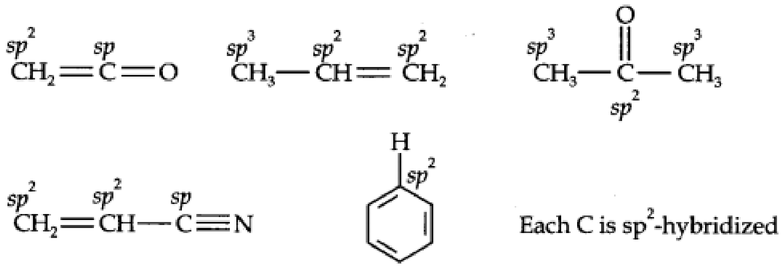
BASIC ORGANIC CHEMISTRY AND HYDROCARBON

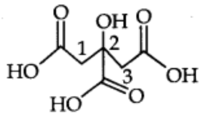
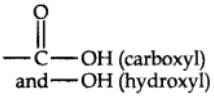
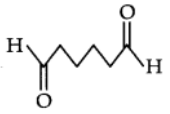
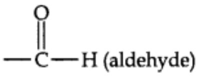
Q1.What are hybridisation states of each carbon atom in the following compounds? $CH_2=C=O$, $CH_3CH=CH_2$, $(CH_3)_2CO$, $CH_2=CHCN$, C_6H_6.

Answer:

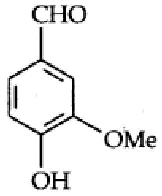


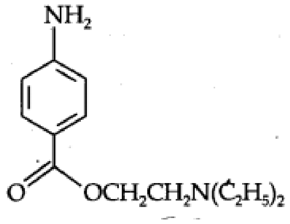
Q2Give condensed and bond line structural formulas and identify the functional group(s) present, if any, for: (a) 2, 2, 4-Trimethylpentane (b) 2-Hydroxy-l, 2, 3-propanetricarboxylic acid (c) Hexanedial.

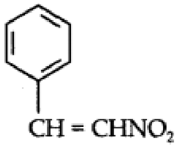
Answer:

Condensed formula	Bond line formula	Functional group/s
(a) $(CH_3)_3CCH_2CH(CH_3)_2$		–
(b) $HOOCCH_2C(OH)$ $(COOH)CH_2COOH$		
(c) $OHC(CH_2)_4CHO$		

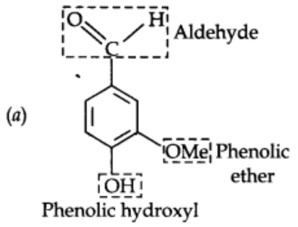
Q3. **Identify the functional groups in the following compounds:**

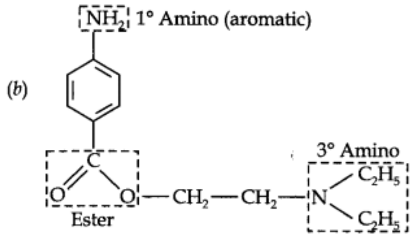
(a)


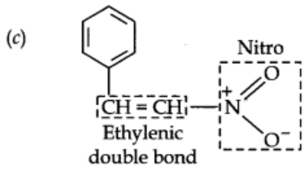
(b)


(c)


Answer:





