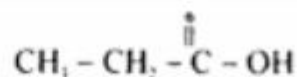

Short Answers and Questions

Q1: Write down the formula of the following?

- | | |
|------------------|-------------------|
| a) Succinic acid | b) Glutauic acid |
| c) Adipic acid | d) Malomic acid |
| e) Oxalic acid | f) Propionic acid |

Answer

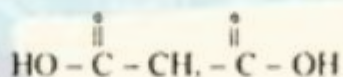
a) Propionic acid



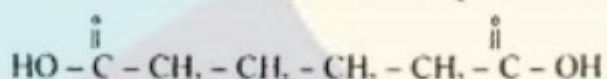
b) Oxalic acid



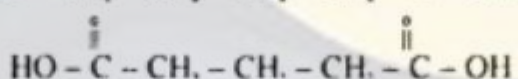
c) Malonic acid



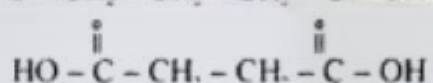
d) Adipic acid



e) Glutaric acid



f) Succinic acid



Q2: Write down the physical properties of carboxylic acid.

Answer

The polar nature of both the O-H and C=O bonds, due to the electronegativity difference of the atoms results in the formation of strong hydrogen bonds with other carboxylic acid molecules or other H bonding system. The implications are:

- 1) High melting and boiling points compared to analogous alcohols.
- 2) High solubility in aqueous media.
- 3) Hydrogen bonded dimers in gas phase and dimers or aggregates in pure liquids.

Q3: Write down the structure and acidity of carboxylic acid?

Answer

The CO₂H unit is planar and consistent with sp² hybridization and a resonance interaction of the lone pairs of the hydroxyl oxygen with that π system of the carboxyl.

Acidity

Carboxylic acid are the most acidic simple organic compounds (pK_a ~ 5).

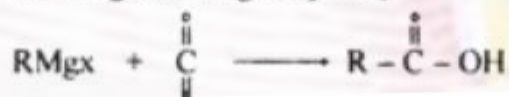
But they are weak acids compared to acids like HCl or H₂SO₄.

Resonance stabilization of the carboxylate allows the negative charge to be delocalized between the two electronegative oxygen atoms. Adjacent electron withdrawing substituents increase the acidity by further stabilizing the carboxylate.

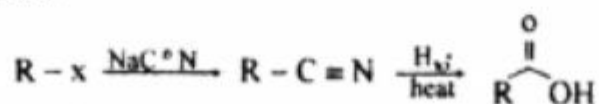
Q4: Write down the preparation of carboxylic acids.

Answer

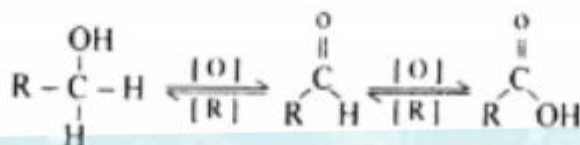
Carbonation of Grignard Reagents RMgX, by CO₂



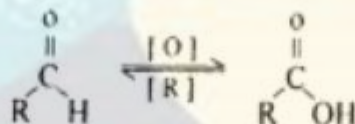
Hydrolysis of Nitriles



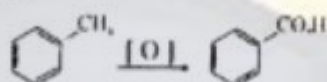
Oxidation of Primary alcohol



Oxidation of Aldehydes



Oxidation of Alkyl Benzenes



Q5: Write down the reaction of carboxylic acids? Carboxylic acids undergo the following types of reaction.

Answer

- The reaction in which hydrogen atom of the carboxyl group in which hydrogen atom of the carboxyl group is involved (salt formation).
- The reaction in which OH group is replaced by another group.
- The reaction involving carboxyl group as:
Reaction involving H atom of the carboxylic group. Carboxylic acids are weaker acids than mineral acids. They furnish H when dissolved in H₂O.

Reaction with Bases

Carboxylic acid react with (NaOH, KOH) to form salts.



Reaction with carbonates and bicarbonates. Carboxylic acids decompose carbonate and bicarbonate evolving carbon dioxide gas with effervescence.

