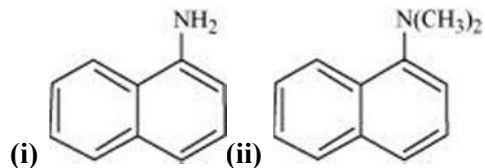


AMINES [4 marks]

Question 13.1: Classify the following amines as primary, secondary or tertiary:



(iii) $(C_2H_5)_2CHNH_2$ (iv) $(C_2H_5)_2NH$

Answer Primary: (i) and (iii) Secondary: (iv) Tertiary: (ii)

Question 13.2: (i) Write structures of different isomeric amines corresponding to the molecular formula, $C_4H_{11}N$

(ii) Write IUPAC names of all the isomers.

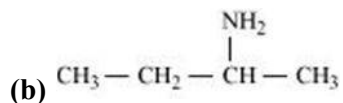
(iii) What type of isomerism is exhibited by different pairs of amines?

Answer

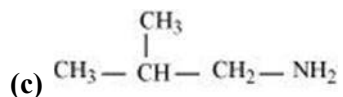
(i), (ii) The structures and their IUPAC names of different isomeric amines corresponding to the molecular formula, $C_4H_{11}N$ are given below:

(a) $CH_3-CH_2-CH_2-CH_2-NH_2$

Butanamine (1^0)

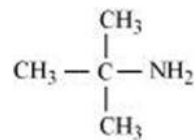


Butan-2-amine (1^0)



2-Methylpropanamine (1^0)

(d)



2-Methylpropan-2-amine (1^0)

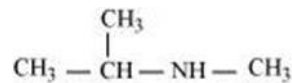
(e) $CH_3-CH_2-CH_2-NH-CH_3$

N-Methylpropanamine (2^0)

(f) $CH_3-CH_2-NH-CH_2-CH_3$

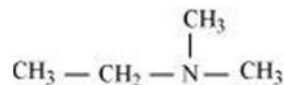
N-Ethylethanamine (2^0)

(g)



N-Methylpropan-2-amine (2^0)

(h)



N,N-Dimethylethanamine (3^0)

(iii) The pairs (a) and (b) and (e) and (g) exhibit position isomerism.

The pairs (a) and (c); (a) and (d); (b) and (c); (b) and (d) exhibit chain isomerism.

The pairs (e) and (f) and (f) and (g) exhibit metamerism.

All primary amines exhibit functional isomerism with secondary and tertiary amines and vice-versa.

Question 13.3: How will you convert?

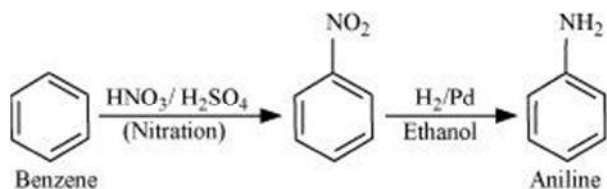
(i) Benzene into aniline

(ii) Benzene into N, N-dimethylaniline

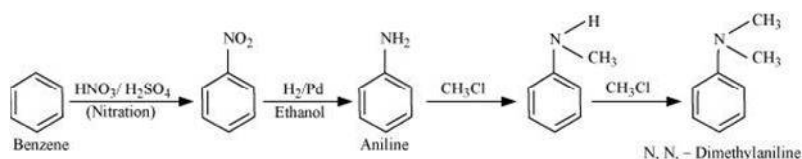
(iii) Cl-(CH₂)₄-Cl into hexan-1, 6-diamine?

Answer

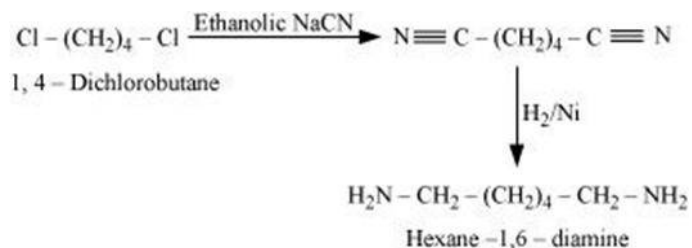
(i)



(ii)



(iii)

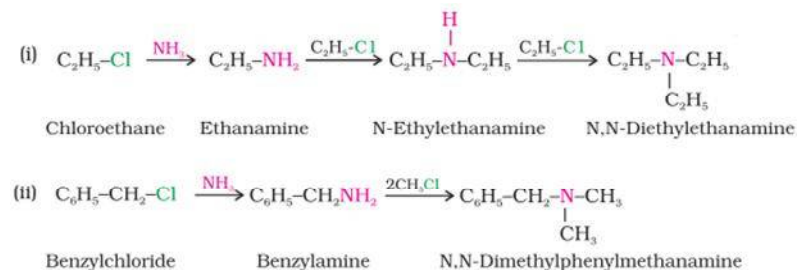


Question 13.4 Write chemical equations for the following reactions:

(i) Reaction of ethanolic NH₃ with C₂H₅Cl.

(ii) Ammonolysis of benzyl chloride and reaction of amine so formed with two moles of CH₃Cl.

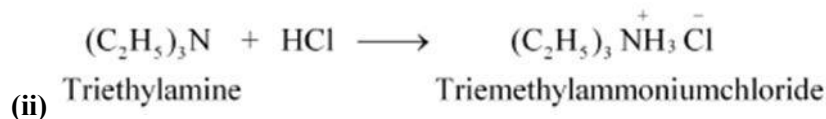
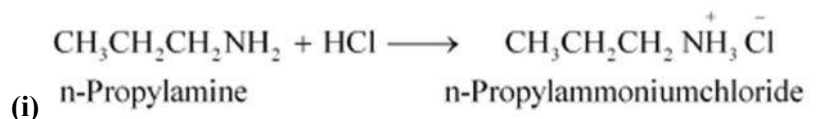
Answer



13.5 Complete the following acid-base reactions and name the products:

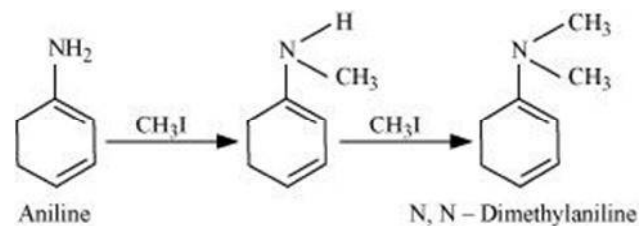


Answer

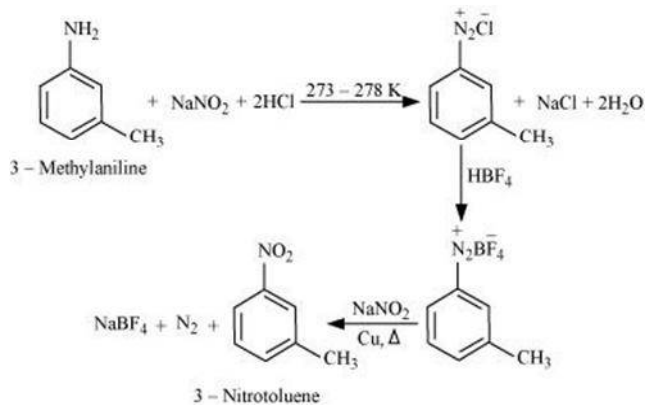


Question 13.6: Write reactions of the final alkylation product of aniline with excess of methyl iodide in the presence of sodium carbonate solution.

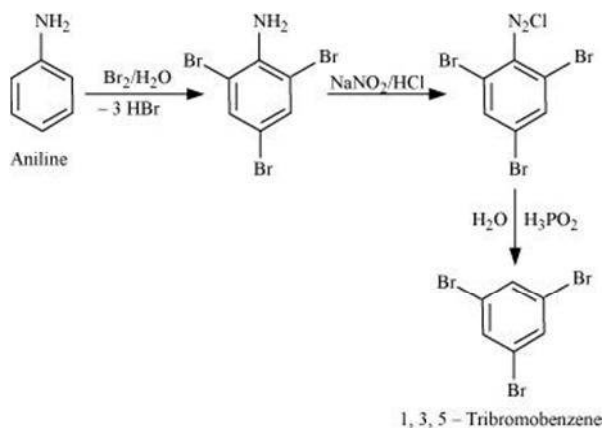
Answer Aniline reacts with methyl iodide to produce N, N-dimethylaniline.



With excess methyl iodide, in the presence of Na₂CO₃ solution, N, N-dimethylaniline produces N, N, N-trimethylanilinium carbonate.



