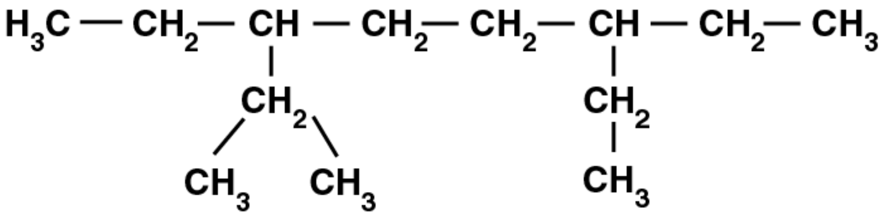
I. Multiple Choice Questions (Type-I)

1. Arrange the following in decreasing order of their boiling points.
(A) n–butane (B) 2–methylbutane
(C) n-pentane (D) 2,2–dimethylpropane
(i) A > B > C > D
(ii) B > C > D > A
(iii) D > C > B > A
(iv) C > B > D > A
Solution:
Option (iv) is the answer.

2. Arrange the halogens F2 , Cl2 , Br2 , I2 , in order of their increasing reactivity with alkanes.
(i) I2 < Br2 < Cl2 < F2
(ii) Br2 < Cl2 < F2 < I2
(iii) F2 < Cl2 < Br2 < I2
(iv) Br2 < I2< Cl2 < F2
Solution:
Option (i) is the answer.

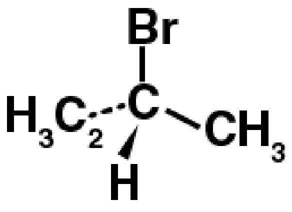
3. The increasing order of reduction of alkyl halides with zinc and dilute HCl is
(i) R–Cl < R–I < R–Br
ii) R–Cl < R–Br < R–I
(iii) R–I < R–Br < R–Cl
(iv) R–Br < R–I < R–Cl
Solution:
Option (ii) is the answer.

4. The correct IUPAC name of the following alkane is

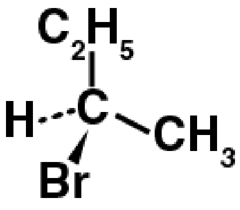


(i) 3,6 – Diethyl – 2 – methyl octane
(ii) 5 – Isopropyl – 3 – ethyloctane
(iii) 3 – Ethyl – 5 – isopropyloctane
(iv) 3 – Isopropyl – 6 – ethyloctane
Solution:
Option (i) is the answer.

5. The addition of HBr to 1-butene gives a mixture of products A, B and C



(A)



(B)

$CH_3-CH_2-CH_2-CH_2-Br$

(c)

The mixture consists of

(i) A and B as major and C as minor products

(ii) B as major, A and C as minor products

(iii) B as minor, A and C as major products

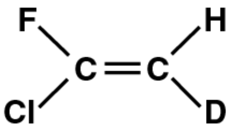
(iv) A and B as minor and C as major products

Solution:

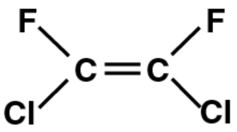
Option (i) is the answer.

6. . Which of the following will not show geometrical isomerism?

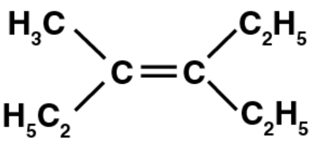
(i)



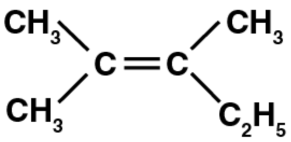
(ii)



(iii)



(iv)



Solution:

Option (iv) is the answer.

7. Arrange the following hydrogen halides in order of their decreasing reactivity with propane.

(i) HCl > HBr > HI
(ii) HBr > HI > HCl
(iii) HI > HBr > HCl
(iv) HCl > HI > HBr

Solution:

Option (iii) is the answer.

8. Arrange the following carbanions in order of their decreasing stability.

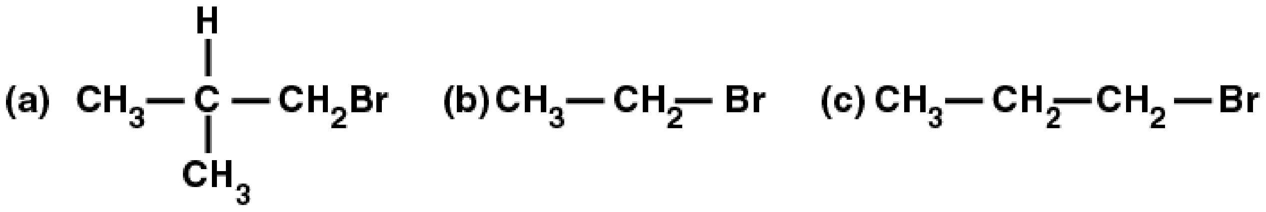
(A) H3C – C ≡ C– (B) H – C ≡ C– (C) H3C-CH$^-$2

(i) A > B > C
(ii) B > A > C
(iii) C > B > A
(iv) C > A > B

Solution:

Option (ii) is the answer.

9. Arrange the following alkyl halides in decreasing order of the rate of β– elimination reaction with alcoholic KOH.



(a) $CH_3-\underset{CH_3}{\overset{H}{C}}-CH_2Br$ (b) CH_3-CH_2-Br (c) $CH_3-CH_2-CH_2-Br$

(i) A > B > C
(ii) C > B > A
(iii) B > C > A
(iv) A > C > B

Solution:

Option (iv) is the answer.