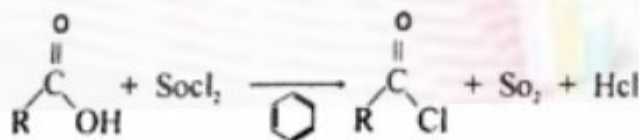


Reaction with Metals

Carboxylic acids reaction with active metals such as Na, K, Ca, Mg etc to form their salts with evolution of hydrogen gas.

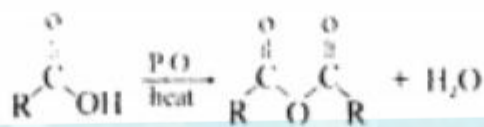


Q6: Write down the preparation of Acyl chlorides.

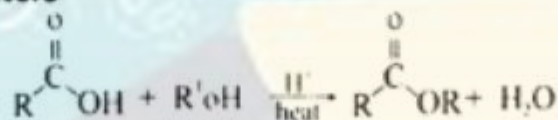


Answer

Acyl chlorides are prepared by treating the carboxylic acid with thionyl chloride SOCl₂ in the presence of a base. Acyl chlorides are by far the most commonly encountered of the acyl halides. Preparation of Acid Anhydrides.



Preparation of Esters



This reaction is known as the Fischer esterification. Esters are obtained by refluxing the parent carboxylic acids with the appropriate alcohol with an acid catalyst.

The equilibrium can be driven to completion by using an excess of either the alcohol or the carboxylic acid, or by removing the H_2O as it forms. Esters can also be made from other carboxylic acid derivatives, especially acyl halides and anhydrides, by reacting them with the appropriate alcohol in the presence of a weak base. If a compound contains both hydrogen and carboxylic acid groups, then cyclic esters or lactones can form via an intramolecular reaction. Reactions that form 5 or 6 membered rings are particularly favourable.

Q7: With mechanism for reaction for Acid catalyzed esterification.

Answer

Step 1

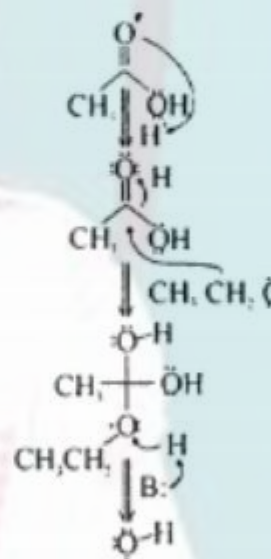
Protonation of carboxyl of acid group

Step 2

The alcohol O functions as the nucleophile and electrons moving towards the oxonium ion, creating the tetrahedral intermediate.

Step 3

An acid/base reaction. Deprotonate the alcoholic oxygen.

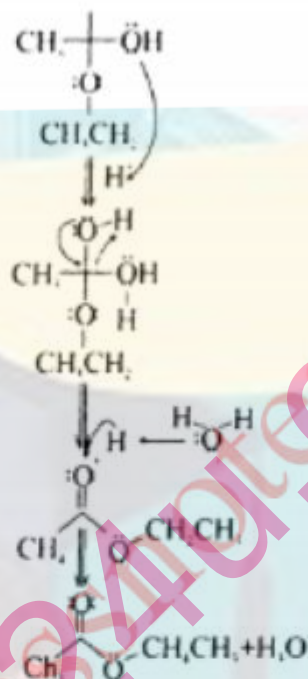


Step 4

Acid base reaction in which OH leave and connect it into a good leaving group by protonation.

Step 5

The electrons of an adjacent oxygen to help "push out" the leaving group a neutral water molecule.

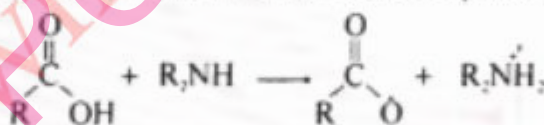


Q8: Write down the preparation of Amides.



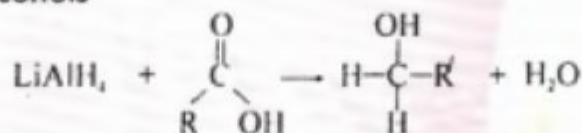
Answer

In general it is not easy to prepare amides directly from the parent carboxylic acid. The acid will protonate the amine preventing further reactions since the carboxylate is a poor electrophile and the ammonium ion is not nucleophilic.