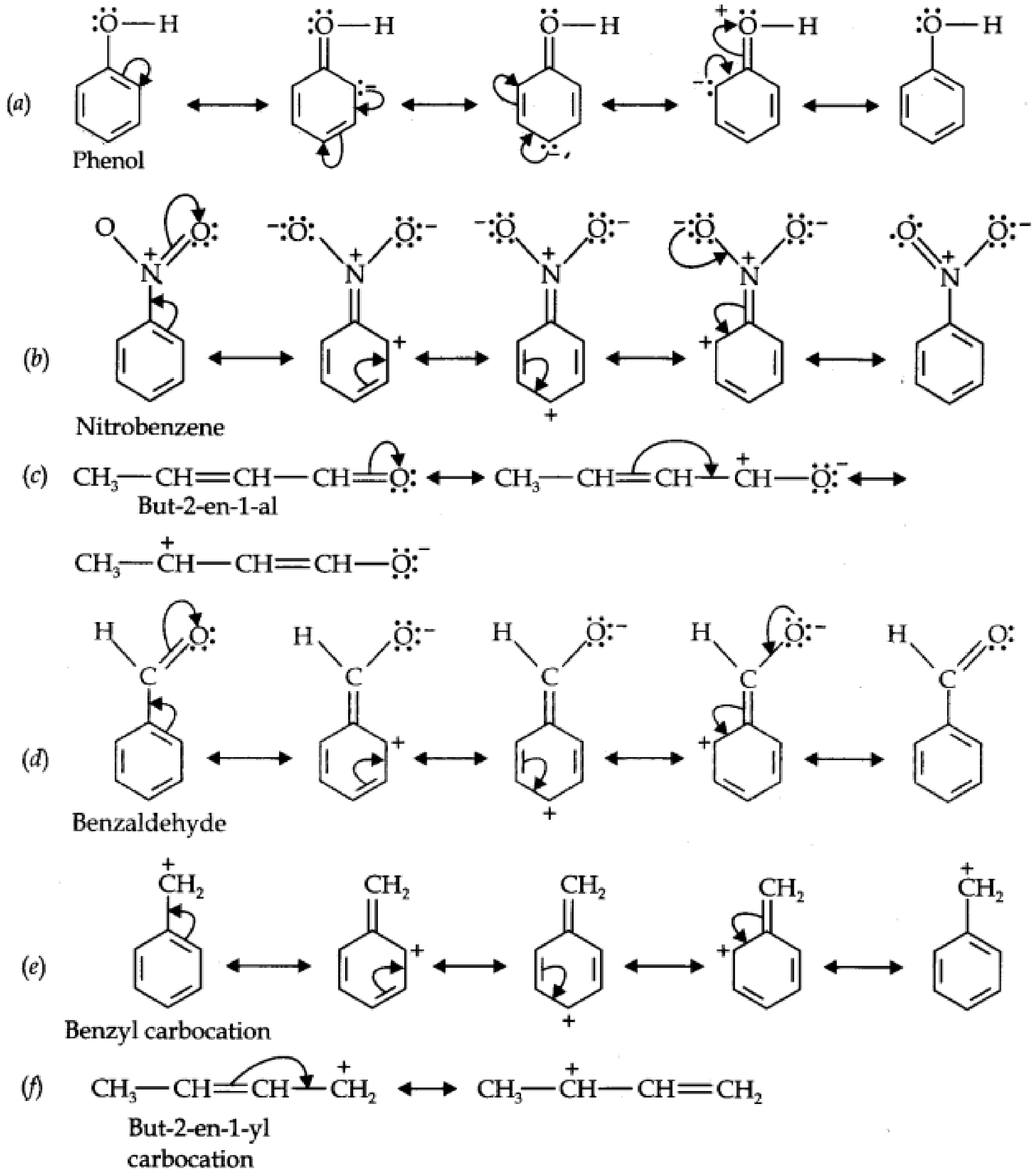


Q4. **Which of the two: $O_2NCH_2CH_2O^-$ or $CH_3CH_2O^-$ is expected to be more stable and why?**

Answer: O_2N——<——- CH_2——<——- CH_2 —<——- O^- is more stable than CH_3——<——-CH_2——<——-O- because NO_2 group has -I-effect and hence it tends to disperse the -ve charge on the O-atom. In contrast, CH_3CH_2 has +I-effect. It, therefore, tends to intensify the -ve charge and hence destabilizes it.

Q5. **Draw the resonance structures for the following compounds. Show the electron shift using curved-arrow notation. (a) C_6H_5OH (b) $C_6H_5N0_2$ (c) $CH_3CH=CHCHO$ (d) C_6H_5—CHO (e) C_6H_5—CH_2 (f) $Ch_3Ch=ChCh_2$**

Answer:



Q6. **What are electrophiles and nucleophiles? Explain with examples:**

Answer: Electrophiles: The name electrophiles means electron loving. Electrophiles are electron deficient. They may be positive ions or neutral molecules.

Ex: H^+, Cl^+, Br^+, NO_2^+, R_3C^+, RN_2^+, $AlCl_3$, BF_3

Nucleophiles: The name nucleophiles means ‘nucleus loving’ and indicates that it attacks the region of low electron density (positive centres) in a substrate molecule. They are electron rich they may be negative ions or neutral molecules.

Ex: Cl^- Br^-, CN^-, OH^-, RCR_2^-, NH_3, RNH_2, H_2O, ROH etc

Q7. **Give a brief description of the principles of the following techniques taking an example in each case: (a) Crystallisation (b) Distillation (c) Chromatography**

Answer: (a) Crystallisation: In this process the impure solid is dissolved in the minimum volume of a suitable solvent. The soluble impurities pass into the solution while the insoluble ones left behind. The hot solution is then filtered and allowed to cool undisturbed till crystallisation is complete. The crystals are then separated from the mother liquor by filtraration and dried.

Example: crystallisation of sugar.

(b) Distillation: The operation of distillation is employed for the purification of liquids from non-volatile impurities. The impure liquid is boiled in a flask and the vapours so formed are collected and condensed to give back pure liquid in another vessel. Simple organic liquids such as benzene toluene, xylene etc. can be purified.

(c) Chromatography: Chromatography is based on the principle of selective distribution of the components of a mixture between two phases, a stationary phase and a moving phase. The stationary phase can be a solid or liquid, while the moving phase is a liquid or a gas. When the stationary phase is solid the basis is adsorption and when it is a liquid the basis is partition. Chromatography is generally used for the Reparation of coloured substances such as plant pigments or dyestuffs

Q8. **Discuss the chemistry of Lassaigne's test.**

Answer: Lassaigne's test: Nitrogen, sulphur, halogens and phosphorous present in an organic compound are detected by Lassaigne's test.
First of all compounds are converted to ionic form by fusing the compound with sodium metal.

$$Na + C + N \xrightarrow{\Delta} NaCN$$
$$2Na + S \xrightarrow{\Delta} Na_2S$$
$$Na + X \xrightarrow{\Delta} NaX$$
$$[X = Cl, Br, I]$$

Q9. **Differentiate between the principle of estimation of nitrogen in an organic compound by (i) Dumas method (ii) Kjeldahl's method.**

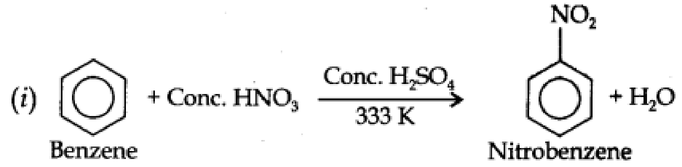
Answer: (i) Dumas method: The organic compound is heated strongly with excess of CuO ' (Cupric Oxide) in an atmosphere of CO_2 when free nitrogen, CO_2 and H_2O are obtained.
(ii)Kjeldahl's method: A known mass of the organic compound is heated strongly with cone. H_2SO_4, a little potassium sulphate and a little mercury (a catalyst). As a result of reaction the nitrogen present in the organic compound is converted to ammonium sulphate.

Q10. **0.3780 g of an organic compound gave 0.5740 g of silver chloride in Carius estimation. Calculate the percentage of chlorine in the compound.**

Answer: Mass of the compound = 0.3780 g
Mass of silver chloride = 0.5740 g

$$\text{Percentage of chlorine} = \frac{35.5}{143.5} \times \frac{\text{Mass of siliver chloride}}{\text{Mass of compound}} \times 100$$
$$= \frac{35.5}{143.5} \times \frac{(0.5740\text{ g})}{(0.3780\text{ g})} \times 100 = \mathbf{37.57\ g}$$

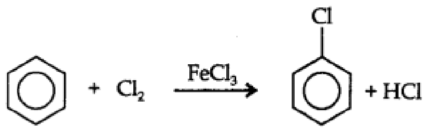
Q11. Give equation for the following:
(i) Electrophilic Substitution
(ii) Nucleophilic Substitution
Answer:



$$(ii)\ CH_3CH_2I + KOH(aq) \longrightarrow \underset{\text{ethanol}}{CH_3CH_2OH} + KI$$

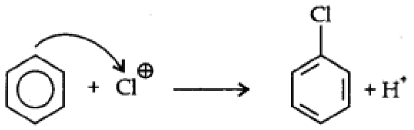
Q12. What are electrophiles? Explain electrophile substitution reaction with the help of example.

