

AIKANES

1

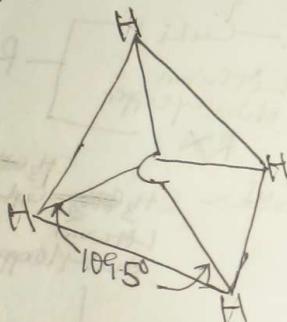
ALKANES

Alkanes are saturated hydrocarbons with a general molecular formula of C_nH_{2n+2} . They consist only of hydrogen and carbon atoms and all the bonds are single bonds.

STRUCTURE OF METHANE

STRUCTURE OF METHANE

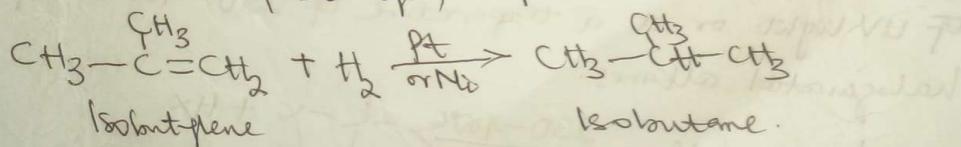
Methane is the simplest member of the alkane homologous series with a formula of CH_4 . The carbon atom of methane is bonded by four other atoms. Methane has sp^3 hybridized orbital. It is tetrahedral in shape with a bond angle of 109.5° .



Tetrahedral Structure of Methane

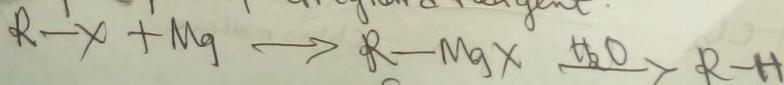
PREPARATION OF ALKANES

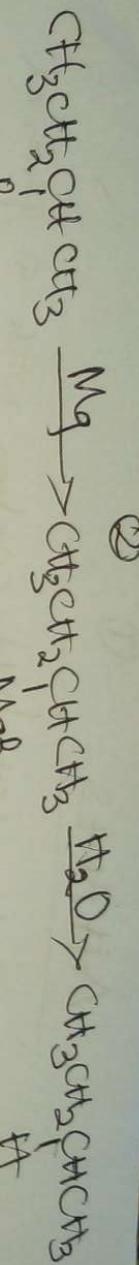
(1) Hydrogenation of Alkenes: When alkene are shaken under a slight pressure of hydrogen gas in the presence of a small amount of catalyst, they are converted to alkanes.



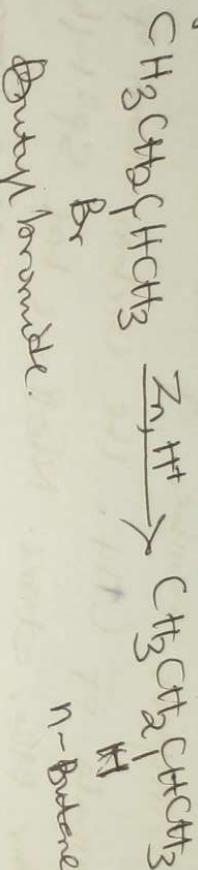
(Q) Reduction of alkyl halides

Q) Hypothesis of Grignard reagent.



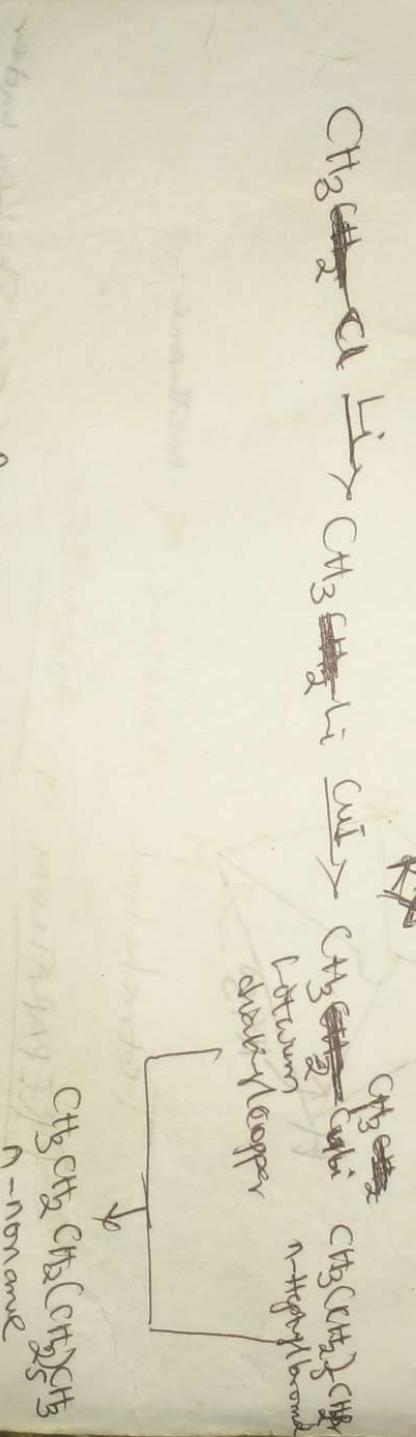
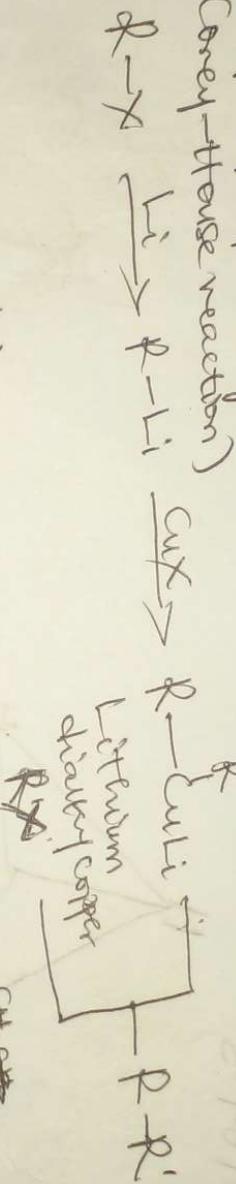


b) Reduction by metal and acid
Alkyl halides are reduced to the corresponding alkanes by metal and acid.



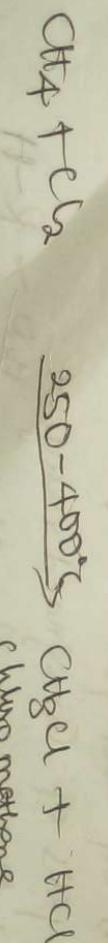
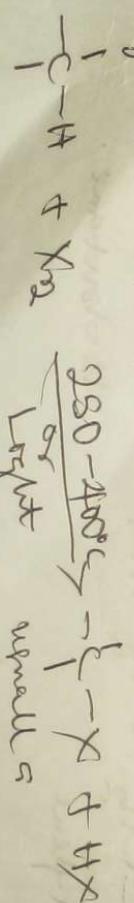
Butyl bromide

3. Coupling of alkyl halides with organometallic compounds (Cory–House reaction)



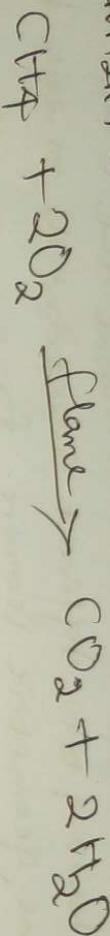
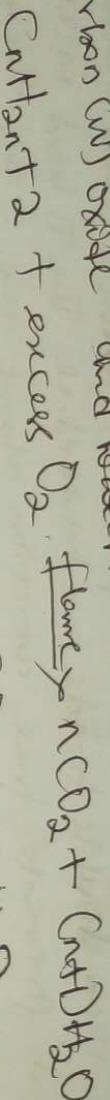
REACTION OF ALKANES

(1) Halo generation: Alkanes react with halogens in the presence of UV light or at a temperature of $250^\circ\text{--}400^\circ\text{C}$ to produce chlorinated alkanes.