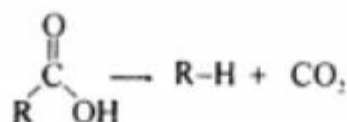


It is much easier to convert the carboxylic acid to the more reactive acyl chloride first.

Reduction to Alcohols

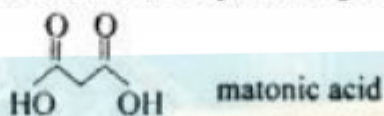


Carboxylic acids are less reactive to reduction by hydride than aldehydes, ketones, or esters. Carboxylic acids are reduced to primary alcohols. As a result of their low reactivity, carboxylic acids can only be reduced by LiAlH₄ not by the less reactive NaBH₄. Decarboxylation.



Loss of carbon dioxide is called decarboxylation. Simple carboxylic acids rarely

undergo decarboxylation, Carboxylic acid with a carboxyl group at the 3 - (or β) position readily undergo thermal decarboxylation e.g. derivatives of malonic acid.



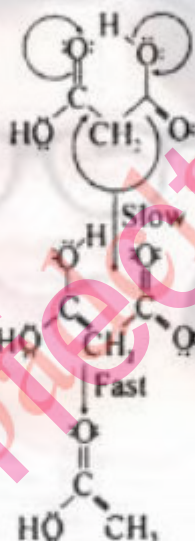
The reaction proceeds via a cyclic transition state giving an enol intermediate that tautomerizes to the carboxyl.

Decarboxylation

The protonation of the carboxyl, break the OH bond and form the π bond, break the C - C and make the C = C. Note the concerted nature of this reaction and the cyclic transition state.

Step 2

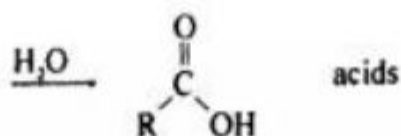
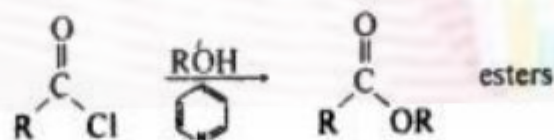
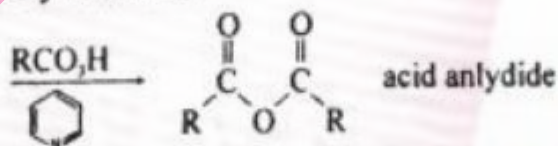
Tautomerization to the acid product.

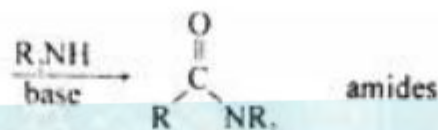


Q9: Write down the Reactions of carboxylic Acid Derivates?

Answer

Interconversion of Acyl chlorides

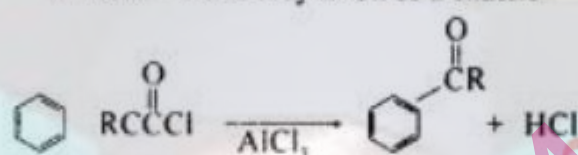




Acyl chlorides are the most reactive of the carboxylic acid derivatives and therefore can be readily converted into other carboxylic acid derivatives.

They are sufficiently reactive that they react quite readily with cold water and hydrolyze to the carboxylic acid. The HCl by product is usually removed by adding a base such as pyridine or triethyl amine.

Friedel – crafts Acylation of Benzene

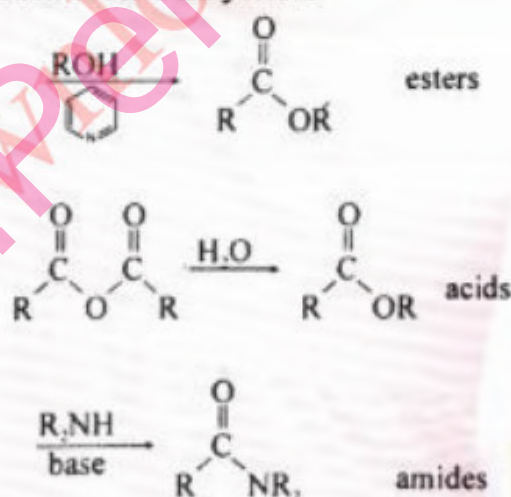


Overall transformation Ar – H to Ar – COR (Ketone). Named after Friedel craft who discovered the Reagent normally the acyl halide (usually RCOCl) with aluminium trichloride AlCl_3 a Lewis acid catalyst. The AlCl_3 enhances the electrophilicity of the acyl halide by complexing with the halide.