Answer: A reagent which can accept an electron pair in a reaction is called an electrophile.
Examples are, H^+, Cl^+, NO_2^+, R_3C^+, $RN_2^{\oplus}$



Mechanism

$$Cl_2 + FeCl_3 \longrightarrow FeCl_4^{\ominus} + Cl^{\oplus}$$



Q13. **0.15 g of an organic compound gave 0.12 g of Ag Br by the Carius method. Find percentage of Br in the compound.**

Answer:

$$\% \text{ of Br} = \frac{80}{188} \times \frac{\text{weight of Ag Br} \times 100}{\text{weight of organic compound}}$$

$$= \frac{80}{188} \times \frac{0.12}{0.15} \times 100$$

$$= 34\%$$

Q14. **(a) What is Lassaigne's extract? Will NaCN give a positive Lassaigne's test for nitrogen?**
(b) Which colour will appear in the Lassaigne's test if the compound contains both nitrogen and sulphur.
(c) Why is Lassaigne's extract prepared in distilled water? Can we detect oxygen in a compound by Lassaigne's test?
Answer: (a) When organic compound is fused with sodium metal and then extracted by water, it is called Lassaigne's extract. Yes.
(b) Blood red colour.
(c) Lassaigne's extract is prepared in distilled water since tap water contains CL ions. No, oxygen cannot be detected by Lassaigne's test

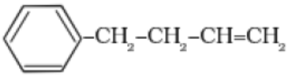
Q15.Write IUPAC names of the following compounds

a. $CH_3CH = C(CH_3)_2$

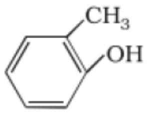
b. $CH_2 = CH - C \equiv C - CH_3$

c.

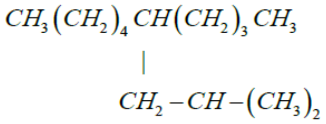
d.



e.

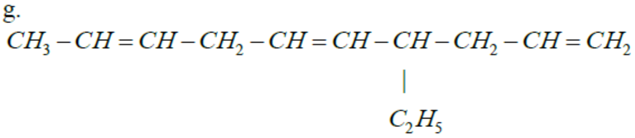


f.



$$\begin{array}{l} CH_3(CH_2)_4CH(CH_2)_3CH_3 \\ \qquad\quad | \\ \qquad CH_2-CH-(CH_3)_2 \end{array}$$

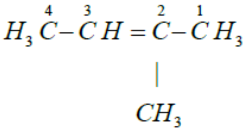
g.



$$\begin{array}{l} CH_3-CH=CH-CH_2-CH=CH-\underset{\displaystyle C_2H_5}{\underset{|}{CH}}-CH_2-CH=CH_2 \end{array}$$

Answer:

(a)



$$\overset{4}{H_3C}-\overset{3}{C}H=\underset{\displaystyle CH_3}{\underset{|}{\overset{2}{C}}}-\overset{1}{C}H_3$$

IUPAC name: 2-Methylbut-2-ene

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

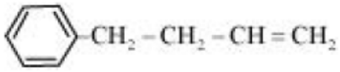
IUPAC name: Pen-1-en-3-yne

(c)

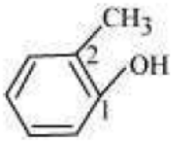
IUPAC name: 1, 3-Butadiene or Buta-1,3-diene

(d)

:

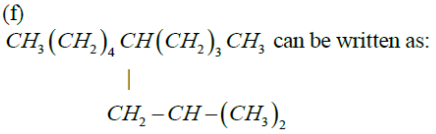


IUPAC name: 4-Phenylbut-1-ene

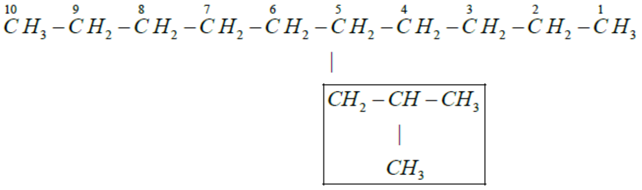


(e)
IUPAC name: 2-Methylphenol

(f)



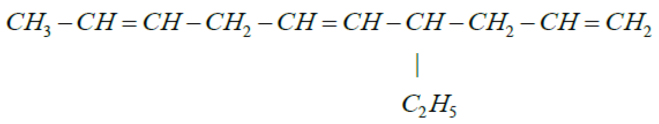
$$\begin{array}{l} CH_3(CH_2)_4CH(CH_2)_3CH_3 \text{ can be written as:} \\ \qquad\quad | \\ \qquad CH_2-CH-(CH_3)_2 \end{array}$$



$$\overset{10}{C}H_3-\overset{9}{C}H_2-\overset{8}{C}H_2-\overset{7}{C}H_2-\overset{6}{C}H_2-\overset{5}{C}H_2-\overset{4}{C}H_2-\overset{3}{C}H_2-\overset{2}{C}H_2-\overset{1}{C}H_3$$

$$\boxed{\begin{array}{c} CH_2-CH-CH_3 \\ | \\ CH_3 \end{array}}$$

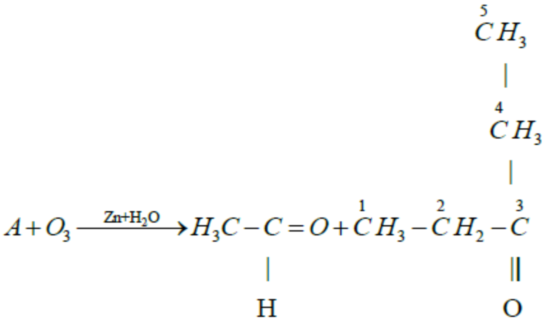
IUPAC name: 5-(2-Methylpropyl)decane
(g)



