisation of that carbon. The increasing order of electronegativity is $sp^3 < sp^2 < sp$. More electronegative carbon means the electrons of C—H bond are more closure to carbon and hence hydrogen can show more acidic character. In ethyne, hydrogen is attached to *sp* hybridised carbon, in benzene it is sp^2 and in *n*-hexane it is sp^3. So the order of acidity is

Ethyne > Benzene > *n*-Hexane.

Q19. *Why does benzene undergo electrophilic substitution reactions easily and nucleophilic substitutions with difficulty?*

Ans. In benzene, there is a π-electron cloud above and below the carbon skeleton. Since these electrons are available for the reagent so electrophiles can attack easily. Nucleophiles, themselves are electron rich species and find it difficult to attack the benzene ring and hence the nucleophilic substitution is difficult. Nucleophilic substitution becomes easy when benzene ring contains strong electrons withdrawing groups like —NO_2 group.

Q20. *How would you convert the following compounds into benzene?*

(*i*) *Ethyne* (*ii*) *Ethene* (*iii*) *Hexane*

Ans. (*i*) $H-C\equiv C-H$ (Ethyne) $\xrightarrow{\text{red hot iron tube}}$  (Benzene)

(*ii*) $H_2C=CH_2$ (Ethene) $\xrightarrow{Br_2}$ $H_2C(Br)-CH_2(Br)$ (1, 2-Dibromoethene) $\xrightarrow{\text{alc. KOH}}$

$H_2C=CH-BR$ (Bromoethene) $\xrightarrow{NaNH_2}$ $HC\equiv CH$ (Ethyne)

$\xrightarrow{\text{red hot iron tube}}$  (Benzene)

(*iii*) C_6H_{14} (Hexane) $\xrightarrow[750-773\ K]{Cr_2O_3-Al_2O_3}$  (Benzene)

Q21. *Write structures of all the alkenes which on hydrogenation give 2-methylbutane.*

Ans. There are three possible alkenes which on hydrogenation would give 2-methylbutane. These are:

(*i*) $CH_3-CH_2-C(CH_3)=CH_2$

2-Methylbut-1-ene

(*ii*) $CH_3-CH(CH_3)-CH=CH_2$

3-Methylbut-1-ene

(*iii*) $CH_3-C(CH_3)=CH-CH_3$

2-Methylbut-2-ene

Q22. *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.

Ans. The expected order of decreasing reactivity with an electrophile is written below.

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

(*b*) Toluene > *p*-H_3C—C_6H_4—NO_2 > *p*-O_2N—C_6H_4—NO_2.

Q23. *Out of benzene, m-dinitrobenzene and toluene, which will undergo nitration most easily and why?*

Ans. Toluene will undergo nitration most easily because it has an electron releasing —CH_3 group. Nitration, being an electrophilic reaction proceeds easily on the compounds having high electron density.

Q24. *Suggest the name of a Lewis acid other than anhydrous aluminium chloride which can be used during ethylation of benzene.*

Ans. Another Lewis acid is $FeCl_3$ which can be used in place of $AlCl_3$ during ethylation of benzene.

Q25. *Why is Wurtz reaction not preferred for the preparation of alkanes containing odd number of carbon atoms? Illustrate your answer by taking one example.*

Ans. Wurtz reaction is not preferred for the preparation of alkanes containing odd number of carbon atoms because this reaction involves the union of two alkyl halide molecules. If the two alkyl halides are different then there is a possibility of formation of three products so the required product is obtained in lesser amount. For example, if we wish to prepare pentane by this method and we carry out the reaction between bromoethane and 1-bromopropane, then butane and hexane are also obtained as side products.

$$\underset{\text{Bromoethane}}{CH_3—CH_2—Br} + \underset{\text{1-Bromopropane}}{CH_3—CH_2—CH_2—Br} \longrightarrow$$

$$\underset{\text{Butane}}{CH_3—CH_2—CH_2—CH_3} + \underset{\text{Pentane}}{CH_3—CH_2—CH_2—CH_2—CH_3}$$

$$+ \underset{\text{Hexane}}{CH_3—CH_2—CH_2—CH_2—CH_2—CH_3}$$

❑❑❑

NCERT Chemistry XI Solutions

Click and Download

Chapter 1

Chapter 2

Chapter 3

Chapter 4

Chapter 5

Chapter 6

Chapter 7

Chapter 8

Chapter 9

Chapter 10

Chapter 11

Chapter 12

Chapter 13

Chapter 14

Other Solutions

Physics 11

Maths 11

Biology 11

NCERT 12

IIT JEE

NEET