Electrophilic species the acyl cation or acylium ion (RCO^+) formed by the removal of the halide by the Lewis acid catalyst. Friedel crafts reactions are limited to arenes as or more reactive than mono halobenzenes. Other sources of acylium can also be used as acid anhydrides with AlCl_3 .

Reaction of Acid Anhydrides hydrolysis

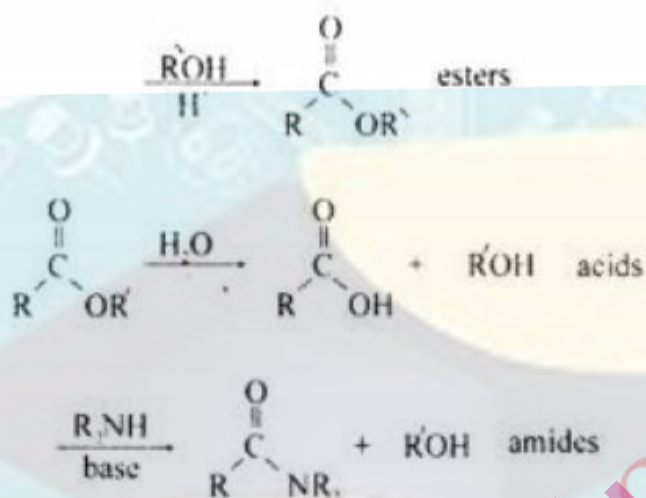
Interconversion Reaction of Acid anhydrides



Acid anhydrides are the second most reactive of the carboxylic acid derivatives and can therefore be fairly readily converted into the other less reactive carboxylic acid derivatives. A base is often added to neutralize the carboxylic acid by product that is formed.

Q10: Write down the reaction of Esters, hydrolysis, Reduction and with Grignard's reagent?

Answer

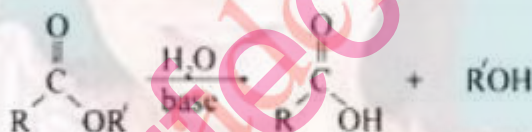


Esters can be converted into other esters the point carboxylic acid (hydrolysis) or amides.

Transesterification heat with alcohol and acid catalyst Amide preparation heat with the amine, methyl or ethyl esters are the most reactive.

Q11: Write down the hydrolysis of Esters?

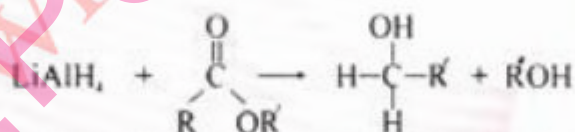
Answer



Carboxylic esters hydrolyze to the parent carboxylic acid and an alcohol. Reagents aqueous acid (e.g. H_2SO_4) heat or aqueous NaOH heat known as saponification.

Q12: Write down the reduction of Esters?

Answer



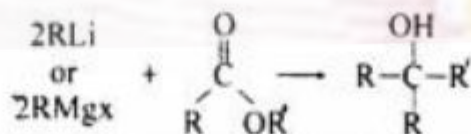
Carboxylic esters are reduced give 2 alcohols one from the alcohol portion of the ester and a 1 alcohol from the reduction of the carboxylate portion.

Esters are less reactive toward Na than aldehydes or ketones.

They can only be reduced by LiAlH_4 and not by the less reactive NaBH_4 .

Q13: Write down the reaction of RLi and MgX with esters.

Answer



Carboxylic acid esters $\text{RCO}_2\text{R''}$ react with 2 equivalent of organolithium or Grignard reagents to give tertiary alcohols. The tertiary alcohol that result contain 2 identical alkyl groups.

The reaction proceeds via a ketone intermediate which then reacts with second equivalent of the organometallic reagents. Since the Ketone is more reactive than the ester, the reaction cannot be used as a preparation of ketones. The mechanism is an example of the reactive system type.