(ii)



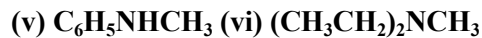
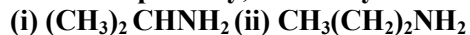
Q 13.10 Arrange the following in decreasing order of their basic strength:



Answer The decreasing order of basic strength of the above amines and ammonia follows the following order:



Q13.11: Write IUPAC names of the following compounds and classify them into primary, secondary and tertiary amines.



Answer (i) propane 2-amine (1^o amine)

(ii) Propan-1-amine (1^o amine)

(iii) N-Methyl-2-methylethanamine (2^o amine)

(iv) 2-Methylpropan-2-amine (1^o amine)

(v) N-Methylbenzamine or N-methylaniline (2^o amine)

(vi) N-Ethyl-N-methylethanamine (3^o amine)

(vii) 3-Bromobenzenamine or 3-bromoaniline (1^o amine)

Q 13.12: Give one chemical test to distinguish between the following pairs of compounds.

(i) Methylamine and dimethylamine

(ii) Secondary and tertiary amines

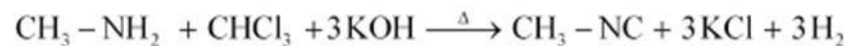
(iii) Ethylamine and aniline

(iv) Aniline and benzylamine

(v) Aniline and N-methylaniline.

Answer (i) Methylamine and dimethylamine can be distinguished by the carbylamine test.

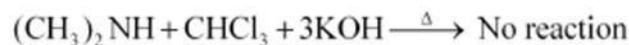
Carbylamine test: Aliphatic and aromatic primary amines on heating with chloroform and ethanolic potassium hydroxide form foul-smelling isocyanides or carbylamines. Methylamine (being an aliphatic primary amine) gives a positive carbylamine test, but dimethylamine does not.



Methylamine (1^o)

Methylisocyanide

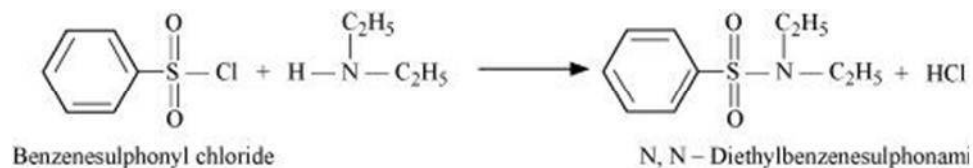
(foul smell)



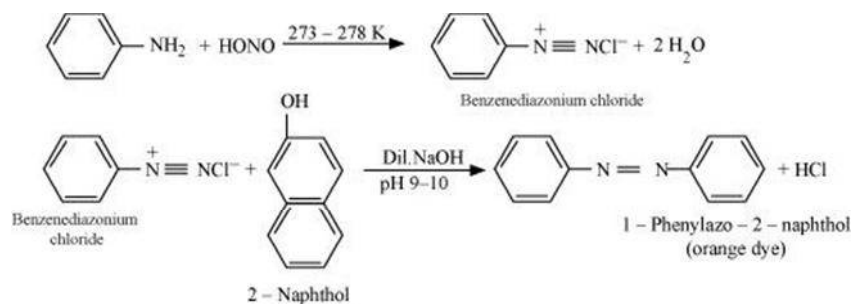
(ii) Secondary and tertiary amines can be distinguished by allowing them to react with Hinsberg's reagent (benzenesulphonyl chloride, C₆H₅SO₂Cl).

Secondary amines react with Hinsberg's reagent to form a product that is insoluble in an alkali. For example, N, N-diethylamine reacts with Hinsberg's reagent to form N, N-diethylbenzenesulphonamide, which is

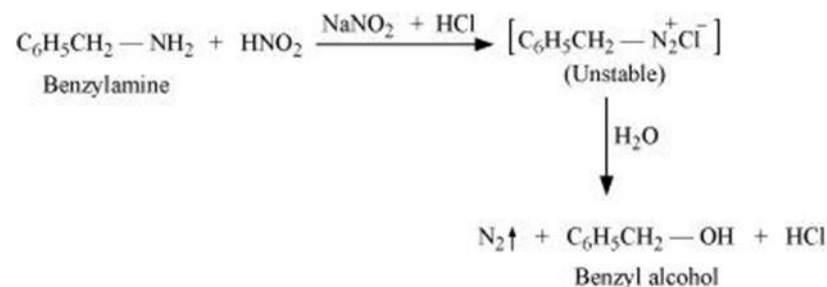
insoluble in an alkali. Tertiary amines, however, do not react with Hinsberg's reagent.



(iii) Ethylamine and aniline can be distinguished using the azo-dye test. A dye is obtained when aromatic amines react with HNO_2 ($\text{NaNO}_2 + \text{dil.HCl}$) at $0-5^\circ\text{C}$, followed by a reaction with the alkaline solution of 2-naphthol. The dye is usually yellow, red, or orange in colour. Aliphatic amines give a brisk effervescence due (to the evolution of N_2 gas) under similar conditions.



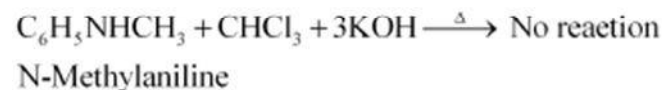
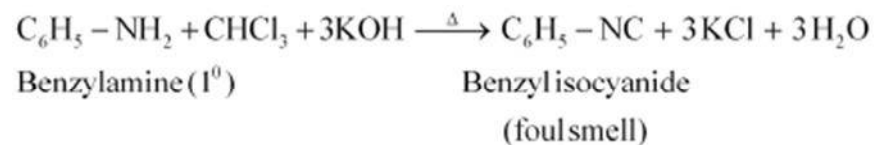
(iv) Aniline and benzylamine can be distinguished by their reactions with the help of nitrous acid, which is prepared in situ from a mineral acid and sodium nitrite. Benzylamine reacts with nitrous acid to form unstable diazonium salt, which in turn gives alcohol with the evolution of nitrogen gas.



On the other hand, aniline reacts with HNO_2 at a low temperature to form stable diazonium salt. Thus, nitrogen gas is not evolved.



(v) Aniline and N-methylaniline can be distinguished using the Carbylamine test. Primary amines, on heating with chloroform and ethanolic potassium hydroxide, form foul-smelling isocyanides or carbylamines. Aniline, being an aromatic primary amine, gives positive carbylamine test. However, N-methylaniline, being a secondary amine does not.



Q 13.13: Account for the following:

(i) $\text{p}K_b$ of aniline is more than that of methylamine.

(ii) Ethylamine is soluble in water whereas aniline is not.

(iii) Methylamine in water reacts with ferric chloride to precipitate hydrated ferric oxide.

(iv) Although amino group is *o*, *p*- directing in aromatic electrophilic substitution reactions, aniline on nitration gives a substantial amount of *m*-nitroaniline.

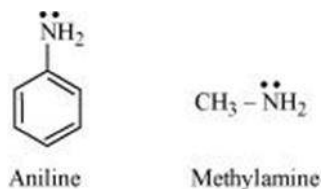
(v) Aniline does not undergo Friedel-Crafts reaction.

(vi) Diazonium salts of aromatic amines are more stable than those of aliphatic amines.

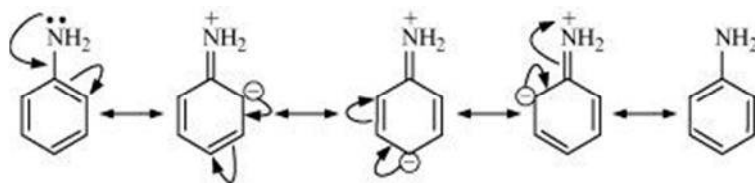
(vii) Gabriel phthalimide synthesis is preferred for synthesising primary amines.

Answer

(i) pK_b of aniline is more than that of methylamine:



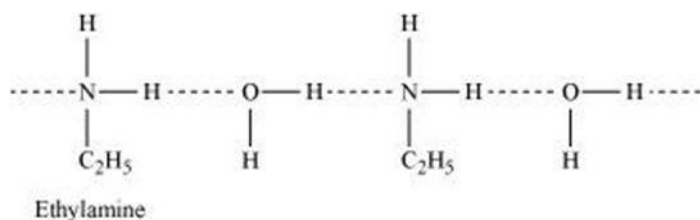
Aniline undergoes resonance and as a result, the electrons on the N-atom are delocalized over the benzene ring. Therefore, the electrons on the N-atom are less available to donate.