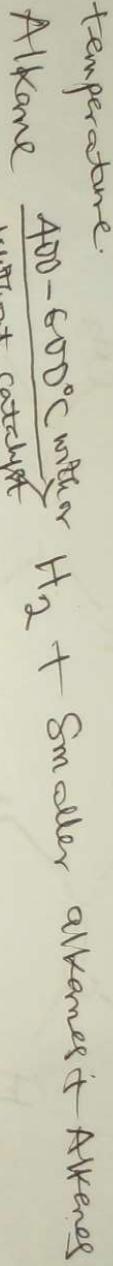


$\text{CH}_3\text{CH}_2\text{CH}_3 \xrightarrow{\text{Mg} + \text{nH}_2\text{O}}$ (3)

2 Combustion : Alkanes reacts with excess oxygen to produce carbon (IV) oxide and water.



(2) Pyrolysis (Cracking) : Higher molecular weight alkanes are broken down into smaller units when they are subjected to high temperature.



USES OF ALKANES

- (1) The gaseous alkanes are used as cooking gas
- (2) The liquid alkanes (C_5 - C_8) are used as gasoline
- (3) The alkanes (C_9 - C_{16}) are used as kerosene jet fuel and diesel fuel
- (4) The alkanes (C_{16} and up) are used as lubricating and heat oil.
They are also used as paraffin wax.

ALKENES

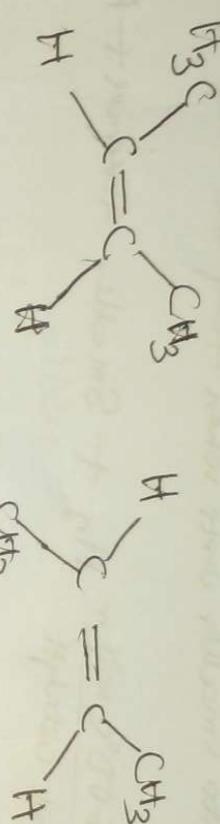
Alkenes are hydrocarbons with carbon-carbon double bonds. Alkenes are sometimes called olefins, a term derived from oleum fons, meaning oil-forming gas. They have a general molecular formula of C_nH_{2n} .

STRUCTURE OF ETHENE (ETHYLENE)

The simplest member of the alkene family is ethene C_2H_4 . The carbon atoms are joined by a double bond to form bonds with three other atoms, carbon have one of three equivalent hybrid orbitals & sp^2 orbital. It is trigonal in shape with a bond angle of 120° .

GEOMETRIC ISOMERISM (5)

Geometric isomers are compounds in which their rotation about the double bonds are hindered i.e. the π bond in the compound prevents free rotation about the $C=C$, therefore an alkene having two different substituents on each double bonded C has geometric isomers. For example, there are two 2-butenes.



CH_3 's on same side
called cis -

CH_3 's on opposite sides
called trans -

The lower ~~rate~~ of boiling point of 1°C has been assigned the cis configuration, and the isomer of boiling point of 1°C has been assigned the trans configuration.

PREPARATION OF ALKENES

(1) Dehydrohalogenation of alkyl halide: When Isopropyl bromide is treated with a hot concentrated alcoholic solution of a strong base like potassium hydroxide, Propene, potassium bromide and water were obtained.

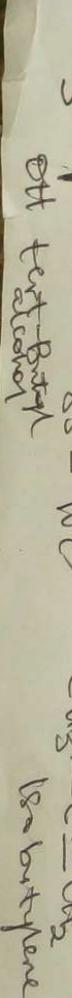
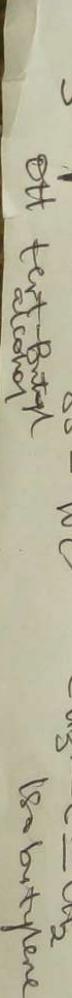
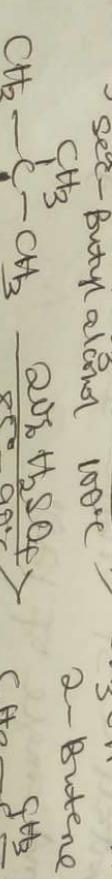
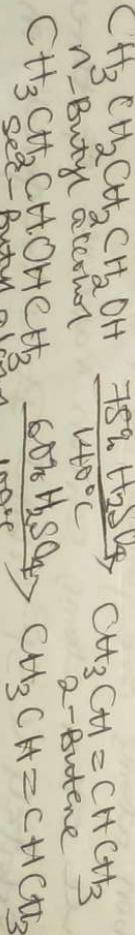
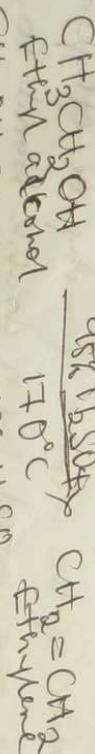


Isopropyl bromide
Isopropyl

Propene

(2) Dehydration of alcohols: An alcohol is converted into an alkene by dehydration i.e. elimination of a molecule of water.

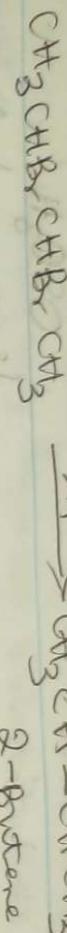
This is carried out in the presence of acid and heat.



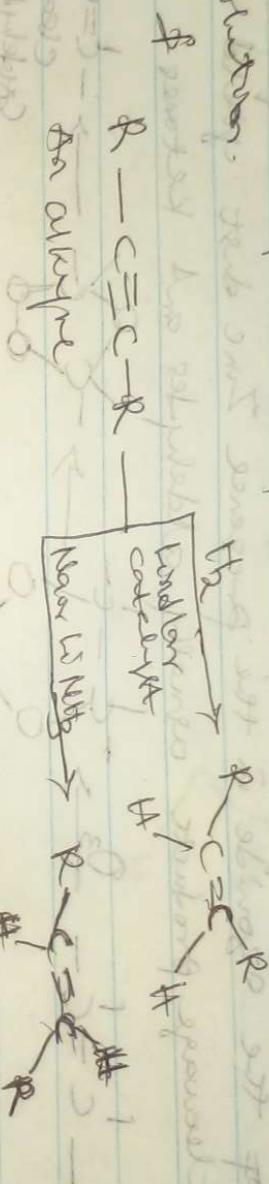
(5)

(2)

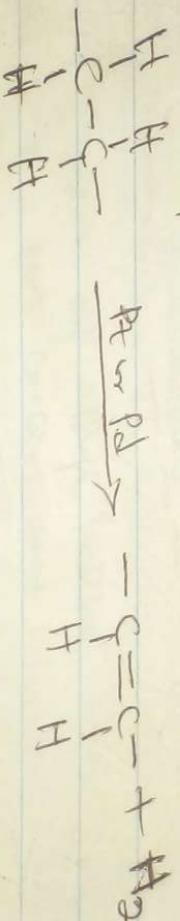
(3) Dehydrogenation of vicinal dihalides : Vicinal dihalides are reduced to alkenes by metallic Zinc (Zn) or Magnesium (Mg)



(4) Reduction of alkynes : Alkynes are reduced to alkenes in the presence of Lindlar catalyst and hydrogen and also in the presence of Sodium or Potassium in ammonia solution.