10. Which of the following reactions of methane is incomplete combustion:

$$\text{(i) } 2CH_4 + O_2 \xrightarrow{Cu/523\ K/100\ atm} 2CH_3OH$$

$$\text{(ii) } CH_4 + O_2 \xrightarrow{Mo_2O_3} HCHO + H_2O$$

$$\text{(iii) } CH_4 + O_2 \longrightarrow C(s) + 2H_2O(l)$$

$$\text{(iv) } CH_4 + 2O_2 \longrightarrow CO_2(g) + 2H_2O(l)$$

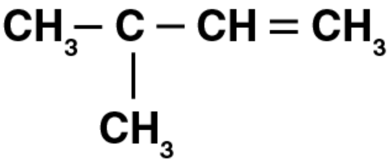
Solution:
Option (iii) is the answer.

II. Multiple Choice Questions (Type-II)
In the following questions, two or more options may be correct.

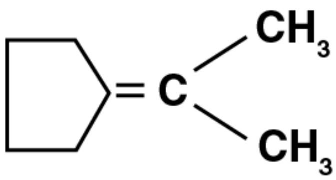
Some oxidation reactions of methane are given below. Which of them is/are controlled oxidation reactions?
(i) CH4 (g) + 2O2 (g)→ CO2 (g) + 2H2O (l)
(ii) CH4 (g) + O2 (g) → C (s) + 2H2O (l)
(iii) CH4 (g) + O2 (g) →(Mo O2 3) HCHO + H2O
(iv) 2CH4 (g) + O2 (g) → (Cu/523/100 atm) 2CH3OH
Solution:
Option (iii) and (iv) are the answers.

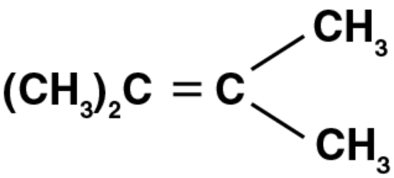
12. Which of the following alkenes on ozonolysis give a mixture of ketones only?

(i) $CH_3-CH=CH-CH_3$

(ii) 

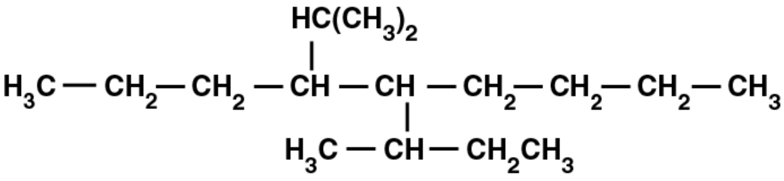
$CH_3-C(CH_3)-CH=CH_3$

(iii) 

(iv) 

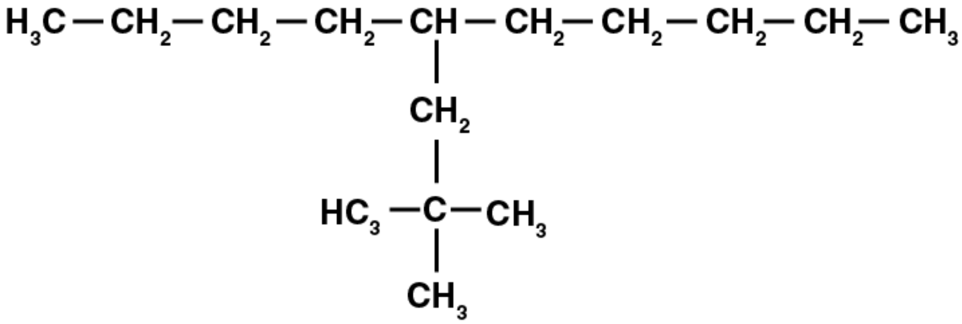
Solution:
Option (iii) and (iv) are the answers.

13. Which are the correct IUPAC names of the following compound?



(i) 5– Butyl – 4– isopropyldecane
(ii) 5– Ethyl – 4– propyldecane
(iii) 5– sec-Butyl – 4– iso-propyldecane
(iv) 4–(1-methoxymethyl)– 5 – (1-methyl propyl)-decane
Solution:
Option (iii) and (iv) are the answers.

14. Which are the correct IUPAC names of the following compound?



(i) 5 – (2′, 2′–Dimethylpropyl)-decane
(ii) 4 – Butyl – 2,2– dimethylnonane
(iii) 2,2– Dimethyl – 4– pentyloctane
(iv) 5 – neo-Pentyldecane
Solution:
Option (i) and (iv) are the answers.

15. For an electrophilic substitution reaction, the presence of a halogen atom in the benzene ring _______.
(i) deactivates the ring by the inductive effect
(ii) deactivates the ring by resonance
(iii) increases the charge density at ortho and para position relative to meta position by resonance
(iv) directs the incoming electrophile to meta position by increasing the charge density relative to ortho and para position.
Solution:
Option (i) and (ii) are the answers.

16. In an electrophilic substitution reaction of nitrobenzene, the presence of nitro group ________.
(i) deactivates the ring by an inductive effect.
(ii) activates the ring by an inductive effect.
(iii) decreases the charge density at ortho and para position of the ring relative to meta position by resonance.
(iv) increases the charge density at meta position relative to the ortho and para positions of the ring by resonance
Solution:
Option (i) and (iii) are the answers.