$$CH_3-CH=CH-CH_2-CH=CH-\underset{\underset{C_2H_5}{|}}{CH}-CH_2-CH=CH_2$$

IUPAC name: 4-Ethyldeca-1, 5, 8-triene

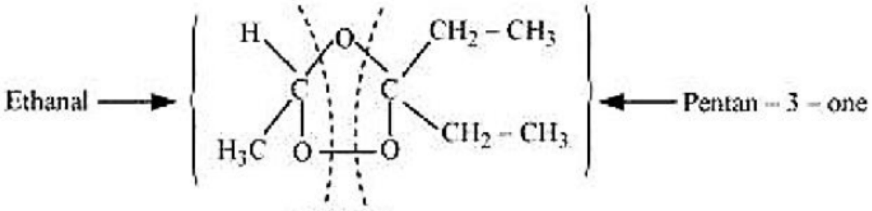
Q16. An alkene 'A' on ozonolysis gives a mixture of ethanal and pentan-3-one. Write structure and IUPAC name of 'A'.
Answer:



$$A+O_3 \xrightarrow{Zn+H_2O} \underset{\underset{H}{|}}{H_3C}-C=O+\overset{1}{C}H_3-\overset{2}{C}H_2-\underset{\underset{O}{\|}}{\overset{\overset{\overset{5}{C}H_3}{|}}{\overset{\overset{\overset{4}{C}H_3}{|}}{\overset{3}{C}}}}}$$

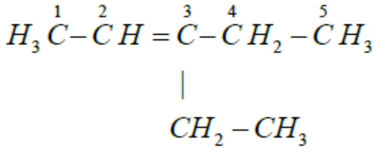
Ethanal Pentan-3-one

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:



Ozonide

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:



$$H_3\overset{1}{C}-\overset{2}{C}H=\underset{\underset{CH_2-CH_3}{|}}{\overset{3}{C}}-\overset{4}{C}H_2-\overset{5}{C}H_3$$

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

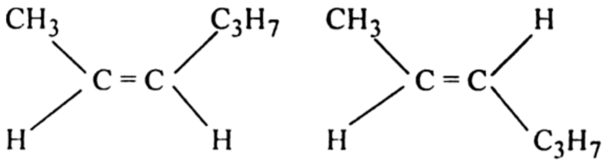
TRY Itself Q17. Write chemical equations for combustion reaction of the following hydrocarbons:
(i) Butane
(ii) Pentene
(iii) Hexyne
(iv) Toluene

Q18. Draw the cis and trans structures of hex-2-ene. Which isomer will have higher b.p. and why?
Answer:

Hex-2-ene is represented as:

$H_3C-HC=CH-CH_2-CH_2-CH_3$

Geometrical isomers of hex-2-ene are:



cis-Hex-2-ene trans-Hex-2-ene

The dipole moment of cis-compound is a sum of the dipole moments of C–CH3 and C– $CH_2CH_2CH_3$ bonds acting in the same direction. The dipole moment of trans-compound is the resultant of the dipole moments of C–CH_3 and C–$CH_2CH_2CH_3$ 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.

Q19. Why is benzene extra ordinarily stable though it contains three double bonds?

Answer: The six π electrons are delocalized and can move freely about the six carbon nuclei. Even after the presence of three double bonds, these delocalized π-electrons stabilize benzene.

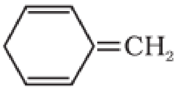
Q20. What are the necessary conditions for any system to be aromatic?

Answer:

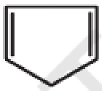
A compound is said to be aromatic if it satisfies the following conditions:
(i) It should have a planar structure.
(ii) It should be cyclic.
(ii) The π –electrons of the compound are completely delocalized in the ring.
(iii) The total number of π –electrons present in the ring should be equal to (4*n*+ 2) π , where *n* = 0, 1, 2 … etc. This is known as Huckel's rule.

Q21. Explain why the following systems are not aromatic?

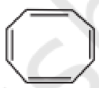
(i)



(ii)

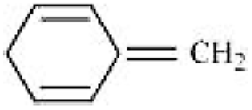


(iii)

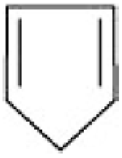


Answer:

(i) In the given compound, one carbon atom is sp^3 hybridized which is tetrahedral (not planar). While for the compound to be aromatic, it should be planar. Hence the given compound is not
aromatic in nature.

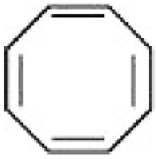


(ii) In the given compound, one carbon atom is sp3 hybridized which is tetrahedral (not planar).
While for the compound to be aromatic, it should be planar.
For the given compound, the number of electrons is 4.
By Huckel's rule,



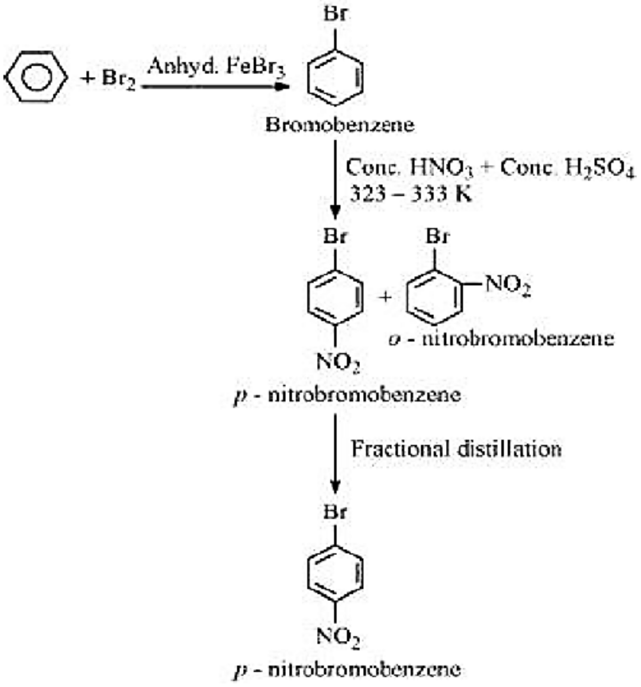
$4n + 2 = 4$
$4n = 2$
$n = ½$ For a compound to be aromatic, the value of *n* must be an integer (*n* = 0, 1, 2…), which is not true for the given compound and it is not planar. Hence, it is not aromatic in nature.