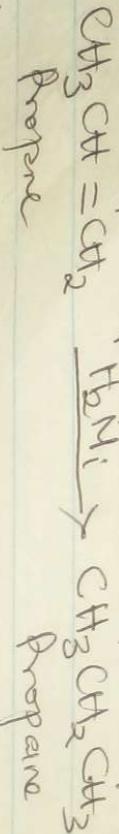


(5) Cracking of hydrocarbons : Cracking of hydrocarbons or the source of commercial alkenes.

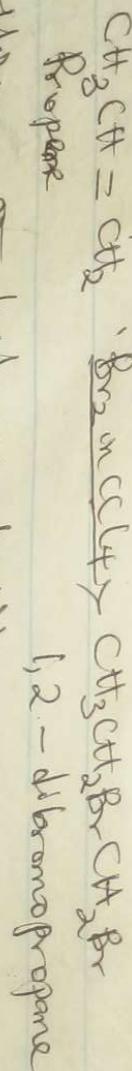


REACTIONS OF ALKENES

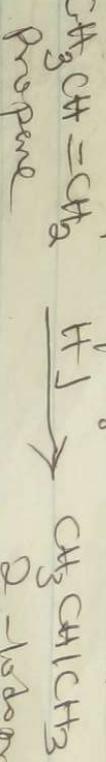
(1) Addition of hydrogen (Catalytic hydrogenation)



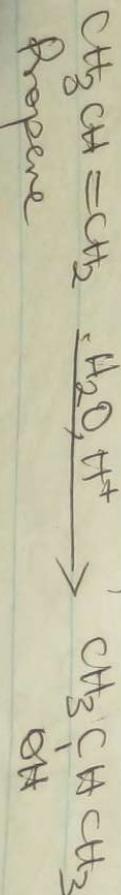
(2) Addition of halogens



(3) Addition of hydrogen halide



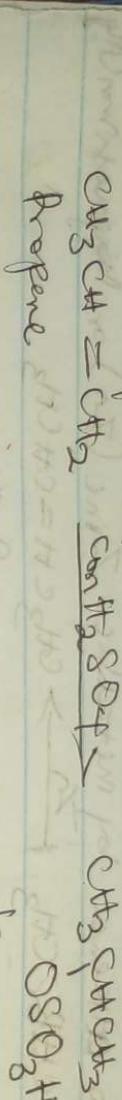
(4) Addition of water (Hydration)



THE WINTERMAN

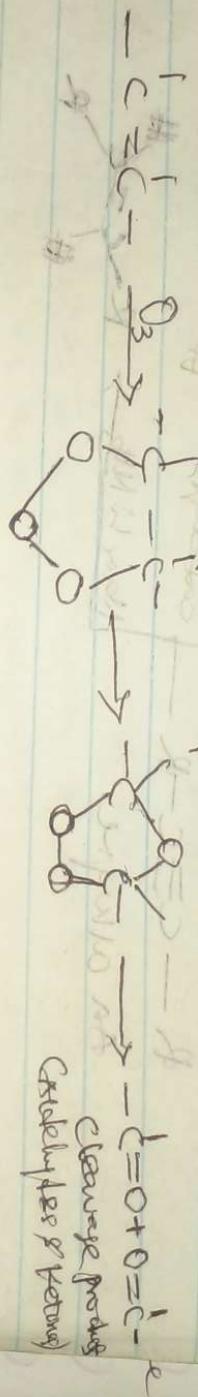
①

(2) Addition of Sulphur acid



凡

Ozone reacts with alkene in presence of carbon tetrachloride to form ozonide. Ozonide then rearranges itself to form ozone. The byproducts of the ozone in the presence Zinc dust yield the cleavage products namely aldehydes and ketones.

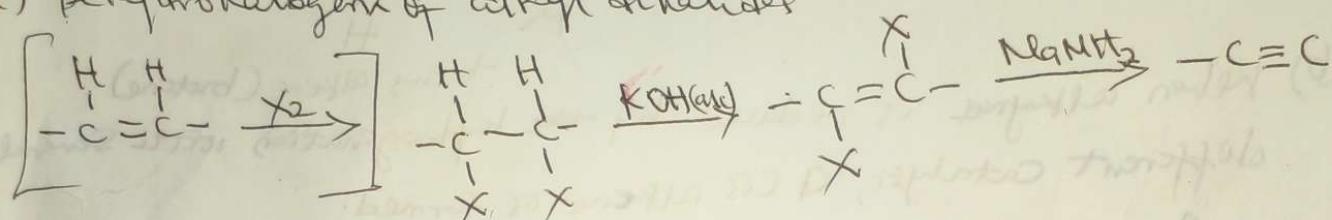


ALKynes (7)

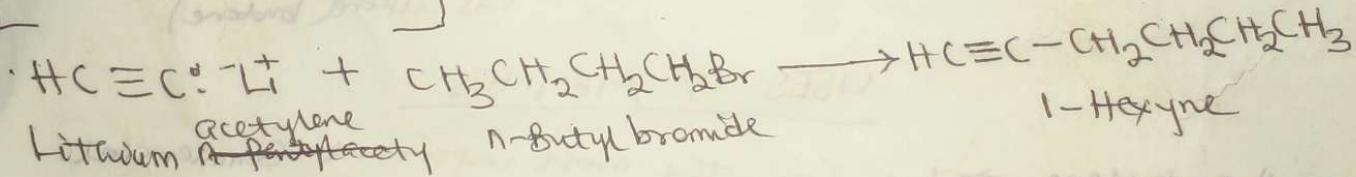
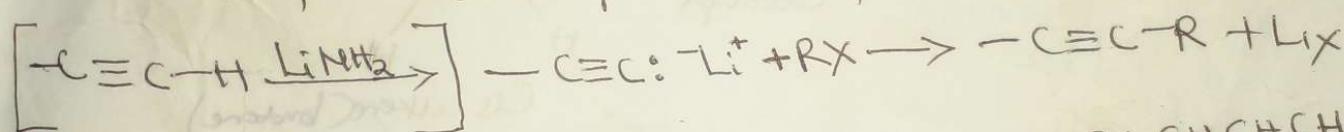
Alkynes are hydrocarbons that contain carbon-carbon triple bond. Alkynes are also called acetylenes because they are derivatives of acetylene, the simplest alkyne. The carbon atoms are joined by a triple bond ($\text{C}\equiv\text{C}$). To form bonds with two other atoms, carbon make use of two equivalent hybrid orbitals i.e. sp orbitals. It is linear in shape with a bond angle of 180° . They have a general molecular formula $\text{C}_n\text{H}_{2n-2}$.