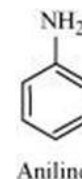
On the other hand, in case of methylamine (due to the +I effect of methyl group), the electron density on the N-atom is increased. As a result, aniline is less basic than methylamine. Thus, pK_b of aniline is more than that of methylamine.

(ii) Ethylamine is soluble in water whereas aniline is not:

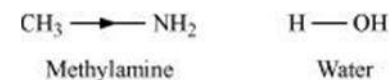
Ethylamine when added to water forms intermolecular H-bonds with water. Hence, it is soluble in water.



But aniline does not undergo H-bonding with water to a very large extent due to the presence of a large hydrophobic $-C_6H_5$ group. Hence, aniline is insoluble in water.



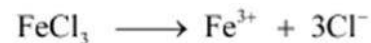
(iii) Methylamine in water reacts with ferric chloride to precipitate hydrated ferric oxide:



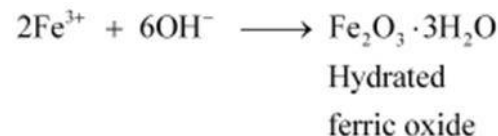
Due to the +I effect of $-CH_3$ group, methylamine is more basic than water. Therefore, in water, methylamine produces OH^- ions by accepting H^+ ions from water.



Ferric chloride (FeCl_3) dissociates in water to form Fe^{3+} and Cl^- ions.



Then, OH^- ion reacts with Fe^{3+} ion to form a precipitate of hydrated ferric oxide.



(iv) Although amino group is *o,p*- directing in aromatic electrophilic substitution reactions, aniline on nitration gives a substantial amount of *m*-nitroaniline:

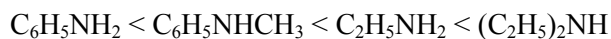
Nitration is carried out in an acidic medium. In an acidic medium, aniline is protonated to give anilinium ion (which is meta-directing).

$C_6H_5NH_2$, $(C_2H_5)_2NH$, $C_2H_5NH_2$.

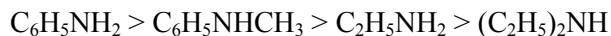
Answer

(i) In $C_2H_5NH_2$, only one $-C_2H_5$ group is present while in $(C_2H_5)_2NH$, two $-C_2H_5$ groups are present. Thus, the +I effect is more in $(C_2H_5)_2NH$ than in $C_2H_5NH_2$. Therefore, the electron density over the N-atom is more in $(C_2H_5)_2NH$ than in $C_2H_5NH_2$. Hence, $(C_2H_5)_2NH$ is more basic than $C_2H_5NH_2$.

Also, both $C_6H_5NHCH_3$ and $C_6H_5NH_2$ are less basic than $(C_2H_5)_2NH$ and $C_2H_5NH_2$ due to the delocalization of the lone pair in the former two. Further, among $C_6H_5NHCH_3$ and $C_6H_5NH_2$, the former will be more basic due to the +T effect of $-CH_3$ group. Hence, the order of increasing basicity of the given compounds is as follows:



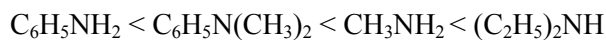
We know that the higher the basic strength, the lower is the pK_b values.



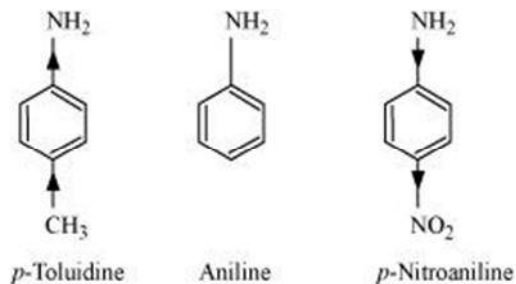
(ii) $C_6H_5N(CH_3)_2$ is more basic than $C_6H_5NH_2$ due to the presence of the +I effect of two $-CH_3$ groups in $C_6H_5N(CH_3)_2$. Further, CH_3NH_2 contains one $-CH_3$ group while $(C_2H_5)_2NH$ contains two $-C_2H_5$ groups. Thus, $(C_2H_5)_2NH$ is more basic than $C_2H_5NH_2$.

Now, $C_6H_5N(CH_3)_2$ is less basic than CH_3NH_2 because of the $-R$ effect of $-C_6H_5$ group.

Hence, the increasing order of the basic strengths of the given compounds is as follows:



(iii) (a)



In p -toluidine, the presence of electron-donating $-CH_3$ group increases the electron density on the N-atom.

Thus, p -toluidine is more basic than aniline.

On the other hand, the presence of electron-withdrawing

$-NO_2$ group decreases the electron density over the N-atom in p -nitroaniline. Thus, p -nitroaniline is less basic than aniline.

Hence, the increasing order of the basic strengths of the given compounds is as follows:



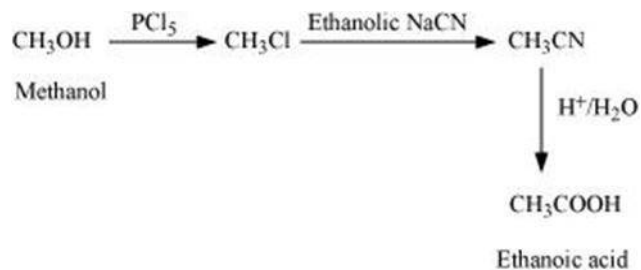
(b) $C_6H_5NHCH_3$ is more basic than $C_6H_5NH_2$ due to the presence of electron-donating $-CH_3$ group in $C_6H_5NHCH_3$.

Again, in $C_6H_5NHCH_3$, $-C_6H_5$ group is directly attached to the N-atom. However, it is not so in $C_6H_5CH_2NH_2$. Thus, in $C_6H_5NHCH_3$, the $-R$ effect of $-C_6H_5$ group decreases the electron density over the N-atom. Therefore, $C_6H_5CH_2NH_2$ is more basic than $C_6H_5NHCH_3$.

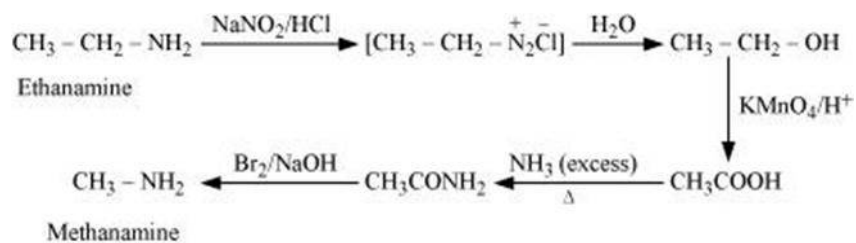
Hence, the increasing order of the basic strengths of the given compounds is as follows:



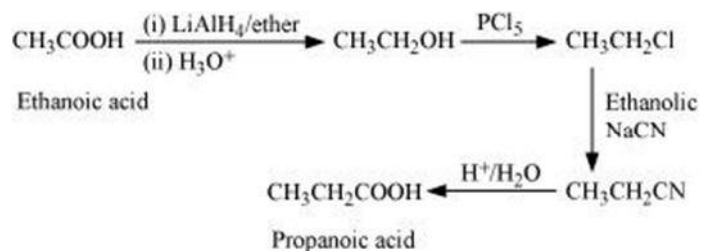
(iv) In the gas phase, there is no solvation effect. As a result, the basic strength mainly depends upon the +I effect. The higher the +I effect, the stronger is the base. Also, the greater the number of alkyl groups, the higher



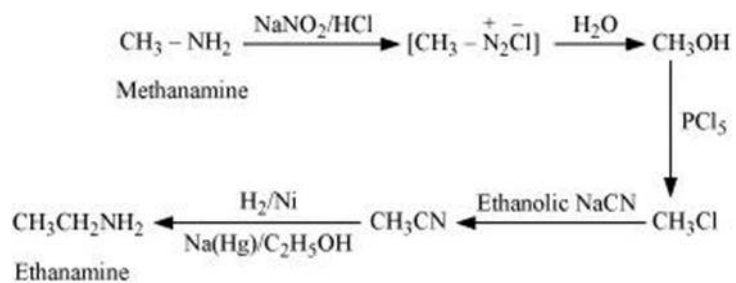
(iv)