17. Which of the following is correct?

(i) $CH_3-O-CH_2^{\oplus}$ Is more stable than $CH_3-CH_2^{\oplus}$

(ii) $(CH_3)_2CH^{\oplus}$ Is less stable than $CH_3-CH_2-CH_2^{\oplus}$

(iii) $CH_2=CH^{\oplus}-CH_2^{\oplus}$ Is more stable than $CH_3-CH_2-CH_2^{\oplus}$

(iv) $CH_2=CH^{\oplus}$ Is more stable than $CH_3-CH_2^{\oplus}$

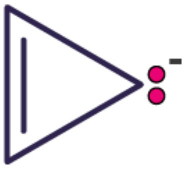
Solution:
Option (i) and (iii) are the answers.

18. Four structures are given in options (i) to (iv). Examine them and select the aromatic structures.

(ii)

(iii)

(iv)



Solution:
Option (i) and (iii) are the answers.

19. The molecules having dipole moment are __________.
(i) 2,2-Dimethylpropane
(ii) trans-Pent-2-ene
(iii) cis-Hex-3-ene
(iv) 2, 2, 3, 3 - Tetramethylbutane.
Solution:
Option (ii) and (iii) are the answers.

III. Short Answer Type

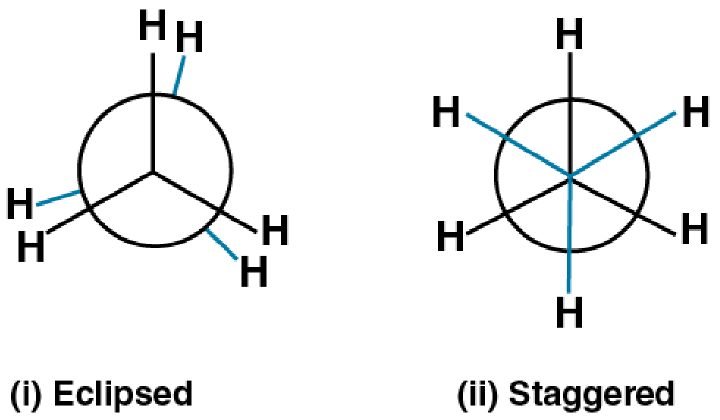
20. Why do alkenes prefer to undergo electrophilic addition reaction while arenes prefer electrophilic substitution reactions? Explain.
Solution:

Alkenes undergo addition reaction to give a more stable saturated product. In this reaction hybridization changes from sp2to sp3.
The resonance stability of arene is maintained by a substitution reaction.

21. Alkynes on reduction with sodium in liquid ammonia form trans alkenes. Will the butene thus formed on the reduction of the 2-butyne show the geometrical isomerism?
Solution:
The negative charged developed on one carbon attacks the proton from NH3 and another sodium atom lose its electron to develop a second negative charge on the atom. This negative charge is finally neutralised by the attack of the second proton to give a trans-but-2-ene.
This but-2-ene produced shows geometrical isomers as cis and trans.

22. Rotation around carbon-carbon single bond of ethane is not completely free. Justify the statement.
Solution:
The single bond in ethane is a σ – bond, which is a coaxial overlap of orbitals, so the C ─ C bond can be rotated on its axis. But this rotation is not completely free due to the torsional strain that the bond undergoes due to rotation.

23. Draw Newman and Sawhorse projections for the eclipsed and staggered conformations of ethane. Which of these conformations is more stable and why?
Solution:

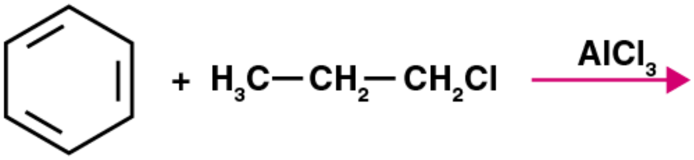


(i) Eclipsed (ii) Staggered

The staggered configuration is more stable as compared to an eclipse, as there is less C – H bond pair repulsion and the atoms are at a maximum distance away from each other.

24. The intermediate carbocation formed in the reactions of HI, HBr and HCl with propane is the same and the bond energy of HCl, HBr and HI is 430.5 kJ mol-1, 363.7 kJ mol-1 and 296.8 kJ mol-1 respectively. What will be the order of reactivity of these halogen acids?
Solution:
HI >HBr>HCl is the increasing order of reactivity. The increasing order of reactivity of halogen is same as their increase in bond energies.

25. What will be the product obtained as a result of the following reaction and why?



Solution:

This reaction is an example of Friedel Crafts alkylation using a lewis acid.
In the first step, there will be a formation of the carbocation, then a secondary carbocation will be formed which is more stable. There will be a hydride shift. At last nucleophilic attack will happen to the benzene ring which forms the major product cumene and a minor product of primary carbocation.

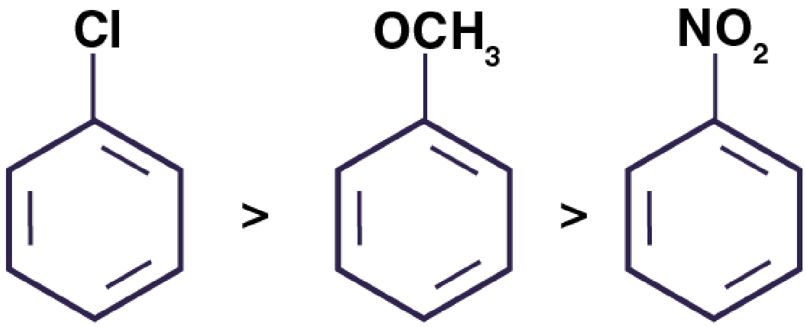
26. How will you convert benzene into
(i) p – nitrobromobenzene
(ii) m – nitrobromobenzene

Solution:

(i) when bromine is treated with Br2 in presence anhydrous FeBr3 it undergoes electrophilic substitution to give bromobenzene. Again treated with conc. HNO3 and Conc. H2SO4 at 323K we get a p-nitrobromobenzene
(ii) We need to deactivate the benzene by the introduction of a nitro group using conc. HNO3 and H2SO4 and then treat with Br2 in presence of FeBr3 we will get m-nitrobromobenzene.