PREPARATION OF ALKYNES

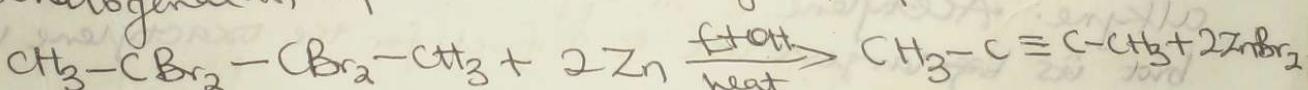
(1) Polyhydrohalogenation of alkyl dihalides



(2) Reaction of metal acetylides with primary alkyl halides

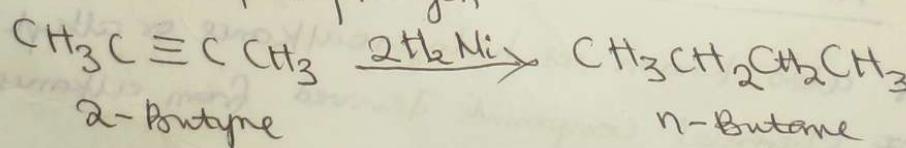


(3) Dehalogenation of vicinal tetrahalogen compounds

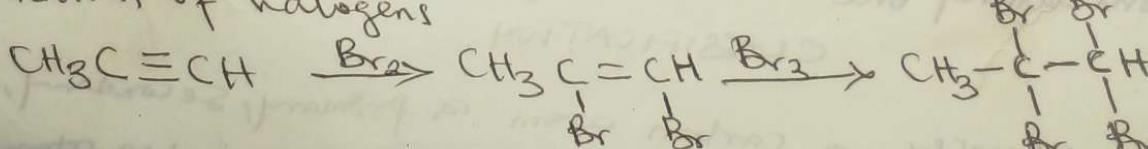


REACTION OF ALKYNES

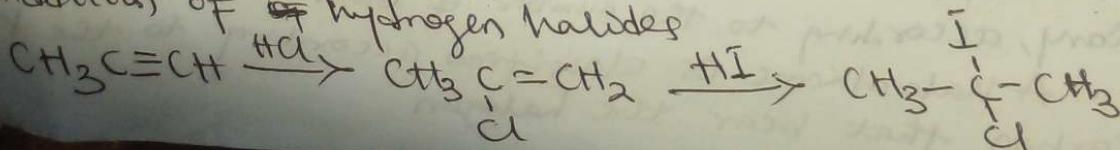
(1) Addition of hydrogen

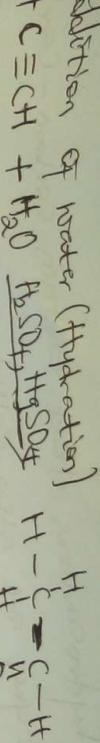


(2) Addition of halogens



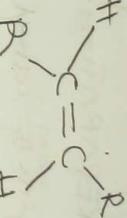
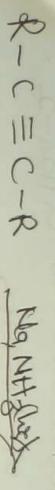
(3) Addition of hydrogen halides



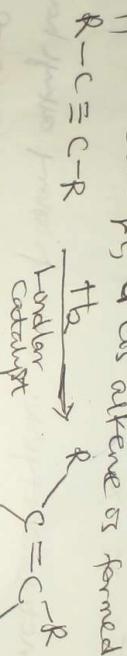


(5) Reduction of Alkenes

(a) When alkene is reduced by sodium or lithium in liquid ammonia a trans alkene is formed.



(b) When alkyne is reduced by hydrogenation with several different catalyst, a cis alkene is formed.



Cis alkene (butene)

USES OF ALKynes

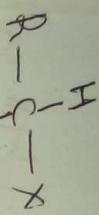
Acetylene or by far the most important commercial alkyne. Acetylene is an important industrial feed stock, but its largest use is a fuel for the oxyacetylene welding torch.

HALOALKANES

The haloalkanes also known as halogenalkanes or alkyl halide are a group of chemical compounds derived from alkanes containing one or more halogens.

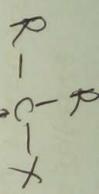
CLASSIFICATION

We classify a carbon atom as primary, secondary, or tertiary according to the number of other carbon atoms attached to it. A haloalkane is classified according to the kind of carbon that bear the halogen.



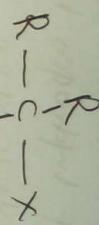
H

Primary
(1°)



H

Secondary
(2°)



H

Tertiary
(3°)

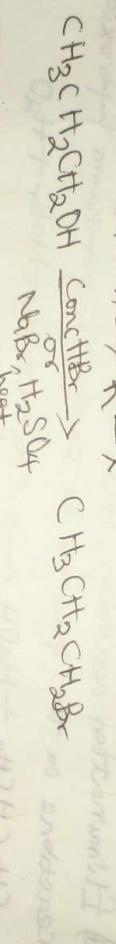
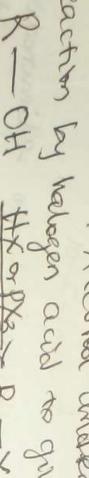
where R is the alkyl group and X is halogen.

PREPARATION OF HALOALKANES

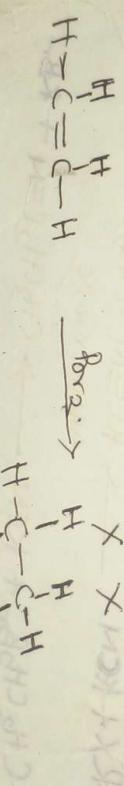
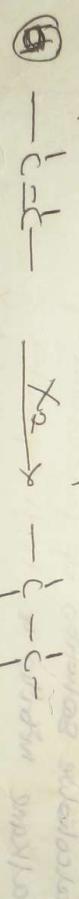
(i) From Alkanes : Alkanes react with Halogens by free radical halogenation.



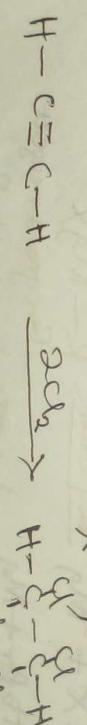
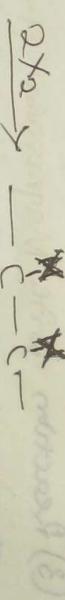
(ii) From alcohols: Alcohols undergo nucleophilic substitution reaction by halogen acid to give haloalkanes.



(iii) From alkenes and alkynes : Alkenes react with halogens to form haloalkanes with two neighbouring halogen atoms in a halogen addition reaction. Alkynes react similarly forming two stere halo compounds.



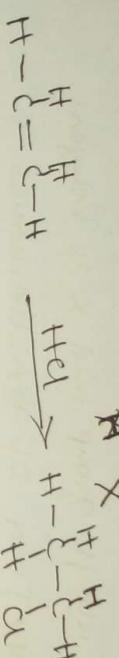
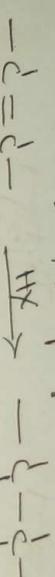
(iv)



1,1,2,2-tetrachloroethane

(4) Addition of hydrogen halides to alkenes.