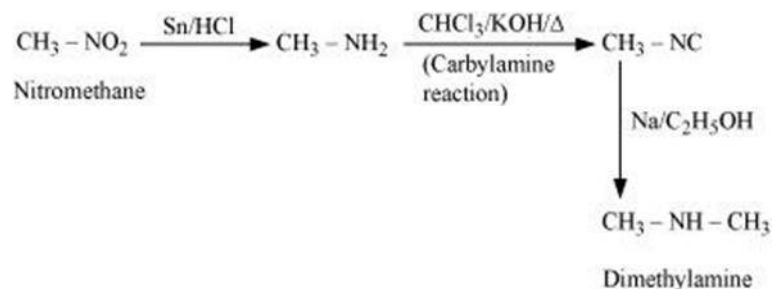
(v)



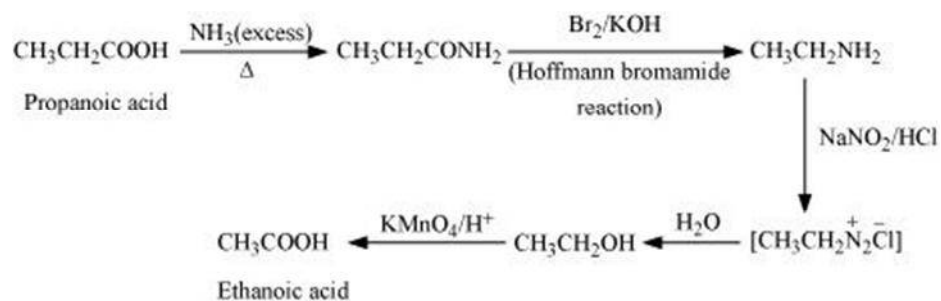
(vi)



(vii)



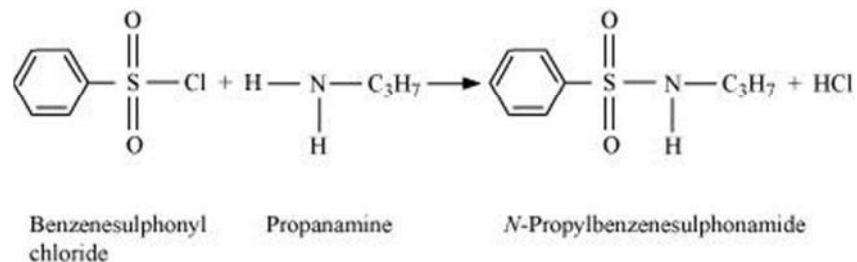
(viii)



Q 13.16: Describe a method for the identification of primary, secondary and tertiary amines. Also write chemical equations of the reactions involved.

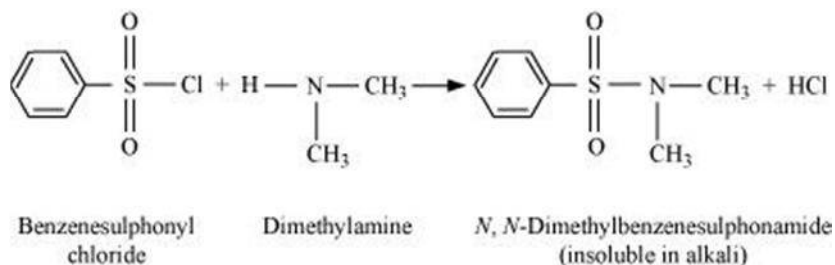
Answer Primary, secondary and tertiary amines can be identified and distinguished by Hinsberg's test. In this test, the amines are allowed to react with Hinsberg's reagent, benzenesulphonyl chloride ($\text{C}_6\text{H}_5\text{SO}_2\text{Cl}$). The three types of amines react differently with Hinsberg's reagent. Therefore, they can be easily identified using Hinsberg's reagent.

Primary amines react with benzenesulphonyl chloride to form N-alkylbenzenesulphonyl amide which is soluble in alkali.



Due to the presence of a strong electron-withdrawing sulphonyl group in the sulphonamide, the H-atom attached to nitrogen can be easily released as proton. So, it is acidic and dissolves in alkali.

Secondary amines react with Hinsberg's reagent to give a sulphonamide which is insoluble in alkali.



There is no H-atom attached to the N-atom in the sulphonamide. Therefore, it is not acidic and insoluble in alkali.

On the other hand, tertiary amines do not react with Hinsberg's reagent at all.

Q 13.17: Write short notes on the following:

(i) Carbylamine reaction (ii) Diazotisation

(iii) Hofmann's bromamide reaction (iv) Coupling reaction

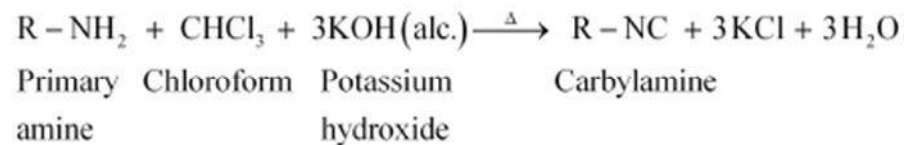
(v) Ammonolysis (vi) Acetylation

(vii) Gabriel phthalimide synthesis.

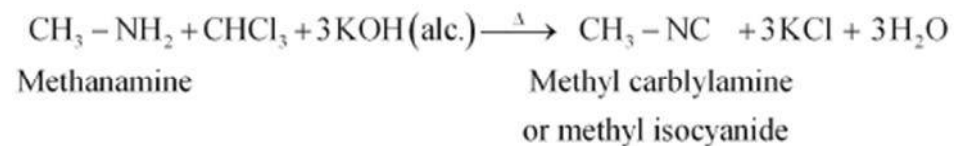
Answer

(i) Carbylamine reaction

Carbylamine reaction is used as a test for the identification of primary amines. When aliphatic and aromatic primary amines are heated with chloroform and ethanolic potassium hydroxide, carbylamines (or isocyanides) are formed. These carbylamines have very unpleasant odours. Secondary and tertiary amines do not respond to this test.



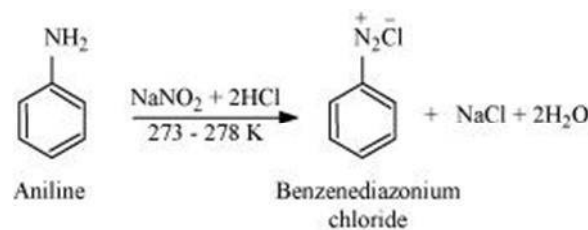
For example,



(ii) Diazotisation

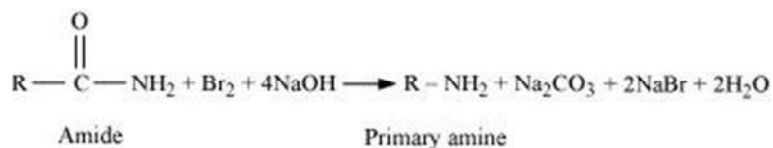
Aromatic primary amines react with nitrous acid (prepared in situ from NaNO_2 and a mineral acid such as HCl) at low temperatures (273-278 K) to form diazonium salts. This conversion of aromatic primary amines into diazonium salts is known as diazotization.

For example, on treatment with NaNO_2 and HCl at 273-278 K, aniline produces benzenediazonium chloride, with NaCl and H_2O as by-products.

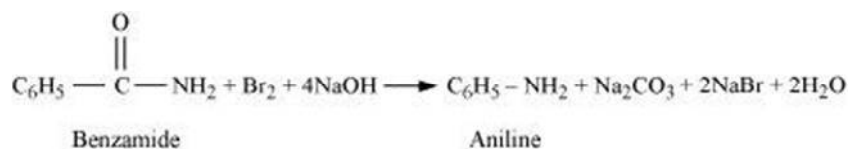
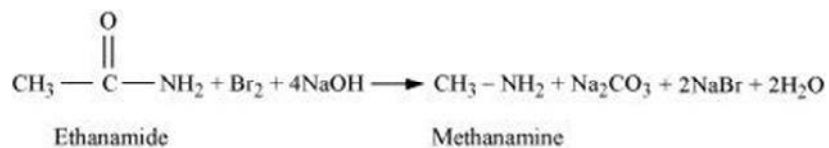


(iii) Hoffmann bromamide reaction

When an amide is treated with bromine in an aqueous or ethanolic solution of sodium hydroxide, a primary amine with one carbon atom less than the original amide is produced. This degradation reaction is known as Hoffmann bromamide reaction. This reaction involves the migration of an alkyl or aryl group from the carbonyl carbon atom of the amide to the nitrogen atom.