27. Arrange the following set of compounds in the order of their decreasing relative reactivity with an electrophile. Give reason.

Solution:

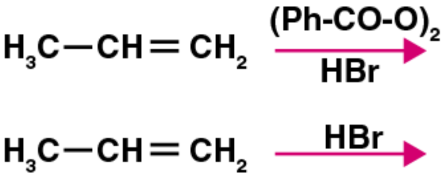


28. Despite their - I effect, halogens are o- and p-directing in halo-arenes. Explain.
Solution:
Halogens have an outer configuration of ns2p5 which shows it can accept one electron and are close to completing its octate; halogens show a strong affinity to attract one electron and thus having a higher electronegativity and show negative inductive effect.

29. Why does the presence of a nitro group make the benzene ring less reactive in comparison to the unsubstituted benzene ring? Explain.
Solution:
Nitro group has a nitrogen atom bonded to two highly electronegative oxygen atoms. This results in a net decrease of electron density around nitrogen atom and imparts a positive δ+ charge on nitrogen.

30. Suggest a route for the preparation of nitrobenzene starting from acetylene?
Solution:
(i) By intermolecular condensation method, we can cycle acetylene and then treated at high temperature in a red hot iron tube.
(ii) The aliphatic compound thus converted into benzene is treated with con.HNO3 and Conc.H2SO4 which undergoes nitration to give nitrobenzene.

31. Predict the major product (s) of the following reactions and explain their formation.



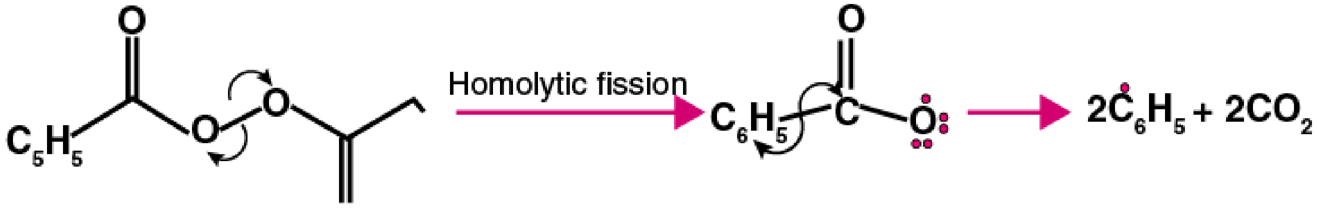
$$H_3C-CH=CH_2 \xrightarrow[HBr]{(Ph\text{-}CO\text{-}O)_2}$$

$$H_3C-CH=CH_2 \xrightarrow{HBr}$$

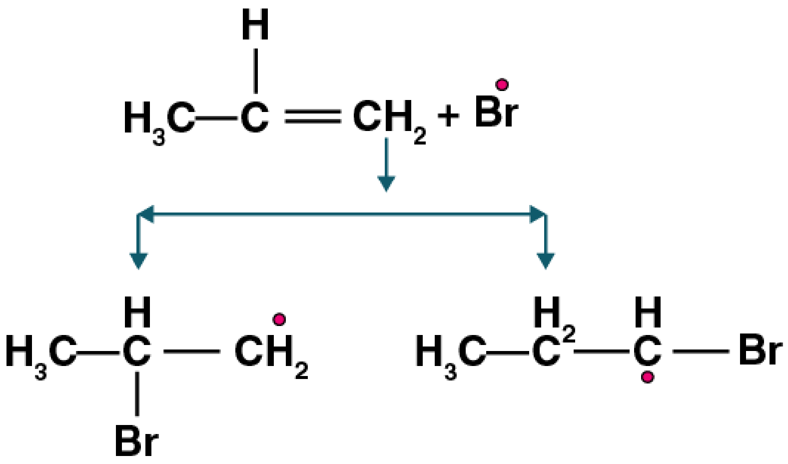
Solution:

$$H_3C-CH=CH_2 + HBr \xrightarrow{(Ph\text{-}CO\text{-}O)_2} H_3C-CH_2-CH_2-Br$$

Step 1: Homolysis of peroxide to from free radicals



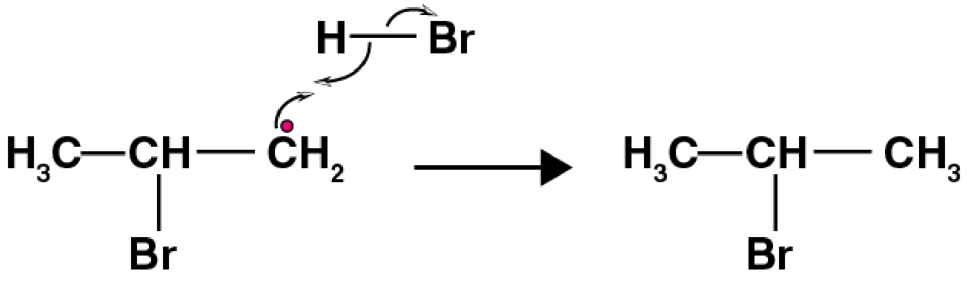
Step 2: Formation of Bromine free radical
·C6H5 + H-BR → C6H6 + Br·