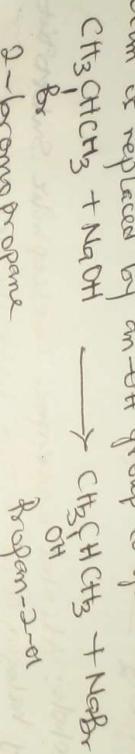
In hydrohalogenation, an alkene reacts with dry hydrogen halide (HX) like hydrogen chloride (HCl) to form a mono-halokane



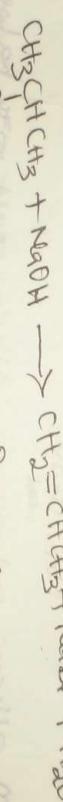
REACTION OF HALOALKANES

(1) Reaction with alkali

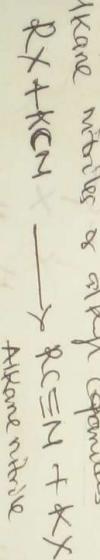
(5) Substitution reaction: In a substitution reaction, the halogen atom is replaced by an -OH group to give an alcohol



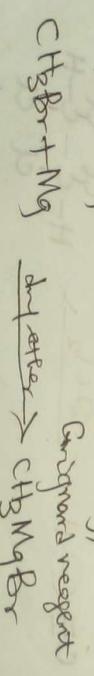
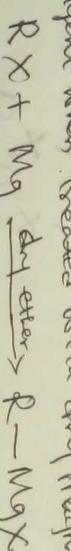
(6) Elimination reaction: Halo alkane undergoes elimination reactions in the presence of sodium or potassium hydroxide



(7) Reaction with alc. KCN: Haloalkanes react with alc. alc. solutions of potassium cyanide (KCN) to give alkane nitriles & alkyl cyanides.



(8) Reaction with Magnesium: Haloalkanes form Grignard reagent when treated with dry magnesium powder in dry ether.

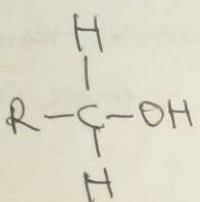


ALCOHOLS

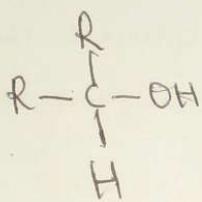
An alcohol is any organic compound in which the hydroxyl function group (-OH) is bound to a carbon. The term alcohol originally referred to the primary alcohol ethanol (ethyl alcohol) which is used as fuel and is the main alcohol present in alcoholic beverages. They have a general molecular formula ~~R-OH~~ $C_nH_{2n+1}OH$.

CLASSIFICATION OF ALCOHOLS

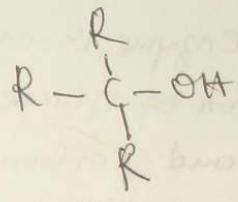
An alcohol is classified as primary, secondary or tertiary according to the kind of carbon that bears the -OH group.



Primary
(1°)



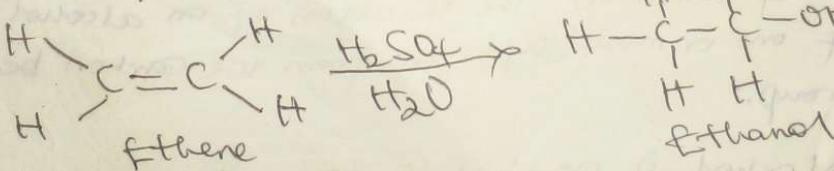
Secondary
(2°)



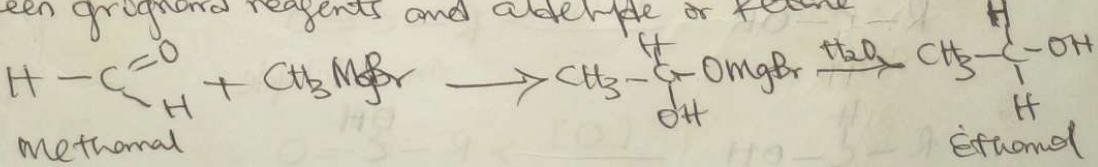
Tertiary
(3°)

PREPARATION OF ALCOHOLS

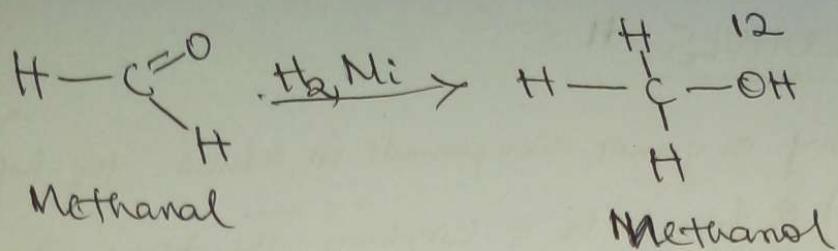
- ① **Hydration of alkenes:** Alcohol is produced by the hydration of alkene with concentrated tetraoxosulphate (VI) acid in the presence of water.



- ② **Grignard reagents:** Alcohol can be prepared by the reaction between grignard reagents and aldehyde or ketone.



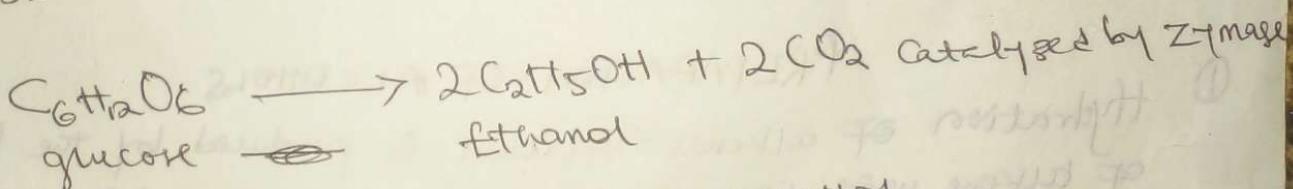
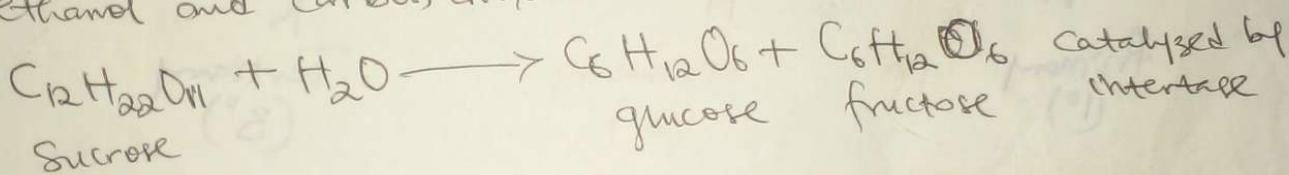
- ③ **Reduction of carbonyl compounds:** Aldehydes and ketones are reduced to alcohol in the presence of hydrogen by a catalyst.