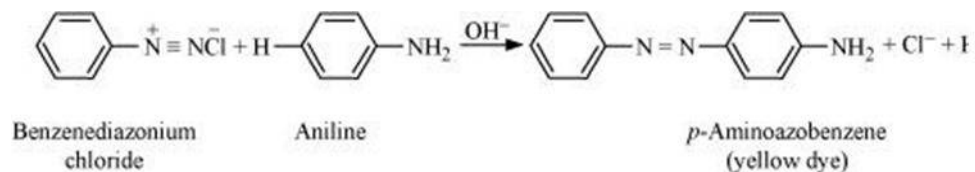
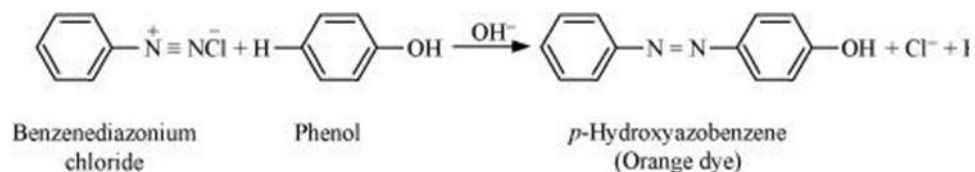


For example,



(iv) Coupling reaction

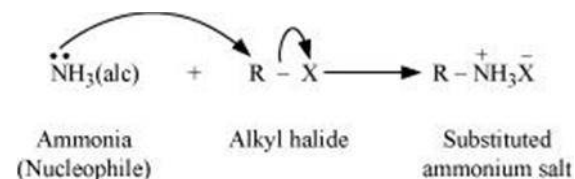
The reaction of joining two aromatic rings through the $-\text{N}=\text{N}-$ bond is known as coupling reaction. Arenediazonium salts such as benzene diazonium salts react with phenol or aromatic amines to form coloured azo compounds.



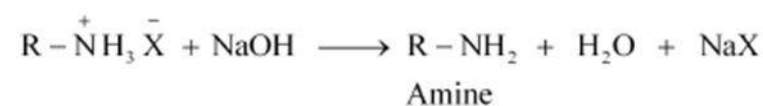
It can be observed that, the para-positions of phenol and aniline are coupled with the diazonium salt. This reaction proceeds through electrophilic substitution.

(v) Ammonolysis

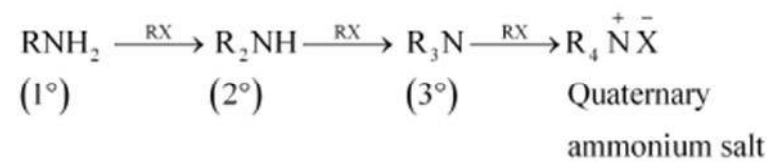
When an alkyl or benzyl halide is allowed to react with an ethanolic solution of ammonia, it undergoes nucleophilic substitution reaction in which the halogen atom is replaced by an amino ($-\text{NH}_2$) group. This process of cleavage of the carbon-halogen bond is known as ammonolysis.



When this substituted ammonium salt is treated with a strong base such as sodium hydroxide, amine is obtained.

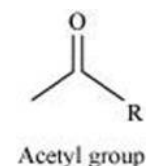


Though primary amine is produced as the major product, this process produces a mixture of primary, secondary and tertiary amines, and also a quaternary ammonium salt as shown.



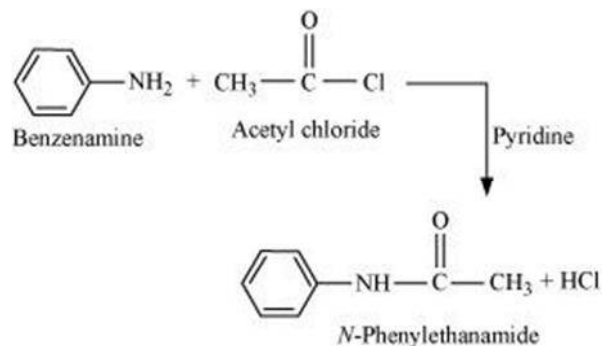
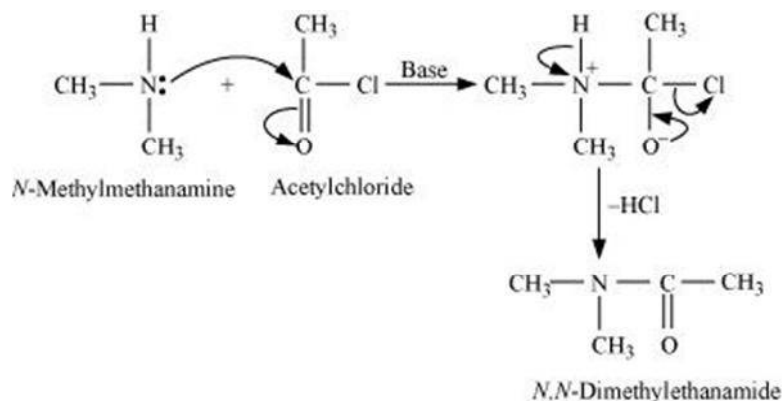
(vi) Acetylation

Acetylation (or ethanoylation) is the process of introducing an acetyl group into a molecule.



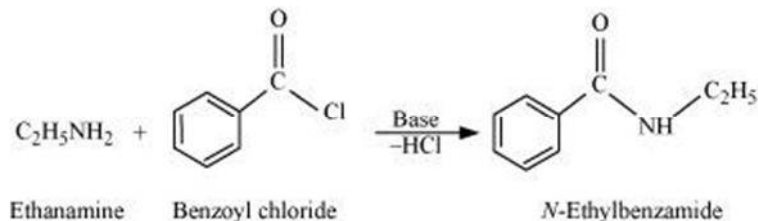
Aliphatic and aromatic primary and secondary amines undergo acetylation reaction by nucleophilic substitution when treated with acid chlorides,

anhydrides or esters. This reaction involves the replacement of the hydrogen atom of $-NH_2$ or $>NH$ group by the acetyl group, which in turn leads to the production of amides. To shift the equilibrium to the right hand side, the HCl formed during the reaction is removed as soon as it is formed. This reaction is carried out in the presence of a base (such as pyridine) which is stronger than the amine.



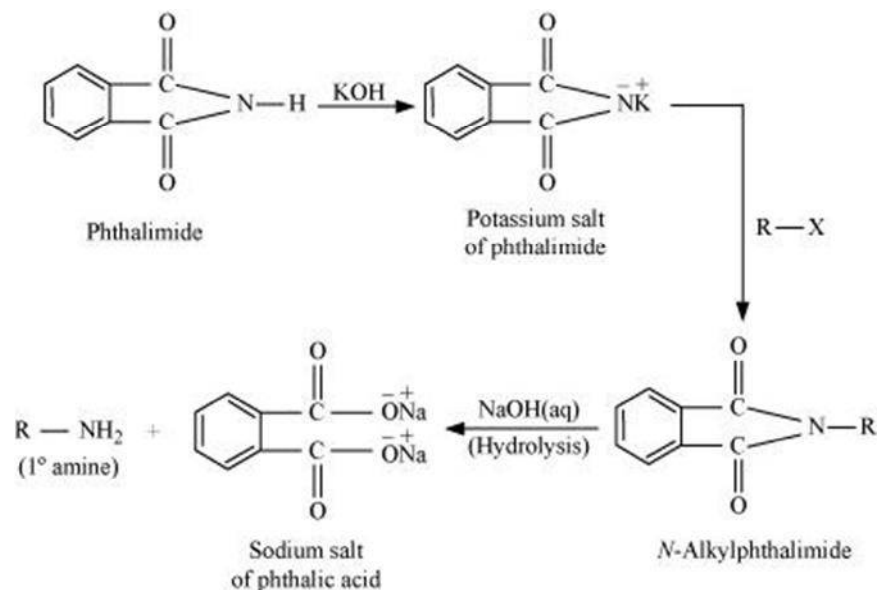
When amines react with benzoyl chloride, the reaction is also known as benzoylation.

For example,



(vii) Gabriel phthalimide synthesis

Gabriel phthalimide synthesis is a very useful method for the preparation of aliphatic primary amines. It involves the treatment of phthalimide with ethanolic potassium hydroxide to form potassium salt of phthalimide. This salt is further heated with alkyl halide, followed by alkaline hydrolysis to yield the corresponding primary amine.