Q14: Write down the mechanism of the acids catalyzed hydrolysis of amides.

Answer

Step 1

An acid/ base reaction since we only have a weak nucleophile and a poor electrophile we need to activate the ester. Protonation of the amide carbonyl makes it more electrophilic.

Step 2

The H_2O O functions as the nucleophile attacking the electrophilic C in the $\text{C}=\text{O}$ with the electrons moving towards the oxonium ion, creating the tetrahedral intermediate.

Step 3

An acid/ base reaction. Deprotonate the oxygen that came from the H_2O molecule.

Step 4

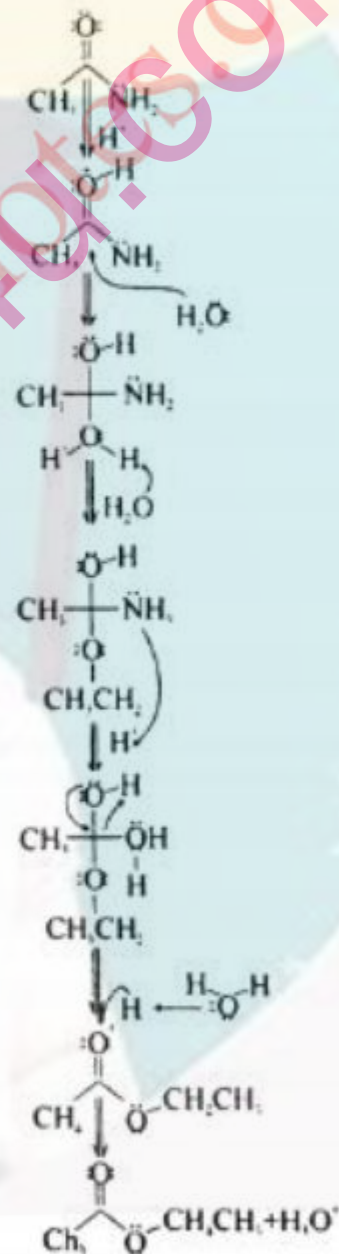
An acid base reaction need to make the NH_2 leave but need to convert it into a good leaving group first by protonation.

Step 5

Use the electrons of an adjacent to help push out the leaving group a neutral ammonia molecule.

Step 6

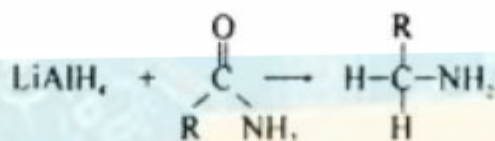
An acid/ base reaction Deprotonation of the oxonium ion reacts the carboxyl in the carboxylic acid produced and regenerates the acid catalyst.



=====

Q15: Write down the reduction of Amides.

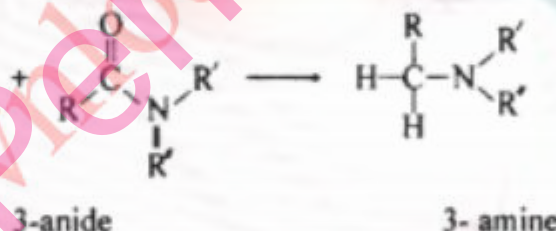
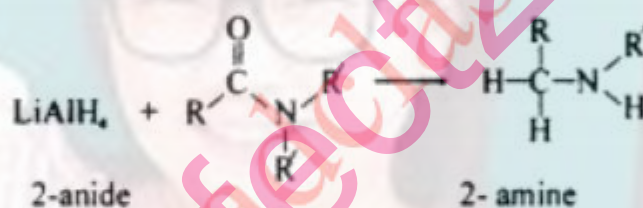
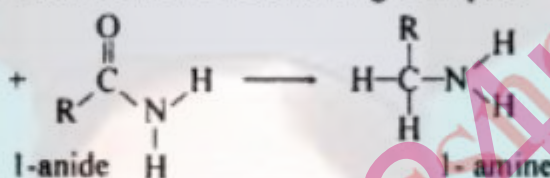
Answer



Amides RCONR_2 can be reduced to the amino RCH_2NR_2 by conversion of the $\text{C}=\text{O}$ to $-\text{CH}_2$.