(4) Hydrolysis of halogen alkynes: Alcohol is prepared by boiling halogenalkynes with Sodium hydroxide solution



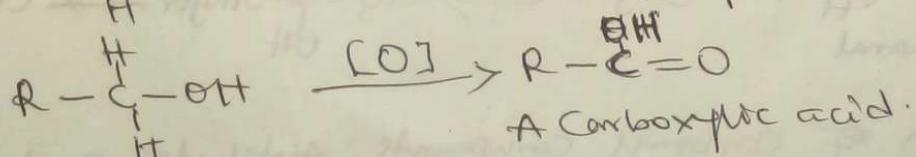
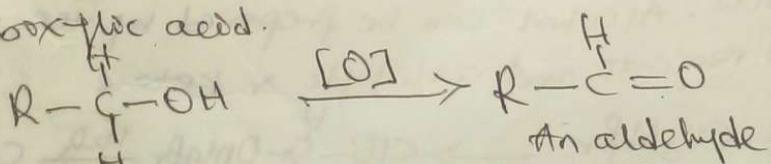
(5) Fermentation: Ethanol is obtained by fermentation using glucose produced sugar from the hydrolysis of starch, in the presence of yeast and temperature of less than 37°C to produce ethanol. For instance, such a process might proceed by the conversion of sucrose by the enzyme invertase into glucose and fructose, then the conversion of glucose by the enzyme complex Zymase into ethanol and carbon dioxide.



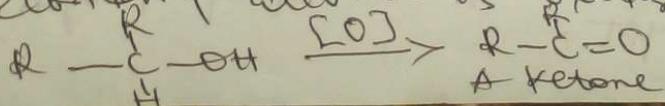
REACTIONS OF ALCOHOL

① OXIDATION OF alcohols: The oxidation of an alcohol involves the loss of one or more hydrogens from the carbon bearing the -OH group.

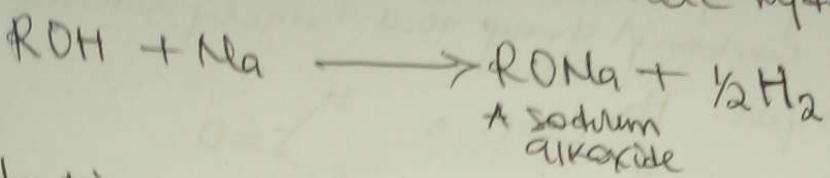
Primary alcohol is oxidized to form either aldehyde or carboxylic acid.



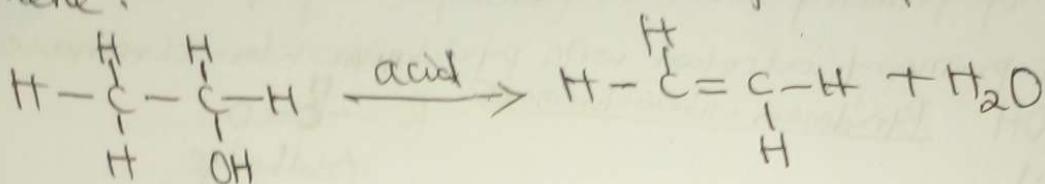
Secondary alcohol is oxidized to form ketone



(2) ALKOXIDE FORMATION: Alkoxide is formed when alcohol reacts with active metals to liberate hydrogen gas.



(3) Dehydration of alcohol: Alcohol is dehydrated by heating it in the presence of a strong acid such as tetraxoxosulphate (VI) or tetraxoxophosphate (V) acid at high temperature to produce ethene.



(4) Esterification reaction: Esterification reaction is the reaction between alcohol and carboxylic acid in the presence of a dehydrating agent to form ester. It is a reversible reaction.

$$RCOOH + R'OH \rightleftharpoons RCOOR' + H_2O$$

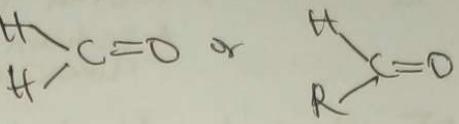
USES OF ALCOHOLS

- (1) Alcohol is used for the production of alcoholic beverages.
- (2) A 50% by volume solution of ethylene glycol in water is commonly used as an antifreeze.
- (3) Ethanol can be used as an antiseptic to disinfect the skin before injections are given. This is ~~also used~~
- (4) Ethanol is also used in making antiseptic soap.
- (5) Some alcohols, mainly ethanol and methanol can be used as an alcohol fuel.
- (6) Alcohol is often used as a preservative for specimens in the field of science and medicine.

ALDEHYDES

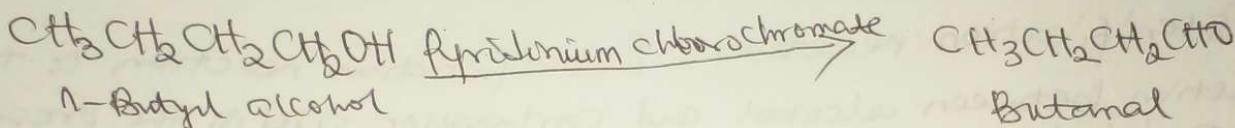
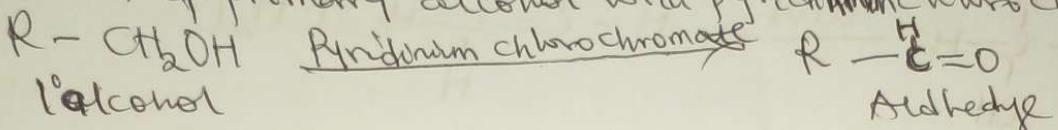
14

Aldehydes are compounds of the general formula of RCCHO . They contain the carbonyl group C=O and are often called carbonyl compounds. It is the carbonyl group that largely determines the chemistry of aldehydes.



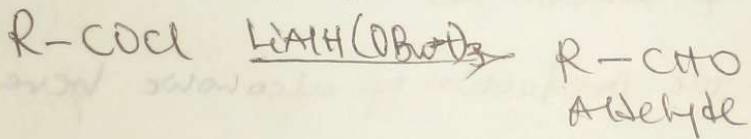
PREPARATION OF ALDEHYDES

- ① Oxidation of primary alcohol: Aldehyde is prepared by the oxidation of primary alcohol with pyridinium chlorochromate.



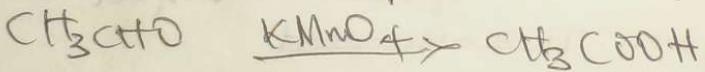
- ② Reduction of a acid chloride:

Aldehydes is prepared by the reduction of acid chloride.

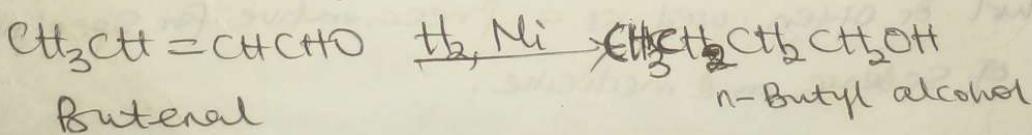


REACTIONS OF ALDEHYDES

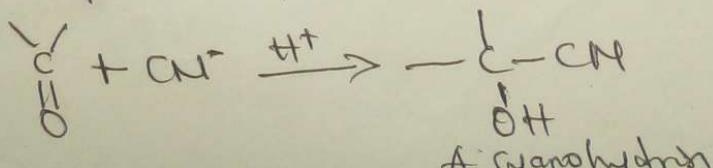
- ① Oxidation: Aldehydes are easily oxidized to carboxylic acids



- ② Reduction: Aldehydes can be reduced to primary alcohol by catalytic hydrogenation.