Question 13.18:

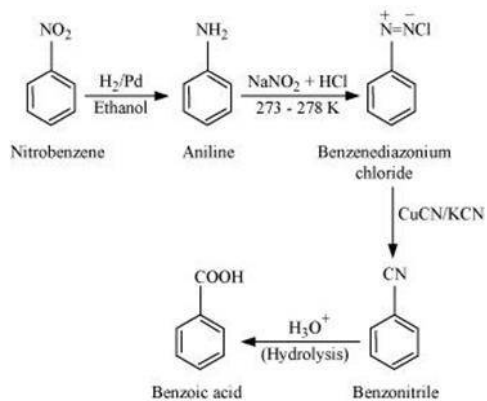
Accomplish the following conversions:

- Nitrobenzene to benzoic acid
- Benzene to *m*-bromophenol
- Benzoic acid to aniline
- Aniline to 2,4,6-tribromofluorobenzene
- Benzyl chloride to 2-phenylethanamine
- Chlorobenzene to *p*-chloroaniline

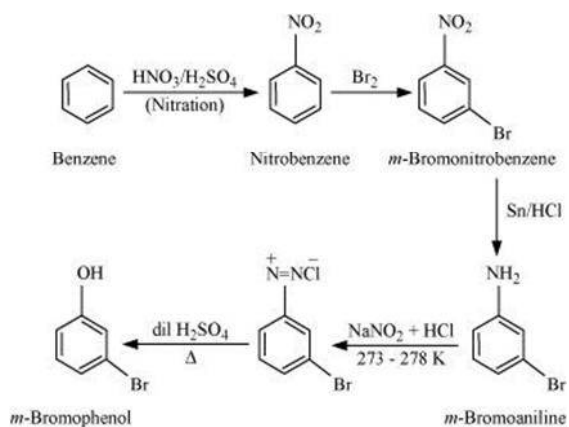
- (vii) Aniline to *p*-bromoaniline
 (viii) Benzamide to toluene
 (ix) Aniline to benzyl alcohol.

Answer

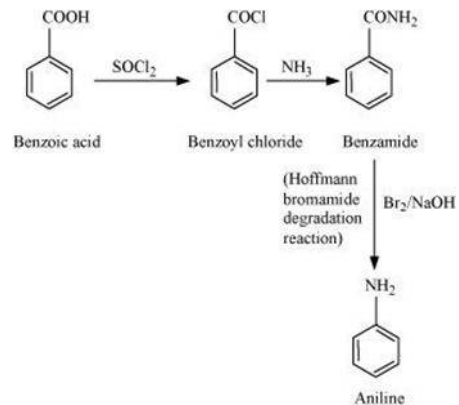
(i)



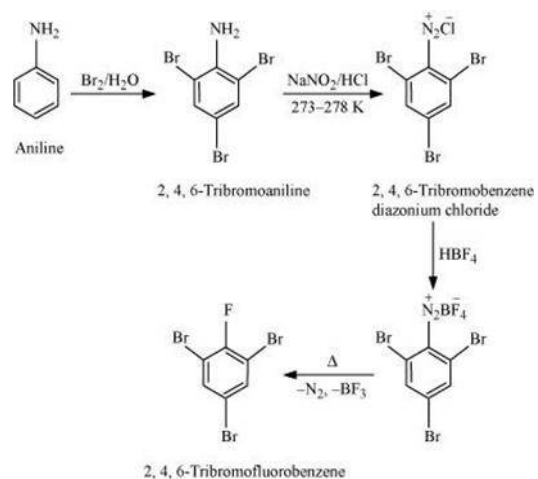
(ii)



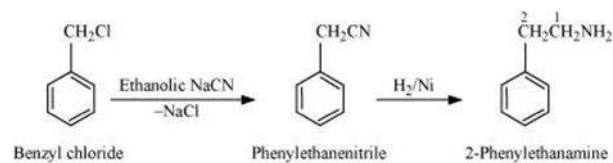
(iii)



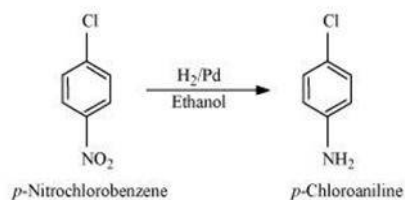
(iv)



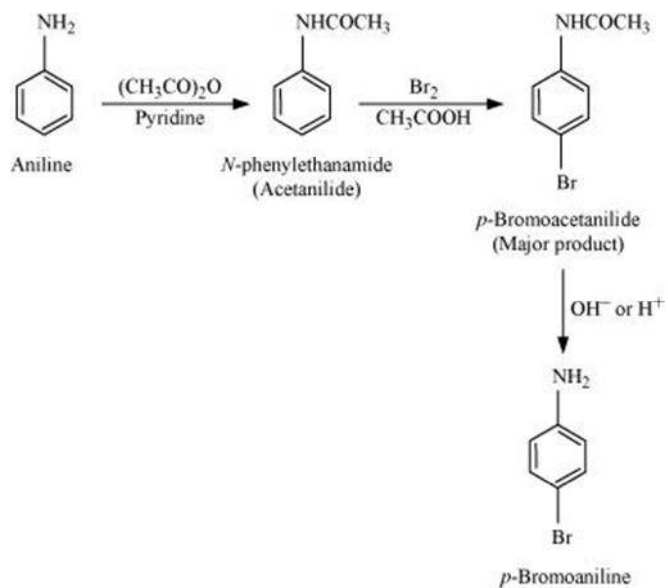
(v)



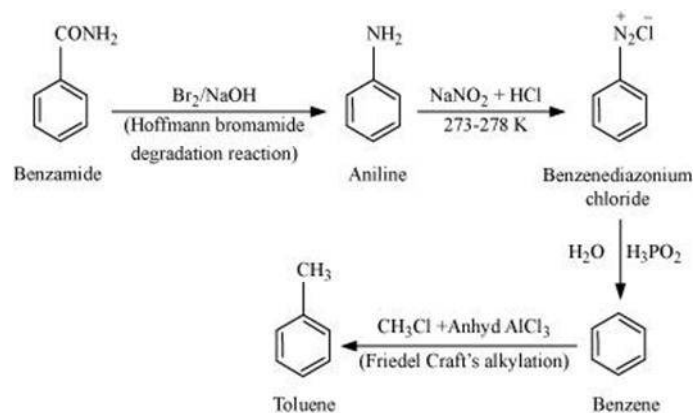
(vi)



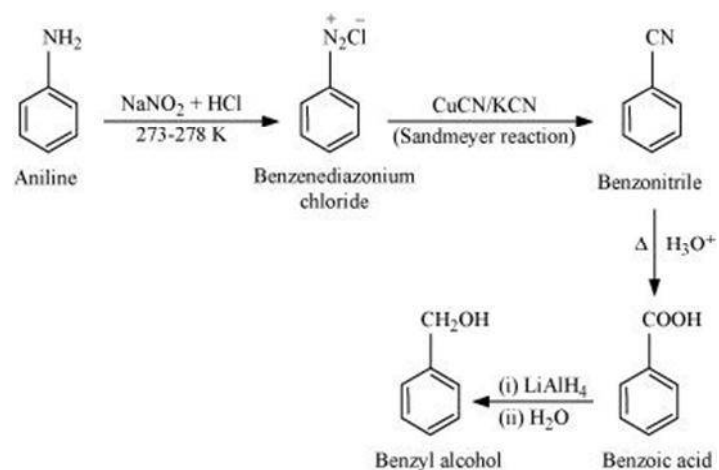
(vii)



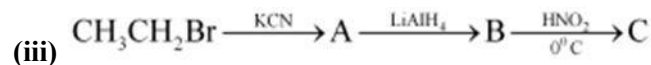
(viii)

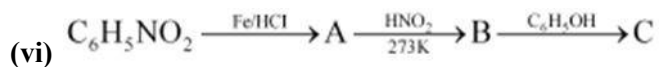


(ix)



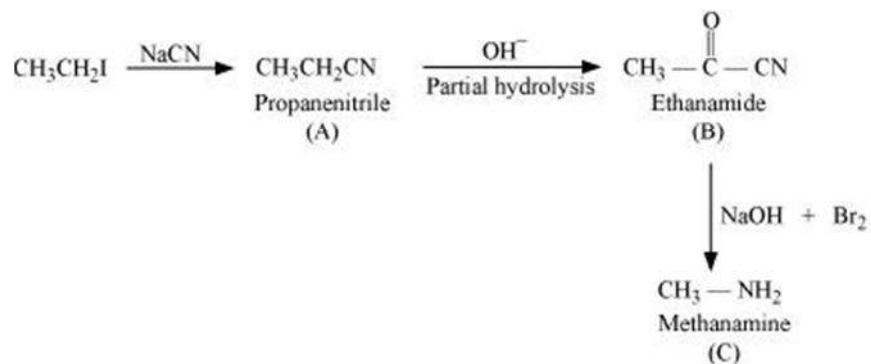
Question 13.19: Give the structures of A, B and C in the following reactions:



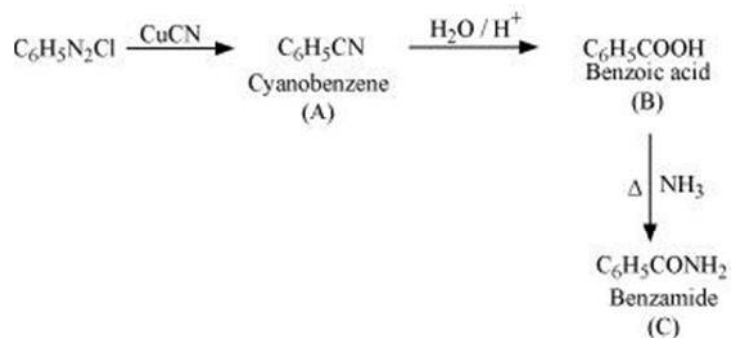


Answer

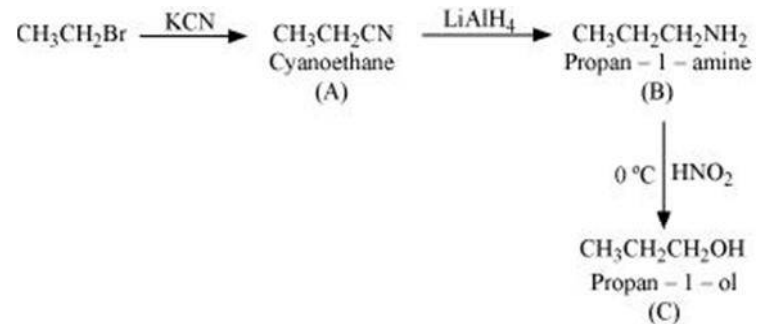
(i)



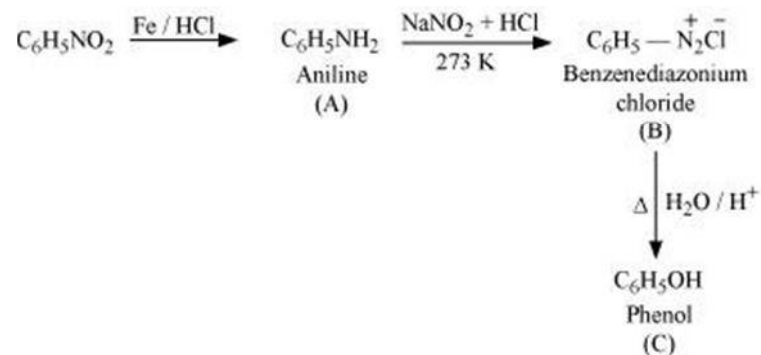
(ii)



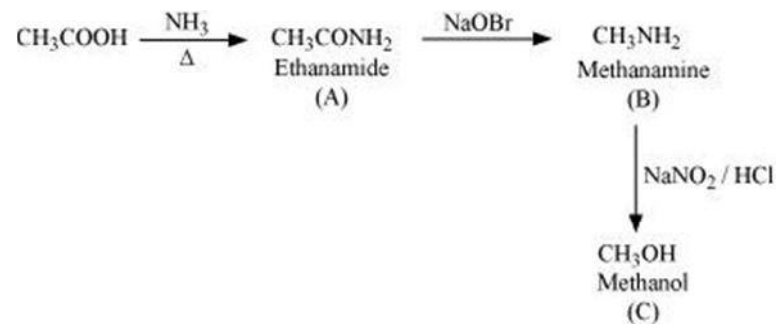
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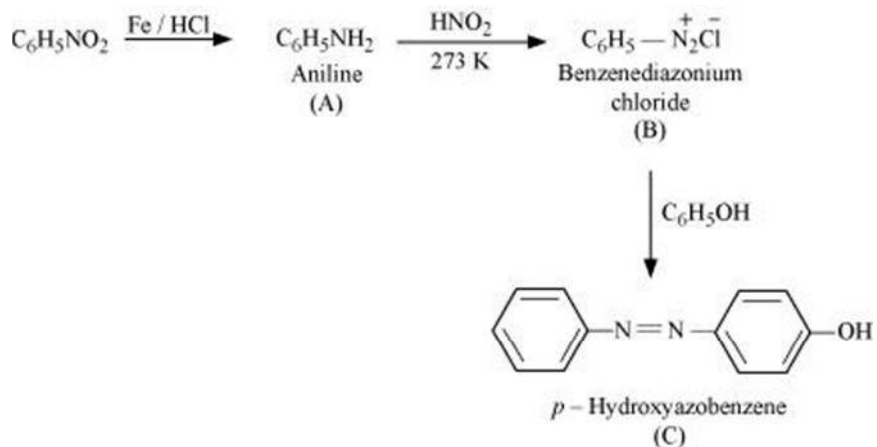
(iv)



(v)



(vi)



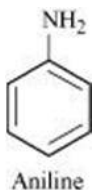
Question 13.20:

An aromatic compound 'A' on treatment with aqueous ammonia and heating forms compound 'B' which on heating with Br₂ and KOH forms a compound 'C'

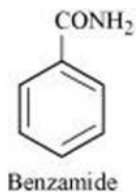
of molecular formula C₆H₇N. Write the structures and IUPAC names of compounds A, B and C.

20 Answer

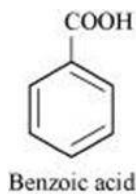
It is given that compound 'C' having the molecular formula, C₆H₇N is formed by heating compound 'B' with Br₂ and KOH. This is a Hoffmann bromamide degradation reaction. Therefore, compound 'B' is an amide and compound 'C' is an amine. The only amine having the molecular formula, C₆H₇N is aniline, (C₆H₅NH₂).



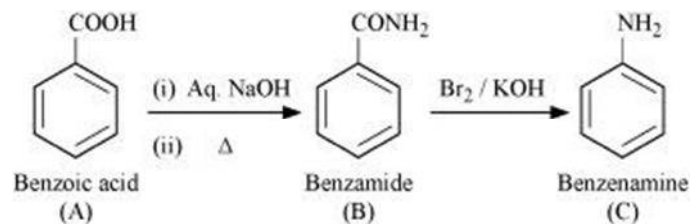
Therefore, compound 'B' (from which 'C' is formed) must be benzamide, (C₆H₅CONH₂).



Further, benzamide is formed by heating compound 'A' with aqueous ammonia. Therefore, compound 'A' must be benzoic acid.

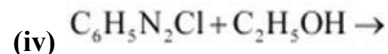
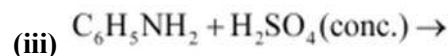
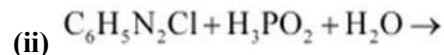
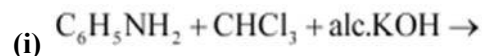


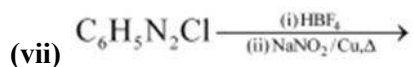
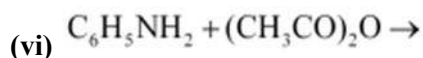
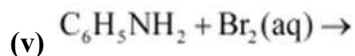
The given reactions can be explained with the help of the following equations:



Question 13.21:

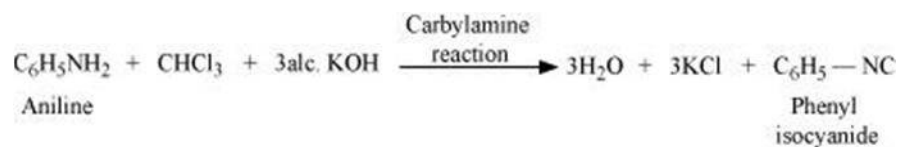
Complete the following reactions:



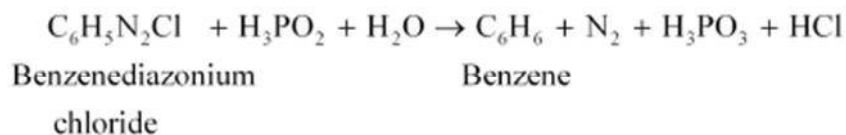


Answer

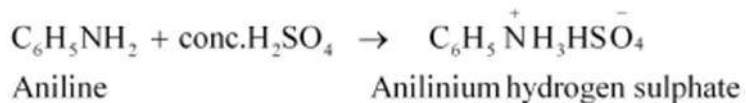
(i)