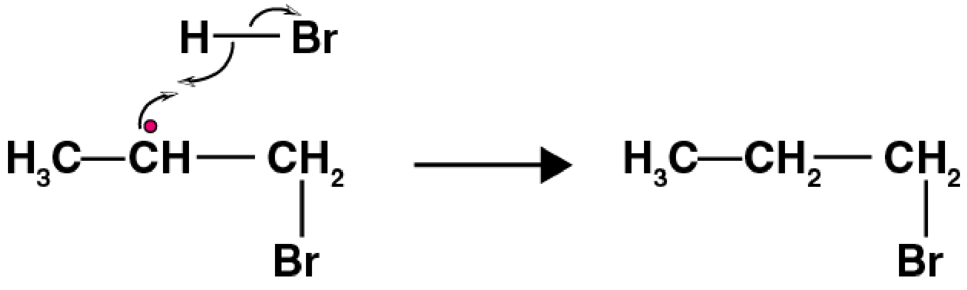
(a) Less stable
1° free radical

(b) more stable
2° free radical

Step 3: reaction of hydrogen bromide with an alkyl radical



2-Bromopropane

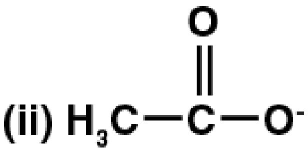


1-Bromopropane

32. Nucleophiles and electrophiles are reaction intermediates having electron-rich and electron-deficient centres' respectively. Hence, they tend to attack electron-deficient and electron-rich centres respectively. Classify the following species as electrophiles and nucleophiles.

(i) H_3CO^-

(ii)



$H_3C-\overset{\overset{\displaystyle O}{\|}}{C}-O^-$

(iii) $\dot{Cl}$

(iv) $Cl_2C:$

(v) $(H_3C)C^+$

(vi) Br^-

(vii) H_3COH

(viii) R−NH−R

Solution:

(i), (vi), (vii), (viii) are nucleophiles

(ii), (iii), (iv), (v) are electrophiles

33. The relative reactivity of 1°, 2°, 3° hydrogen's towards chlorination is 1: 3.8: 5. Calculate the percentages of all mono-chlorinated products obtained from 2-methyl butane.

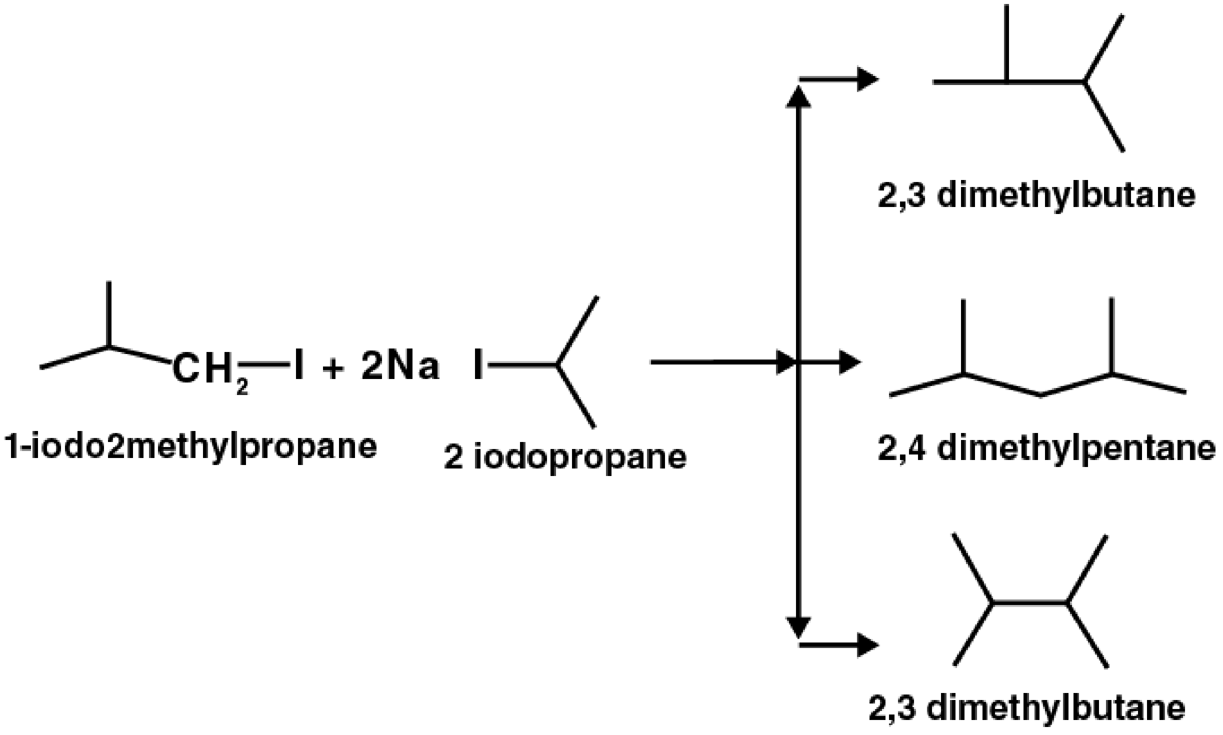
Solution:

Amount of mono-chlorinated products = No. of hydrogen reactivity

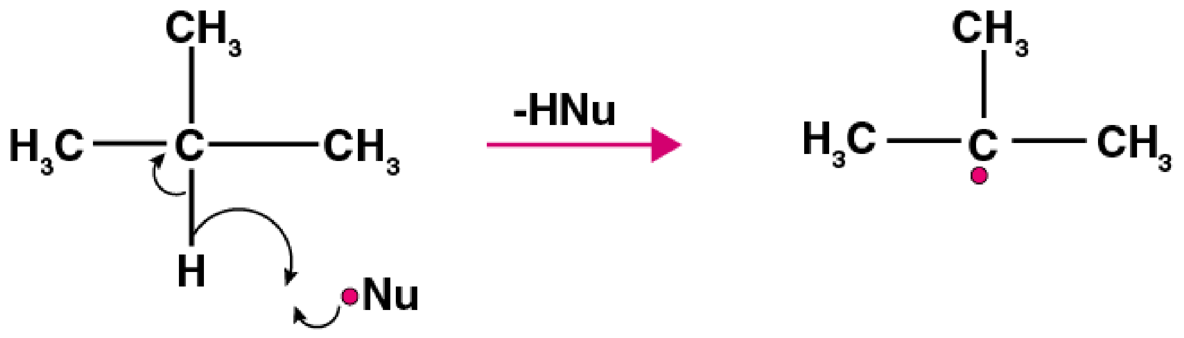
Mono-chlorinated products from 1° H = 9 1 = 9

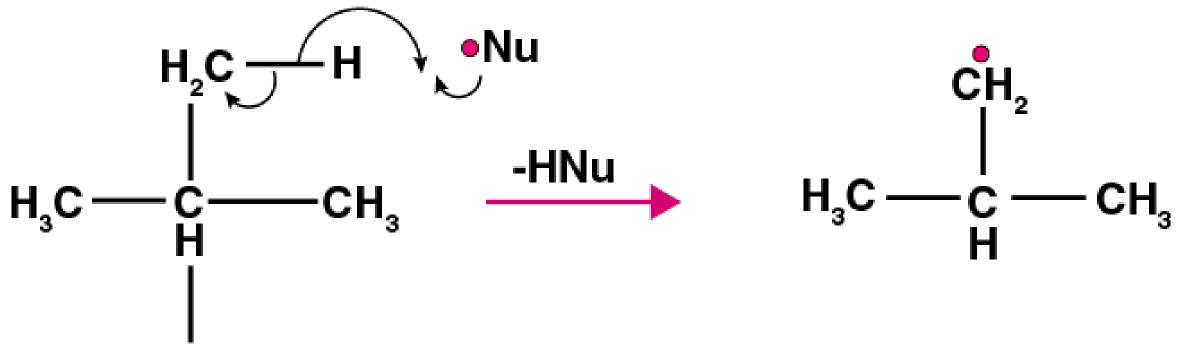
Mono-chlorinated products from 2° H = 2 3.8 = 7.6
Mono-chlorinated products from 3° H = 1 5 = 5
Total mono-chlorinated products = 9+7.6+5 = 21.6
Yield % for 1° H chlorination = 9×100/21.6 = 41.67%
Yield % for 2° H chlorination = 7.6×100/21.6 = 35.18%
Yield % for 3° H chlorination = 5×100/21.6 = 23.15%

34. Write the structures and names of products obtained in the reactions of sodium with a mixture of 1-iodo-2-methylpropane and 2-iodopropane.
Solution:
When the mixture of 1-iodo-2-methylpropane and 2-iodopropane is treated with sodium it gives a mixture of three products formed by intermolecular and intramolecular reaction as follows:



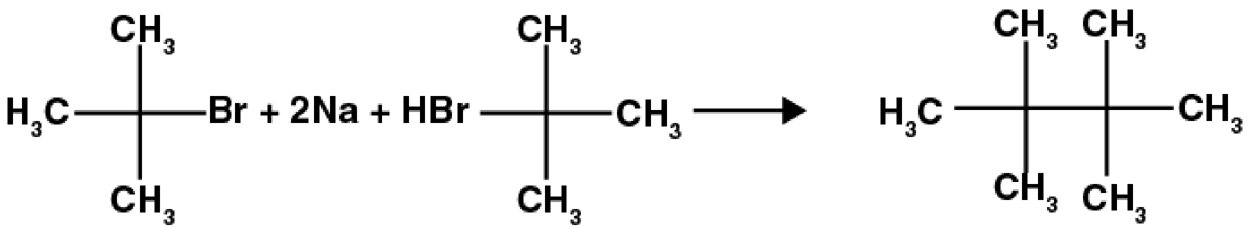
35. Write hydrocarbon radicals that can be formed as intermediates during monochlorination of 2-methylpropane? Which of them is more stable? Give reasons.
Solution:





The 3° free radical is stabilised by 9 hyperconjugation structures and thus has more stability as compared to 1° free radical.

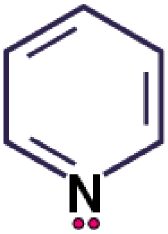
36. An alkane C8H18 is obtained as the only product on subjecting a primary alkyl halide to Wurtz reaction. On monobromination, this alkane yields a single isomer of a tertiary bromide. Write the structure of alkane and the tertiary bromide.
Solution:



2,2,3,3-tetramethylbutane

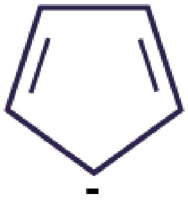
37. The ring systems having the following characteristics are aromatic.

(i) Planar ring containing conjugated π bonds.
(ii) Complete delocalisation of the π−electrons in-ring system i.e. each atom in the ring has unhybridised p-orbital, and
(iii) Presence of (4n+2)−electrons in the ring where n is an integer (n = 0, 1, 2,..........) [Huckel rule].
Using this information classifies the following compounds as aromatic/non-aromatic.