(iii)

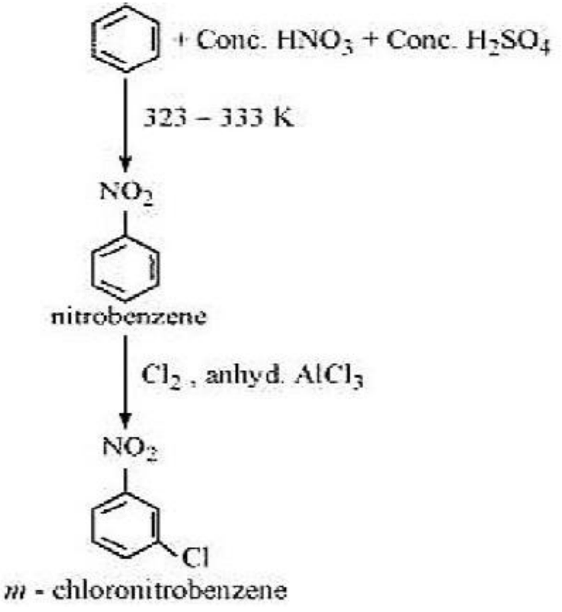


For the given compound, the number of π -electrons is 8.
By Huckel's rule,
$4n + 2 = 8$
$4n = 6$
$N=3/2$ For a compound to be aromatic, the value of *n* must be an integer (*n* = 0, 1, 2…). Since the value of *n* is not an integer, the given compound is not aromatic in nature.

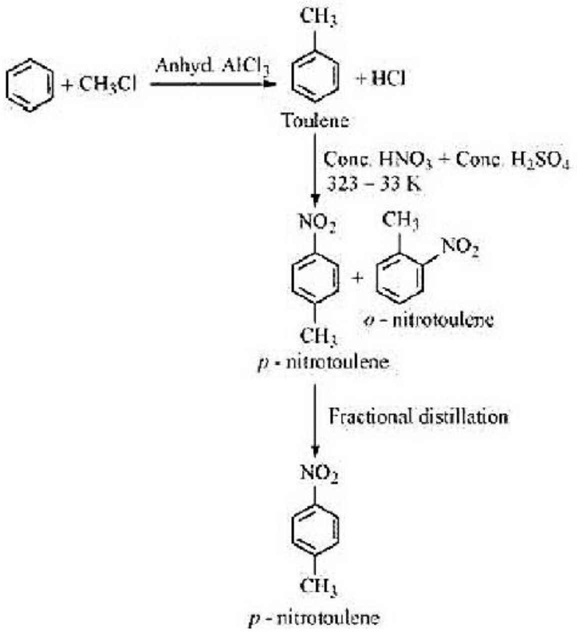
Q22. How will you convert benzene into
(i) *p*-nitrobromobenzene
(ii) *m*-nitrochlorobenzene
(iii) *p* -nitrotoluene
(iv) acetophenone
Answer:



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



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



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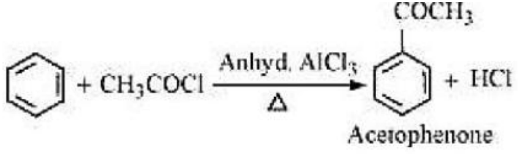
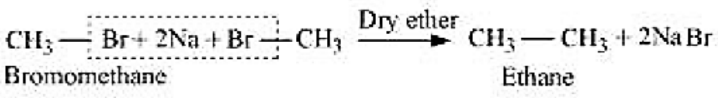
(iv) Benzene can be converted into acetophenone as:



Q23. Why is Wurtz reaction not preferred for the preparation of alkanes containing odd number of carbon atoms? Illustrate your answer by taking one example.

Answer : 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.



$$CH_3-\boxed{Br + 2Na + Br}-CH_3 \xrightarrow{\text{Dry ether}} CH_3-CH_3 + 2NaBr$$

Bromomethane Ethane

Q1.Assign oxidation number to the underlined elements in each of the following species:

(a) $NaH_2\underline{P}O_4$ (b) $NaH\underline{S}O_4$ (c) $H_4\underline{P}_2O_7$ (d) $K_2\underline{Mn}O_4$
(e) $Ca\underline{O}_2$ (f) $Na\underline{B}H_4$ (g) $H_2\underline{S}_2O_7$ (h) $KAl(\underline{S}O_4)_2.12H_2O$

Answer:

(a) P in $\overset{+1}{Na}\,\overset{+1}{H_2}\,\overset{x}{P}\,\overset{-2}{O_4}$

$$(+1) + 2(+1) + x + 4(-2) = 0$$
$$x + 3 - 8 \text{ or } x = +5$$

(b) S in $NaHSO_4$

$\overset{+1}{Na}\,\overset{+1}{H}\,\overset{x}{S}\,\overset{-2}{O_4}$

$$(+1) + (+1) + x + 4(-2) = 0$$
$$x - 6 = 0$$
$$x = +6$$

(c) P in $H_4P_2O_7$

$\overset{+1}{H_4}\,\overset{x}{P_2}\,\overset{-2}{O_7}$

$$4(+1) + 2x + 7(-2) = 0$$
$$2x - 10 = 0$$
$$x = +5$$

(d) Mn in K_2MnO_4

$\overset{+1}{K_2}\overset{x}{Mn}\overset{-2}{O_4}$

$$2(+1) + x + 4(-2) = 0$$
$$x - 6 = 0$$
$$x = +6 \text{ oxygen.}$$

(e) Let the oxidation number of CaO_2 be x.

$$2 + 2x = 0 \qquad (\because \text{ oxy No. of } a = +2)$$
$$x = -1$$

Thus, oxidation number of O in CaO_2 = **–1.**

(f) In $NaBH_4$, H is present as hydride ion. Therefore, its oxidation number is –1. Thus,

$\overset{+1}{Na}\,\overset{x}{B}\,\overset{-1}{H_4}$ $\therefore$ $1(+1) + x + 4(-1) = 0$ or $x = +3$

Thus, the oxidation number of B in $NaBH_4$ = **+ 3.**

(g) $\overset{+1}{H_2}\,\overset{x}{S_2}\,\overset{-2}{O_7}$ $\therefore$ $2(+1) + 2(x) + 7(-2) = 0$ or $x = +6$

Thus, the oxidation number of S in $H_2S_2O_7$ = **+ 6.**

(h) $\overset{+1}{K}\,\overset{+3}{Al}\,(\overset{x}{S}\,\overset{-2}{O_4})_2\,12\,(\overset{+1}{H_2}\,\overset{-2}{O})$ or $+1 + 3 + 2x + 8(-2) + 12(2 \times 1 - 2)$ or $x = +6$

Alternatively, since H_2O is a neutral molecule, therefore, sum of oxidation numbers of all the atoms in H_2O may be taken as zero. As such water molecules may be ignored white computing the oxidation number of S.