Amides can be reduced by LiAlH_4 but Not the less reactive NaBH_4 .

This reaction is different to that of other $\text{C}=\text{O}$ compounds which reduce to alcohols. The nature of the amine obtained depends on the substituents present on the original amide look at the N substituents in the following examples.



R, R' or R'' may be either alkyl or acyl substituents in the potential mechanisms with O System note that it is an O system that leaves. This is consistent with O system being better leaving groups than the less electronegative N systems.

Q16: Write down the reaction of LiAlH_4 with an amide.

Answer

Step 1

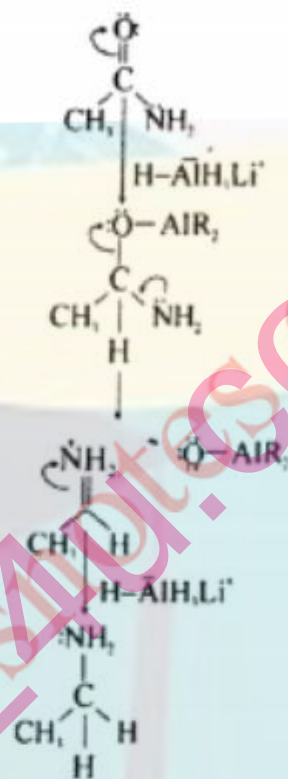
The nucleophilic H from the hydride reagent adds to the electrophilic C in the polar carboxyl group of the esters. Electrons from the C = O move to the electronegative O creating an intermediate metal alkoxide complex.

Step 2

The tetrahedral intermediate collapses and displaces leaving group thus produces a highly reactive iminium ion as an intermediate.

Step 3

Rapid reduction by the nucleophilic H from the hydride reagent as it adds to the electrophilic C in the iminium system. π electrons from the C = N move to the cationic N neutralizing the charge to create amine product.



Q17: Write down the mechanisms of the acid catalyzed hydrolysis of nitriles.

Answer

Step 1

An acid/ base reaction.

Since we only a weak nucleophile so active the nitrile, protonation make it more electrophitic.

Step 2

The water O functions as the nucleophile attacking the electrophilic C in the CN with the electrons moving towards the positive center.

Step 3

An acid/ base reaction, Deprotonate the oxygen that came from the H₂O molecule. The remaining task is a tautomerization are N and O centers.

Step 4

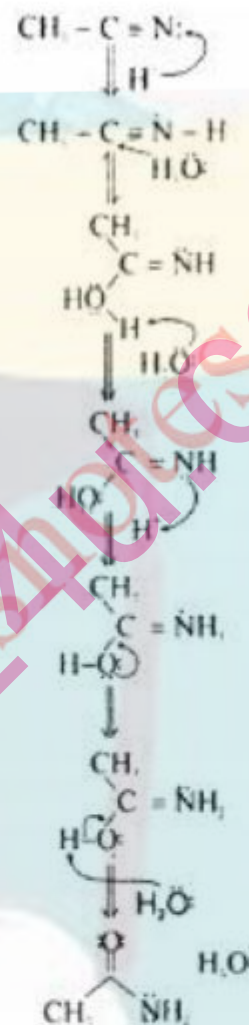
An acid/ base reaction. Protonate the N gives us the - NH₂ we need.

Step 5

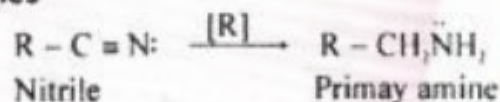
Use the electrons of an adjacent O to the neutralise the positive at the N and from the bond in the C = O.

Step 6

An acid/ base reaction/ Deportation of the oxonium ion reveals the carboxyli in the amide intermediate half way to the acid.



Reduction of Nitriles



Reaction types: Nucleophetic Addition.

The nitrile $\text{RC} \equiv \text{N}$ give the 1° amine by conversion of the $\text{C} \equiv \text{N}$ to $\text{CH}_2 - \text{NH}_2$

Nitriles can be reduced by LiAlH_4 but Not the less reactive NaBH_4 . Typical reagents LiAlH_4 . Typical reagents LiAlH_4 ether solvent followed by aqueous work up.