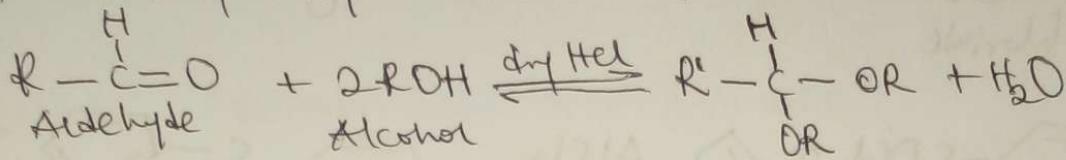


- ③ Addition of cyanide: Cyanides are added to the carbonyl group of aldehydes to yield compounds known as cyanohydrins



(4) Addition of alcohols (Acetal formation)

Alcohols are added to the carbonyl group of aldehydes in the presence of anhydrous acids to yield acetals.



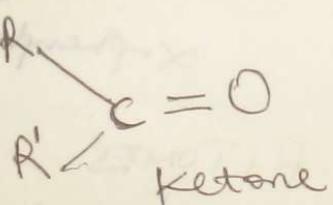
USES

- ① Formaldehyde is mainly used in the production of resins.
- ② Butyraldehyde which is prepared by hydroformylation is a precursor to 2-ethylhexanol which is used as a plasticizer.
- ③ Acetaldehyde is mainly used as precursor to acetic acid.
- ④ Many other aldehydes are commercially used as precursors to alcohols, the so-called oxo alcohols which are used in detergents.

KETONES

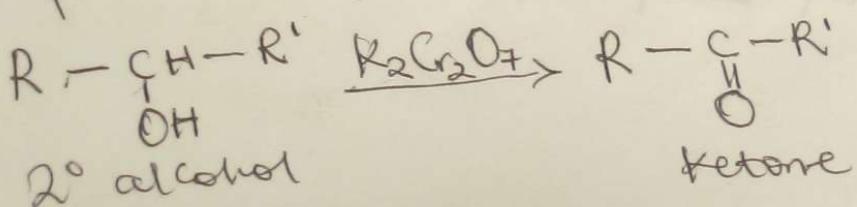
Ketones are compounds of the general formula $\text{RR}'\text{CO}$.

The groups R and R' may be aliphatic or aromatic. Ketones contain the carbonyl group $\text{C}=\text{O}$ and is called a carbonyl compound. The carbonyl group determines the chemistry of ketones.

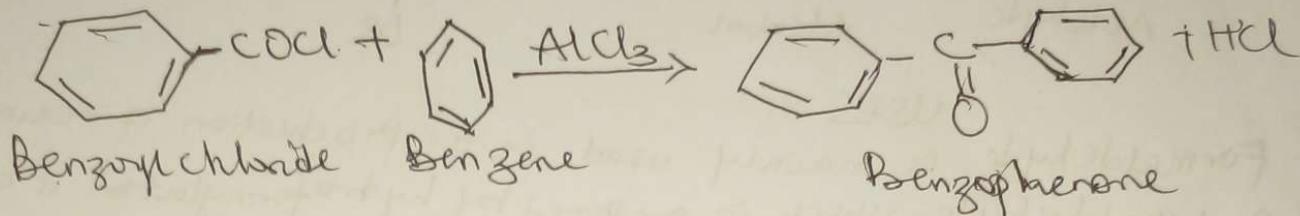
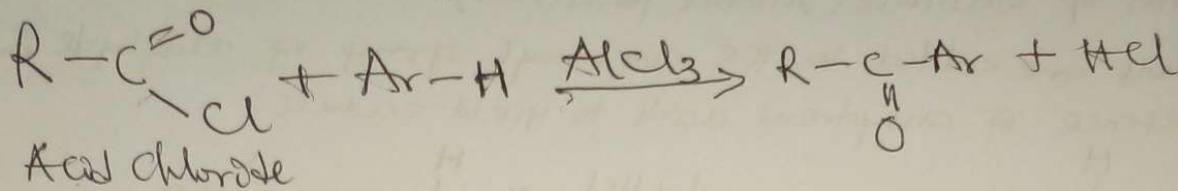


PREPARATION OF KETONES

- ① Oxidation of secondary alcohols: Ketones are prepared by the oxidation of secondary alcohols in the presence of potassium heptachlorodichromate (VI).

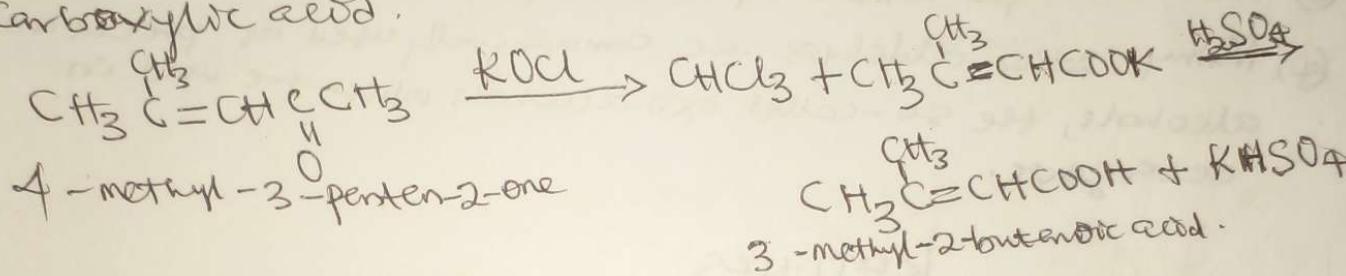


A) Friedel-Crafts Acylation 16

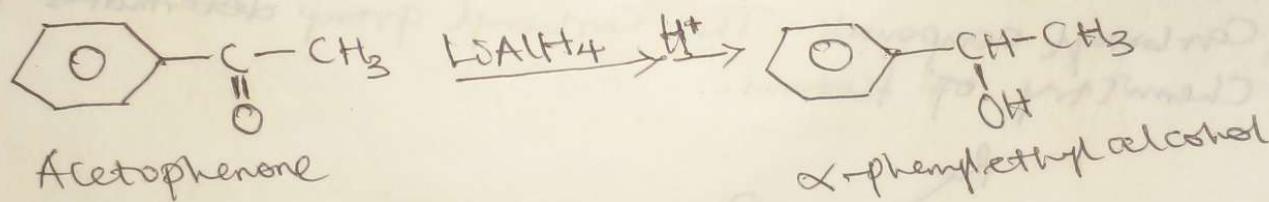


REACTIONS OF KETONES

(1) Oxidation reaction: Methyl Ketones are oxidized to Carboxylic acid.