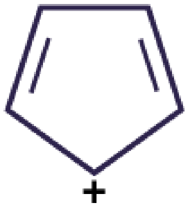


(A)

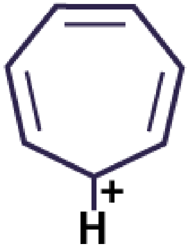
(B)



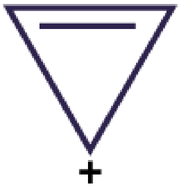
(C)



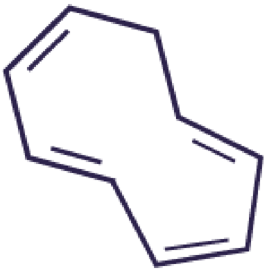
(D)



(E)



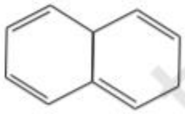
(F)

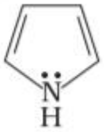


(G)

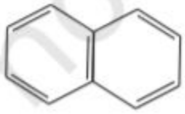
Solution:
Aromatic compounds: A, E and F
Non-Aromatic : B, C, D and G

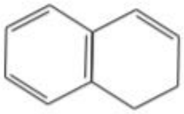
38. Which of the following compounds are aromatic according to Huckel's rule?

(A)


(B)


(C)

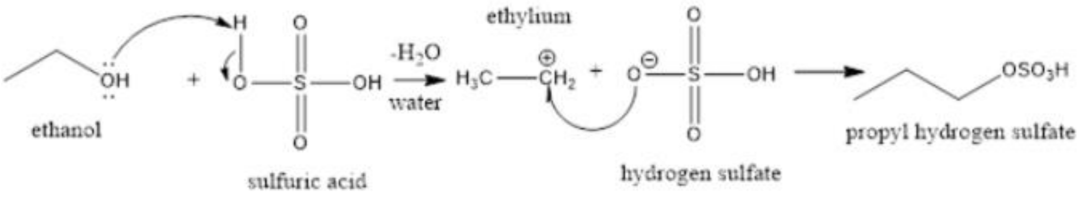

(D)


(E)


(F)


Solution:
According to Huckel's rule, it should satisfy $(4n+\pi)$ rule
Compound B, C, D and F are aromatic.

39. Suggest a route to prepare ethyl hydrogen sulphate (CH3–CH2–OSO2—OH) starting from ethanol (C2H5OH)
Solution;
Ethanol when treated with sulphuric acid at around 140°C gives hydrogen sulphate. The reaction is



IV. Matching Type

40. Match the reagent from Column I which on reaction with CH3 —CH=CH2 gives some product given in Column II as per the codes given below :

Column I	**Column II**
(i) O3/Zn + H2O	**(a) Acetic acid and CO2**
(ii) KMnO4/H+	**(b) Propan-1-ol**
(iii) KMnO4/OH–	**(c) Propan-2-ol**
(iv) H2O/H+	**(d) Acetaldehyde and formaldehyde**
(v) B2H6/NaOH and H2O2	**(e) Propane-1,2-diol**

Solution:
(i) is d
(ii) is a
(iii) is e
(iv) is c

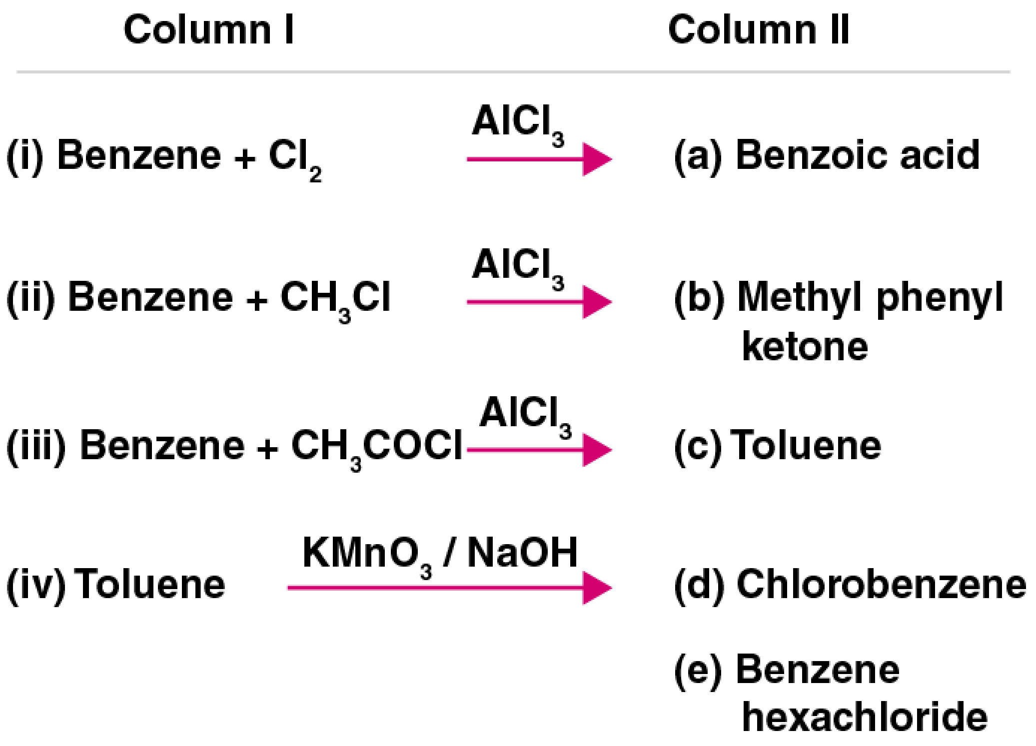
(v) is b

41. Match the hydrocarbons in Column I with the boiling points given in Column II.

Column I	**Column II**
(i) n–Pentane	**(a) 282.5 K**
(ii) iso-Pentane	**(b) 309 K**
(iii) neo-Pentane	**(c) 301 K**