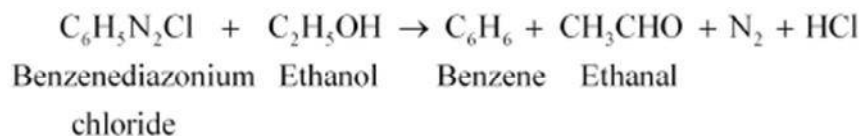
(ii)



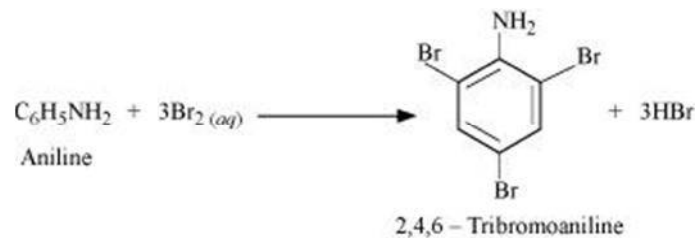
(iii)



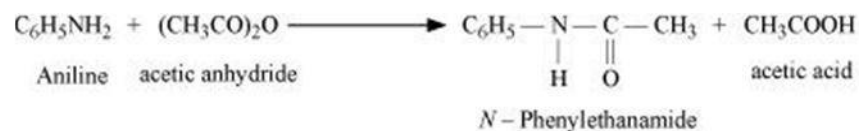
(iv)



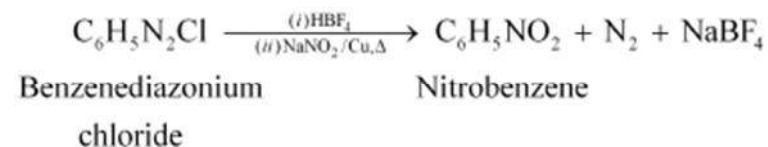
(v)



(vi)



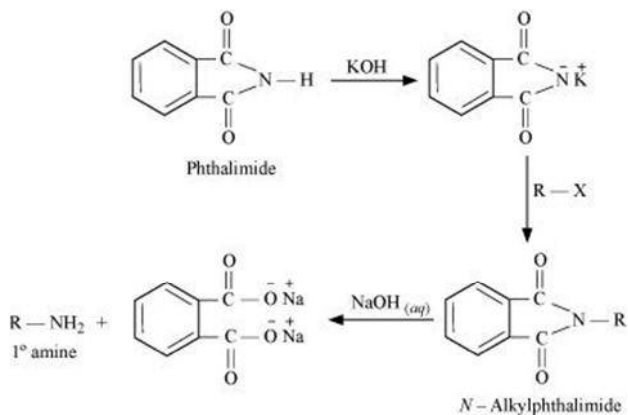
(vii)



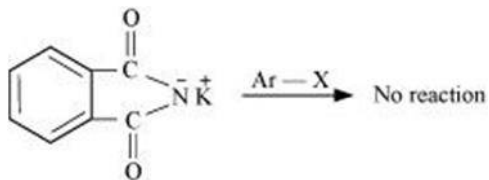
Question 13.22: Why cannot aromatic primary amines be prepared by Gabriel phthalimide synthesis?

Answer

Gabriel phthalimide synthesis is used for the preparation of aliphatic primary amines. It involves nucleophilic substitution (S_N2) of alkyl halides by the anion formed by the phthalimide.



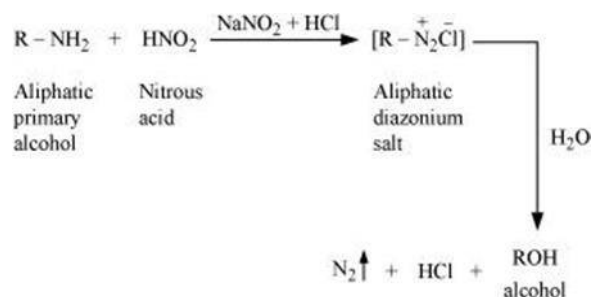
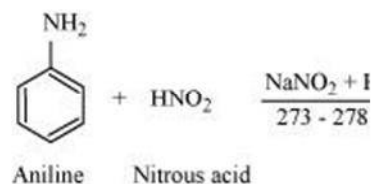
But aryl halides do not undergo nucleophilic substitution with the anion formed by the phthalimide.



Hence, aromatic primary amines cannot be prepared by this process.

Question 13.23: Write the reactions of (i) aromatic and (ii) aliphatic primary amines with nitrous acid.

Answer (i) Aromatic amines react with nitrous acid (prepared in situ from NaNO_2 and a mineral acid such as HCl) at 273 – 278 K to form stable aromatic diazonium salts i.e., NaCl and H_2O .



(ii) Aliphatic primary amines react with nitrous acid (prepared in situ from

NaNO_2 and a mineral acid such as HCl) to form unstable aliphatic diazonium salts, which further produce alcohol and HCl with the evolution of N_2 gas.

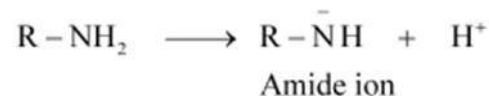
Question 13.24 Give plausible explanation for each of the following:

(i) Why are amines less acidic than alcohols of comparable molecular masses?

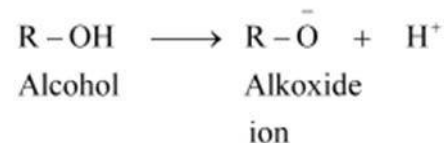
(ii) Why do primary amines have higher boiling point than tertiary amines?

(iii) Why are aliphatic amines stronger bases than aromatic amines?

Answer (i) Amines undergo protonation to give amide ion.

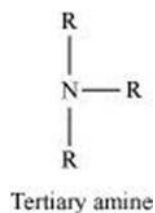
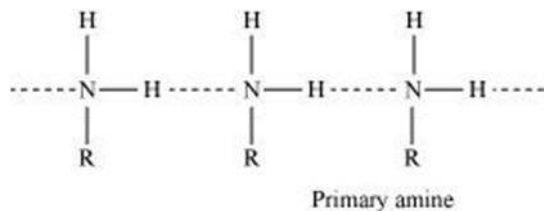


Similarly, alcohol loses a proton to give alkoxide ion.



In an amide ion, the negative charge is on the N-atom whereas in alkoxide ion, the negative charge is on the O-atom. Since O is more electronegative than N, O can accommodate the negative charge more easily than N. As a result, the amide ion is less stable than the alkoxide ion. Hence, amines are less acidic than alcohols of comparable molecular masses.

(ii) In a molecule of tertiary amine, there are no H-atoms whereas in primary amines, two hydrogen atoms are present. Due to the presence of H-atoms, primary amines undergo extensive intermolecular H-bonding.



As a result, extra energy is required to separate the molecules of primary amines. Hence, primary amines have higher boiling points than tertiary amines.

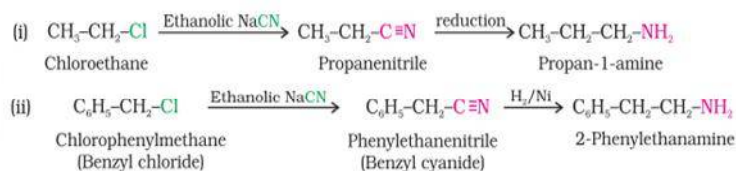
(iii) Due to the -R effect of the benzene ring, the electrons on the N-atom are less available in case of aromatic amines. Therefore, the electrons on the N-atom in aromatic amines cannot be donated easily. This explains why aliphatic amines are stronger bases than aromatic amines.

Question 13.25 Write chemical equations for the following conversions:

(i) $\text{CH}_3\text{-CH}_2\text{-Cl}$ into $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{-NH}_2$

(ii) $\text{C}_6\text{H}_5\text{-CH}_2\text{-Cl}$ into $\text{C}_6\text{H}_5\text{-CH}_2\text{-CH}_2\text{-NH}_2$

Solution



Question 13.26

Write structures and IUPAC names of

(i) the amide which gives propanamine by Hoffmann bromamide reaction.

(ii) the amine produced by the Hoffmann degradation of benzamide.

Solution

(i) Propanamine contains three carbons. Hence, the amide molecule must contain four carbon atoms. Structure and IUPAC name of the starting amide with four carbon atoms are given below:



(ii) Benzamide is an aromatic amide containing seven carbon atoms. Hence, the amine formed from benzamide is aromatic primary amine containing six carbon atoms.



Question 13.27 How will you convert 4-nitrotoluene to 2-bromobenzoic acid?

Solution