$\therefore + 1 + 3 + 2x - 16 = 0$ or $x = +6$

Thus, the oxidation number of S in $KAl(SO_4)_2.12H_2O$ = **+6.**

Q2.What are the oxidation number of the underlined elements in each of the following and how do you rationalise your results ?

(a) $K\underline{I}_3$ (b) $H_2\underline{S}_4O_6$ (c) $\underline{Fe}_3O_4$ (d) $CH_3\underline{C}H_2OH$ (e) $CH_3\underline{C}OOH$.

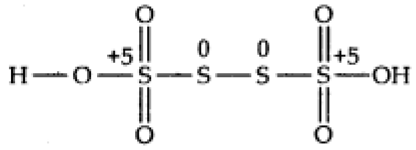
Answer: (a) In KI_3, since the oxidation number of K is +1, therefore, the average oxidation number of iodine = -1/3. But the oxidation number cannot be fractional. Therefore, we must consider its structure, $K^+[I — I <— I]^-$. Here, a coordinate bond is formed between I_2 molecule and I^- ion. The oxidation number of two iodine atoms forming the I_2 molecule is zero while that of iodine forming the coordinate bond is -1. Thus, the O.N. of three I atoms, atoms in KI_3 are 0, 0 and -1 respectively.

(*b*) *By conventional method.* O.N. of S in $H_2S_4O_6 = \overset{+1}{H_2}\,\overset{x}{S_4}\,\overset{-2}{O_6}$

or $2(+1) + 4x + 6(-2) = 0$ or $x = +2.5$ (*wrong*)

But it is wrong because all the four S atoms cannot be in the same oxidation state.

By chemical bonding method. The structure of $H_2S_4O_6$ is shown below:



The O.N. of each of the S-atoms linked with each other in the middle is zero while that of each of the remaining two S-atoms is +5.

(*c*) *By conventional method.* O.N. of Fe in $\overset{x}{Fe_3}\,\overset{-2}{O_4}$ or $3x + 4(-2) = 0$ or $x = 8/3$.

By stoichiometry. $Fe_3O_4 \equiv \overset{+2}{Fe_3}\,\overset{-2}{O}\cdot\overset{+3}{Fe_2}\,\overset{-2}{O_3}$.

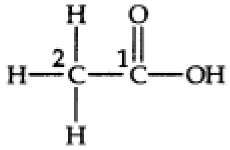
$\therefore$ O.N. of Fe in Fe_3O_4 is + 2 and + 3

(*d*) *By conventional method.* O.N. of C in $CH_3CH_2OH = \overset{x}{C_2}\,\overset{+1}{H_6}\,\overset{-2}{O}$

or $2x + 6(+1) + 1(-2) = 0$ or $x = -2$.

(*e*) *By conventional method.* $CH_3COOH = \overset{x}{C_2}\,\overset{+1}{H_4}\,\overset{-2}{O_2}$ or $2x + 4 - 4 = 0$ or $x = 0$

By chemical bonding method, C_2 is attached to three *H*-atoms (less electronegative than carbon) and one—COOH group (more electronegative than carbon).



therefore, O.N. of $C_2 = 3(+1) + x + 1(-1) = 0$ or $x = -2$

C_1 is, however, attached to one oxygen atom by a double bond, one OH (O.N. = −1) and one CH_3 (O.N. = +1) group, therefore, O.N. of $C_1 = +1 + x + 1(-2) + 1(-1) = 0$ or $x = +2$

Q3. **Identify the substance oxidised, reduced, oxidising agent and reducing agent for each of the following reactions.**

(*a*) $2AgBr(s) + C_6H_6O_2(aq) \longrightarrow 2Ag(s) + 2HBr(aq) + C_6H_4O_2(aq)$

(*b*) $HCHO(l) + 2[Ag(NH_3)_2]^+(aq) + 3OH^-(aq) \longrightarrow 2Ag(s) + HCOO^-(aq) + 4NH_3(aq) + 2H_2O(l)$

(*c*) $HCHO(l) + 2Cu^{2+}(aq) + 5OH^-(aq) \longrightarrow Cu_2O(s) + HCOO^-(aq) + 3H_2O(l)$

(*d*) $N_2H_4(l) + 2H_2O_2(l) \longrightarrow N_2(g) + 4H_2O(l)$

(*e*) $Pb(s) + PbO_2(s) + 2H_2SO_4(aq) \longrightarrow 2PbSO_4(s) + 2H_2O(l)$

Answer:

	Substance oxidised	**Substance reduced**	**Oxidising agent**	**Reducing agent**
(*a*)	$C_6H_6O_2(aq)$	$AgBr(s)$	$AgBr(s)$	$C_6H_6O_2(aq)$
(*b*)	$HCHO(aq)$	$[Ag(NH_3)_2]^+$	$[Ag(NH_3)_2]^+$	$HCHO(aq)$
(*c*)	$HCHO(aq)$	$Cu^{2+}(aq)$	$Cu^{2+}(aq)$	$HCHO(aq)$
(*d*)	$N_2H_4(l)$	$H_2O_2(l)$	$H_2O_2(l)$	$N_2H_4(l)$
(*e*)	$Pb(s)$	$PbO_2(s)$	$PbO_2(s)$	$Pb(s)$