Solution:
(i) is b
(ii) is c
(iii) is a

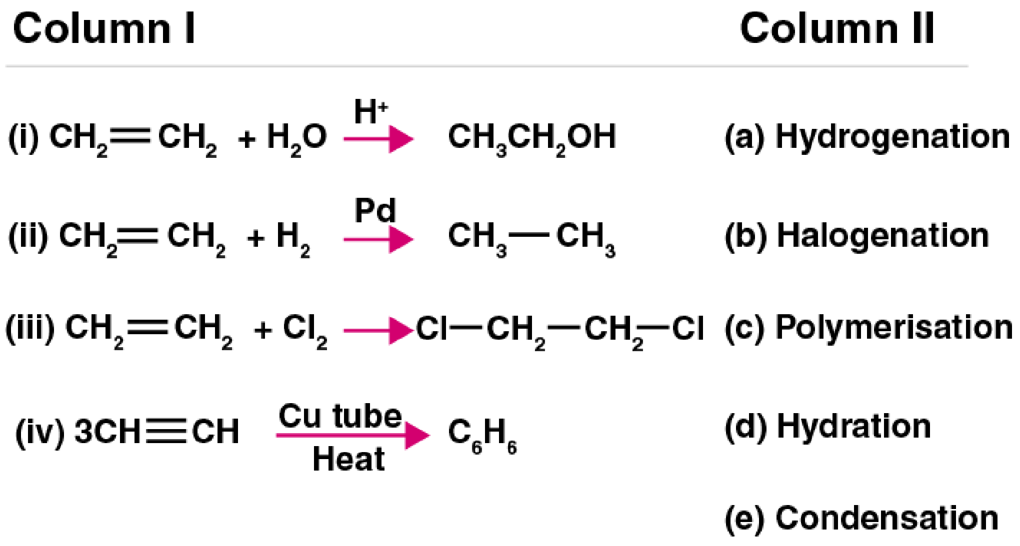
42. Match the following reactants in Column I with the corresponding reaction products in Column II.



Column I		Column II
(i) Benzene + Cl_2	$\xrightarrow{AlCl_3}$	(a) Benzoic acid
(ii) Benzene + CH_3Cl	$\xrightarrow{AlCl_3}$	(b) Methyl phenyl ketone
(iii) Benzene + CH_3COCl	$\xrightarrow{AlCl_3}$	(c) Toluene
(iv) Toluene	$\xrightarrow{KMnO_4 / NaOH}$	(d) Chlorobenzene
		(e) Benzene hexachloride

Solution:
(i) is d
(ii) is c
(iii) is b
(iv) is a

43. Match the reactions given in Column I with the reaction types in Column II.



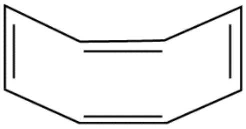
Column I	Column II
(i) $CH_2{=}CH_2 + H_2O \xrightarrow{H^+} CH_3CH_2OH$	(a) Hydrogenation
(ii) $CH_2{=}CH_2 + H_2 \xrightarrow{Pd} CH_3{-}CH_3$	(b) Halogenation
(iii) $CH_2{=}CH_2 + Cl_2 \longrightarrow Cl{-}CH_2{-}CH_2{-}Cl$	(c) Polymerisation
(iv) $3CH{\equiv}CH \xrightarrow[\text{Heat}]{\text{Cu tube}} C_6H_6$	(d) Hydration
	(e) Condensation

Solution:

(i) is d
(ii) is a
(iii) is b
(iv) is c

V. Assertion and Reason Type
In the following questions, a statement of assertion (A) followed by a statement of the reason (R) is given. Choose the correct option out of the choices given below each question.

44. Assertion (A): The compound cyclooctane has the following structural



formula:
It is cyclic and has conjugated 8π-electron system but it is not an aromatic compound.
Reason (R) : (4n + 2) π electrons rule does not hold good and the ring is not planar.
(i) Both A and R are correct and R is the correct explanation of A.
(ii) Both A and R are correct but R is not the correct explanation of A.
(iii) Both A and R are not correct.
(iv) A is not correct but R is correct.
Solution:
Option (i) is correct.

45. Assertion (A): Toluene on Friedel Crafts methylation gives o– and p–xylene.
Reason (R): CH3-group bonded to benzene ring increases electron density at o– and p– position.
(i) Both A and R are correct and R is the correct explanation of A.
(ii) Both A and R are correct but R is not the correct explanation of A.
(iii) Both A and R are not correct.
(iv) A is not correct but R is correct.
Solution:
Option (i) is correct

46. Assertion (A): Nitration of benzene with nitric acid requires the use of concentrated sulphuric acid.
Reason (R): The mixture of concentrated sulphuric acid and concentrated nitric acid produces the electrophile, NO2+.
(i) Both A and R are correct and R is the correct explanation of A.
(ii) Both A and R are correct but R is not the correct explanation of A.
(iii) Both A and R are not correct.
(iv) A is not correct but R is correct.
Solution:
Option (i) is correct

47. Assertion (A): Among isomeric pentanes, 2, 2-dimethylpentane has the highest boiling point.
Reason (R): Branching does not affect the boiling point.
(i) Both A and R are correct and R is the correct explanation of A.
(ii) Both A and R are correct but R is not the correct explanation of A.
(iii) Both A and R are not correct.
(iv) A is not correct but R is correct.
Solution:
Option (iii) is correct.