Catalytic hydrogenation ($\text{H}_2/\text{catalyst}$) can also be used giving the same product.

R may be either allcyl or acyl substituents.

Q18: Write down reaction of RMgx with an nitrile?

Answer

Step 1

The nucleophilic C in the organometallic reagents adds to the electrophilic C in the polar nitride group. Electrons from the C = N move to the electronegative N creating an intermediate imine salt complex.

Step 2

An acid/base reaction. On addition of aqueous acid, the intermediate salt protonates giving the imine.

Step 3

An acid/base reaction. Imines undergo nucleophilic addition but require activation by protonation.

Step 4

Now the Nucleophilic O of a water molecule attacks the electrophilic C with the C=N bond breaking to neutralize the charge on N.

Step 5

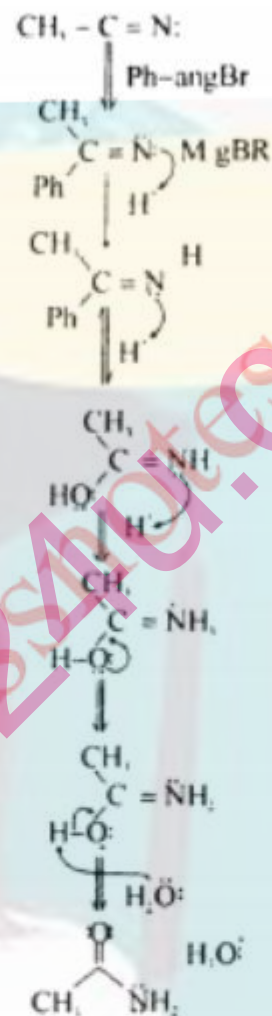
An acid/base reaction Deprotonate the O from the H₂O molecule to neutralize the positive charge.

Step 6

An acid/base reaction. Before the N system leaves, it needs to be made into a better leaving group by protonation.

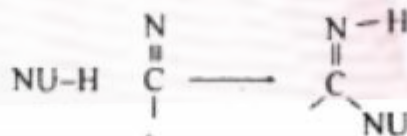
Step 7

Use the electron on the O in order to push out the N leaving group, a neutral molecule of ammonia.



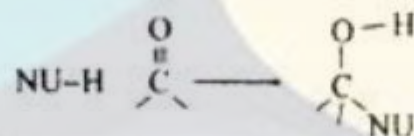
Q19: Write down the reaction of Nitriles, Hydrolysis Reduction and reaction with Grignard's reagent.

Answer

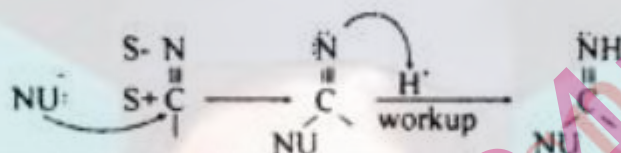


Nitriles typically undergo nucleophilic addition to give product that often undergoes a further reaction.

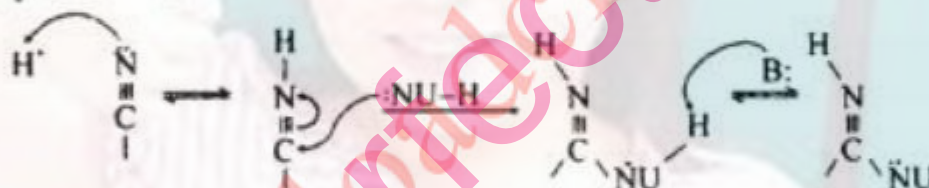
The chemistry of the nitrile functional group C≡N of aldehydes and ketones.



Strong Nucleophilic anionic add directly to the $\text{C}=\text{N}$ to form an intermediate imine salt that protonates.



Example are RMgX , RLi , $\text{RC} \equiv \text{CM}$, LiAlH_4 . Weaker nucleophiles neutral require that the $\text{C}=\text{N}$ be activated prior to attack of the Nu. This can be done increasing a acid catalyst which protonates on the Lewis basic N and make the system more electrophilic.



Example are H_2O , ROH . The protonation of a nitrile gives a structure that can be reaction in another resonance from that results the electrophilic character of the C since it is a carbocation.