Vimp.Q4. **Balance the following redox reactions by ion-electron method.**

(a) MnO_4^-(aq) +I^-(aq) ———>MnO_2(s) + I_2 (s) (in basic medium)

(b) MnO_4^-(aq) + S02(g) ——-> Mn^{2+}(aq) +$H_2SO_4^-$(in acidic solution)

(c) H_2O_2(aq) + Fe2+(aq) ———-> Fe^3+(aq) + H_2O(l) (in acidic solution)

(d) $Cr_2O_7^{2-}$ (aq) + SO_2 (g)——> Cr^{3+} (aq) + SO_4^{2-}(aq) (in acidic solution)

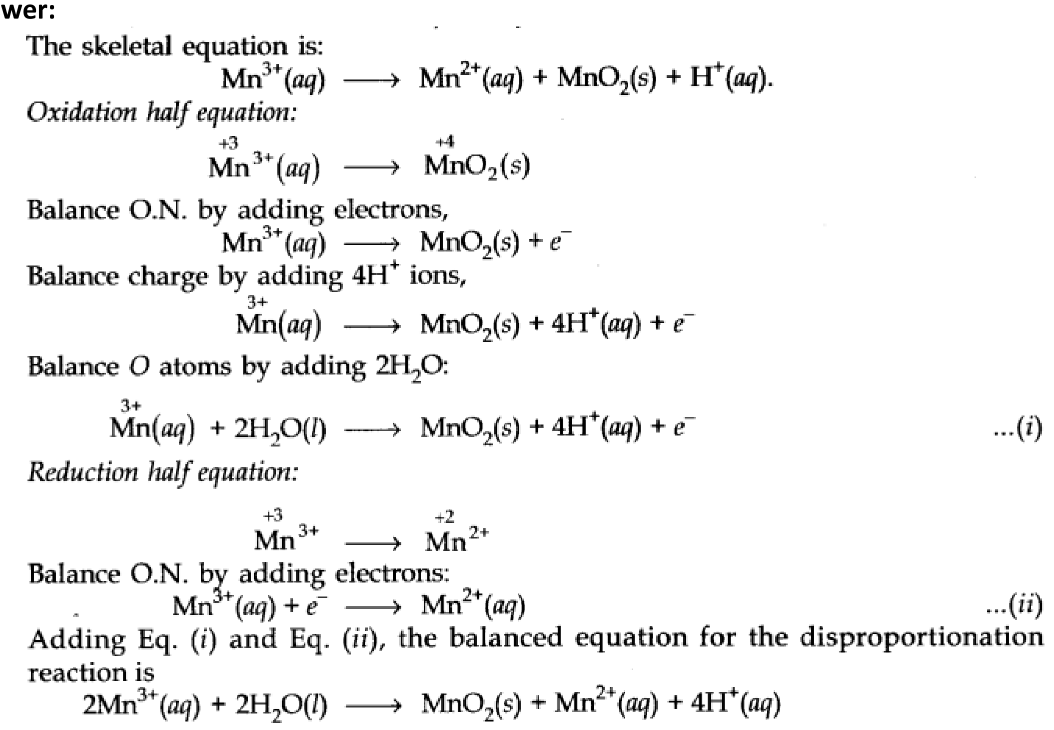
Answer: (a) Do it yourself.

(b) The balanced half reaction equations are:
Oxidation half equation:
$S0_2(g) + 2H_2O(l) \longrightarrow HS0_4^-(aq) + 3H^+(aq) + 2e^-$ ...(i)
Reduction half equation:
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \longrightarrow Mn^{2+}(aq) + 4H_2O(l)$ ....(ii)
Multiply Eq. (i) by 3 and Eq. (ii) by 2 and add, we have,
$2MnO_4^-(aq) + 5S0_2(g) + 2H_20(l) + H^+(aq) \longrightarrow 2Mn^{2+}(aq) + 5HSO_4^-(aq)$

(c) Oxidation half equation: $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-$ ...(i)
Reduction half equation: $H_2O_2(aq) + 2H^+(aq) + 2e^- \longrightarrow 2H_2O(l)$ ...(ii)
Multiply Eq. (i) by 2 and add it to Eq. (ii), we have,
$H_2O_2(aq) + 2Fe^{2+}(aq) + 2H^+(aq) \longrightarrow 2Fe^{3+}(aq) + 2H_2O(l)$

(d) Following the procedure detailed on page 8/23, the balanced half reaction equations are:
Oxidation half equation:
$SO_2(g) + 2H_2O(l) \longrightarrow SO_4^{2-}(aq) + 4H^+(aq) + 2e^-$ ...(i)
Reduction half equation:
$Cr_2O_72^-(aq) + 14H^+(aq) + 6e^- \longrightarrow 2Cr^{3+}(aq) + 7H_20(l)$ ...(ii)
Multiply Eq. (i) by 3 and add it to Eq. (ii), we have,
$Cr_2O_72^-(aq) + 3SO_2(q) + 2H^+(aq) \longrightarrow 2Cr^{3+}(aq) + 3SO_4^{2-}(aq) + H_20(l)$

Q5. **The Mn^{3+} ion is unstable in solution and undergoes disproportionation to give Mn^{2+}, MnO_2 and H^+ ion. Write a balanced ionic equation for the reaction.**
Answer:



The skeletal equation is:
$$Mn^{3+}(aq) \longrightarrow Mn^{2+}(aq) + MnO_2(s) + H^+(aq).$$
Oxidation half equation:
$$\overset{+3}{Mn}{}^{3+}(aq) \longrightarrow \overset{+4}{Mn}O_2(s)$$
Balance O.N. by adding electrons,
$$Mn^{3+}(aq) \longrightarrow MnO_2(s) + e^-$$
Balance charge by adding $4H^+$ ions,
$$\overset{3+}{Mn}(aq) \longrightarrow MnO_2(s) + 4H^+(aq) + e^-$$
Balance *O* atoms by adding $2H_2O$:
$$\overset{3+}{Mn}(aq) + 2H_2O(l) \longrightarrow MnO_2(s) + 4H^+(aq) + e^- \quad ...(i)$$
Reduction half equation:
$$\overset{+3}{Mn}{}^{3+} \longrightarrow \overset{+2}{Mn}{}^{2+}$$
Balance O.N. by adding electrons:
$$Mn^{3+}(aq) + e^- \longrightarrow Mn^{2+}(aq) \quad ...(ii)$$
Adding Eq. (*i*) and Eq. (*ii*), the balanced equation for the disproportionation reaction is
$$2Mn^{3+}(aq) + 2H_2O(l) \longrightarrow MnO_2(s) + Mn^{2+}(aq) + 4H^+(aq)$$

Q6.Using the standard electrode potentials given in Table 8.1, predict if the reaction between the following is feasible:
(a) Fe^{3+}(aq) and I-(aq) **(b) Ag^+ (aq) and Cu(s)**
(c) Fe^{3+}(aq) and Cu(s) **(d)Ag(s) and Fe^{3+}(aq)**
(e) Br_2 (aq) and Fe^{3+} (aq).
Answer: (a 7)
Overall reaction: $2Fe^{3+}(aq) + 2I^-(aq) \longrightarrow 2Fe^{2+}(aq) + I_2(s)$; E° = + 0.23 V
Since the EMF for the above reaction is positive, therefore, the above reaction is feasible.

(b) The possible reaction between $Ag^+(aq)$ and Cu(s) is $Cu(s) + 2Ag^+(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$

Oxidation: $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$; $E° = -0.34$ V
Reduction: $Ag^+(aq) + e^- \longrightarrow Ag(s)] \times 2$; $E° = +0.80$ V

Overall reaction: $Cu(s) + 2Ag^+(aq) \longrightarrow Cu^{2+}(aq) + 2Ag(s)$; $E° =$ **+0.46 V**

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equation.

$$Cu(s) + 2Fe^{3+}(aq) \longrightarrow 3Cu^{2+}(aq) + 2Fe^{2+}(aq)$$

The above reaction can be split into the following two half reactions. Writing electrode potential for each half reaction from Table **8.1,** we have,

Oxidation: $Cu(s) \longrightarrow Cu^{2+}(aq) + 2e^-$; $E° = -0.34$ V
Reduction: $Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)] \times 2$; $E° = +0.77$ V

Overall reaction: $Cu(s) + 2Fe^{3+}(aq) \longrightarrow Cu^{2+}(aq) + 2Fe^{2+}(aq)$; $E° =$ **+0.43 V**
Since the EMF of the reaction is positive, therefore, *the above reaction is feasible.*

(d)

equation:

$$Ag(s) + Fe^{3+}(aq) \longrightarrow Ag^+(aq) + Fe^{2+}(aq)$$

The above reaction can be split into the following two half reactions. Writing electrode potential for each half reaction from Table **8.1,** we have,

Oxidation: $Ag(s) \longrightarrow Ag^+(aq) + e^-$; $E° = -0.80$ V
Reduction: $Fe^{3+}(aq) + e^- \longrightarrow Fe^{2+}(aq)$; $E° = +0.77$ V

Overall reaction: $Ag(s) + Fe^{3+}(aq) \longrightarrow Ag^+(aq) + Fe^{2+}(aq)$; $E° = -0.03$ V
Since the EMF of the reaction is **negative,** therefore, the above reaction is *not feasible.*

(e)

The above reaction can be split into the following two half reactions. Writing electrode potential for each half reaction from the Table **8.1,** we have

Oxidation: $Fe^{2+}(aq) \longrightarrow Fe^{3+}(aq) + e^-] \times 2$; $E° = -0.77$ V
Reduction: $Br_2(aq) + 2e^- \longrightarrow 2Br^-(aq)$; $E° = +1.09$ V

Overall reaction: $2Fe^{2+}(aq) + Br_2(aq) \longrightarrow 2Fe^{3+}(aq) + 2Br^-(aq)$; $E° = +0.32$ V
Since the EMF for the above reaction is **positive,** therefore, *this reaction is feasible.*

Q7. **Given the standard electrode potentials,**
$K^+/K = -2.93$ V, $Ag^+/Ag = 0.80$ V, $Hg^{2+}/Hg = 0.79$ V, $Mg^{2+}/Mg = -2.37$ V,
$Cr^{3+}/Cr = -0.74$ V. Arrange these metals in increasing order of their reducing power.

Answer: **Lower the electrode potential, better is the reducing agent**. Since the electrode potentials increase in the oder; K^+/K (-2.93 V), Mg^{2+}/Mg (-2.37 V), Cr^{3+}/Cr (-0.74 V), Hg^{2+}/Hg (0.79 V), Ag^+/Ag (0.80 V), therefore, reducing power of metals decreases in the same order, i.e., K, Mg, Cr, Hg, Ag.

What is meant by cell potential?

Answer: It is the difference in Standard Reduction Potential (SRP) of cathode and SRP of anode.

$$E°_{\text{cell}} = E°_{\text{catode (SRP)}} - E°_{\text{anode (SRP)}}$$

How can CuS0₄ solution not be stored in an iron vessel?

Answer:

It is because $E°\ Fe^{2+}/Fl = -0.44$ V which is lower than that of Cu.

$$\begin{aligned} E°_{\text{Cell}} &= E°_{Cu^{2+}/Cu} - E°_{Fe^{2+}/Fe} \\ &= +0.34\text{ V} - (-0.44\text{ V}) \\ &= 0.78\text{ V} \end{aligned}$$

Since, $E°_{\text{Cell}} = +\text{ve}$, $\Delta G = -\text{ve}$

i.e., reaction will take place, we cannot store $CuSO_4$ in an iron container.

Write the cell reactions:

$Zn \mid Zn^{2+}(1M) \parallel Cd^{2+}(1M) \mid Cd$
$E°\ Zn^{2+}/Zn = -0.76$ V, $E°\ Cd^{2+}/Cd = 0.40$ V

Answer:

At anode: $Zn(s) \longrightarrow Zn^{2+}(aq) + 2e^-$
At cathode: $Cd^{2+}(aq) + 2e^- \longrightarrow Cd(s)$

$$Zn(s) + Cd^{2+}(aq) \longrightarrow Zn^{2+}(aq) + Cd(s)$$