(2) Reduction to alcohol: Ketones are reduced to secondary alcohol by the use of chemical reducing agent like lithium aluminium hydride, LiAlH_4



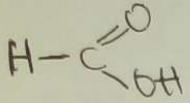
USES OF KETONES

- (1) Ketones are often used in perfumes and faint to stabilize the other ingredients so that they don't degrade as quickly over time.
- (2) Ketones are used as solvent and intermediate in chemical industry. ~~Example of~~

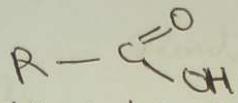
17 CARBOXYLIC ACIDS

Carboxylic acids

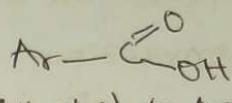
Carboxylic acids are group of organic compounds that contain the carboxyl group attached to hydrogen (HCOOH), an alkyl group (RCOOH), or an aryl group (ArCOOH)



Attached to hydrogen



Attached to Alkyl group

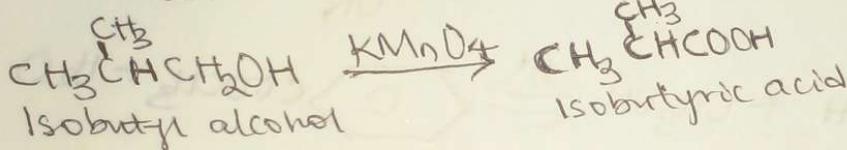
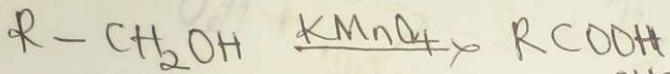


Attached to Aryl group

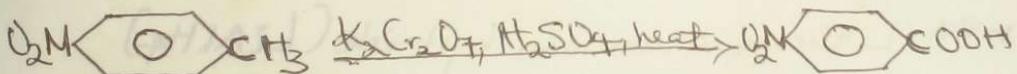
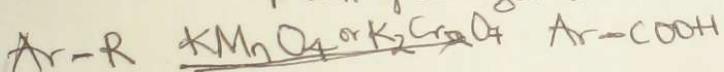
Whether the group is aliphatic or aromatic, saturated or unsaturated, substituted, or unsubstituted, the properties of the carboxylic group are essentially the same.

PREPARATION OF CARBOXYLIC ACIDS

(i) Oxidation of primary alcohols. Primary alcohols are oxidized to carboxylic acid in the presence of potassium tetrabromo-manganese (VII) ($KMnO_4$)



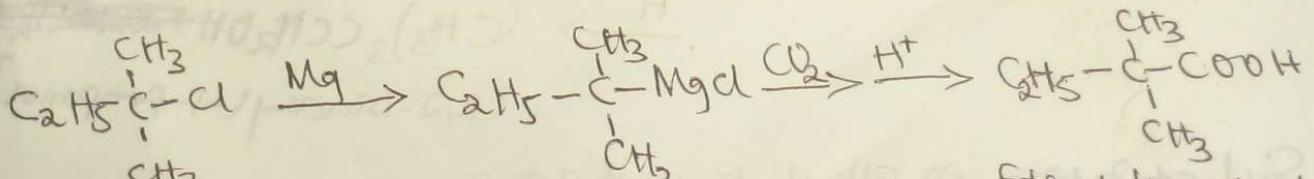
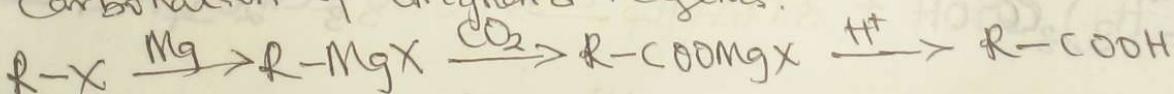
(2) Oxidation of alkylbenzenes



P-Nitrotoluene

P-nitrobenzoic acid.

③ Combination of Grignard reagents.



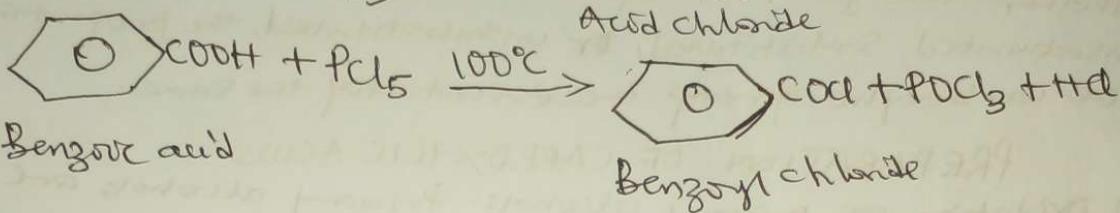
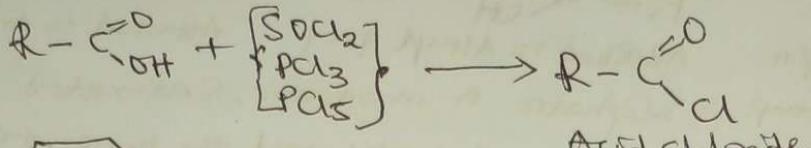
tert-Pentyl chloride

REACTIONS¹⁸ OF CARBOXYLIC ACIDS

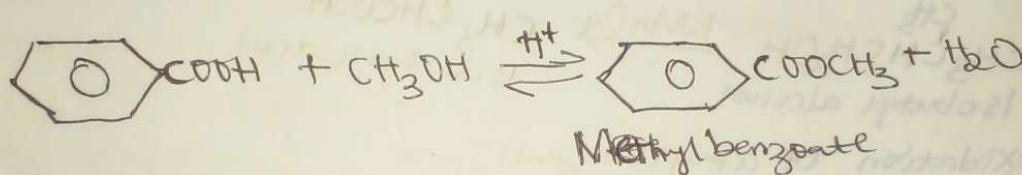
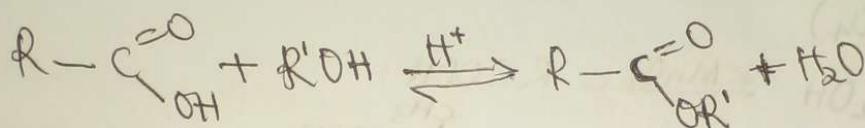
(i) Conversion into functional derivatives

The OH of an acid can be replaced by a Cl, OR' or NH₂ group to yield an acid chloride, an ester and amide.

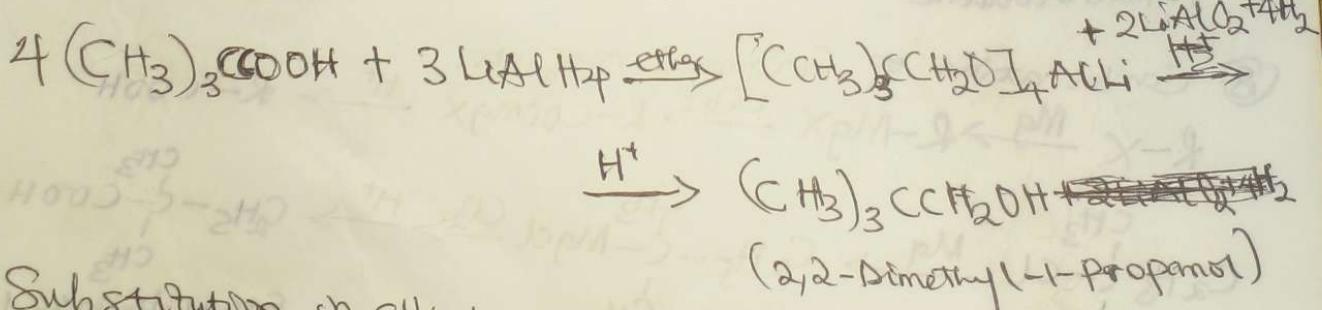
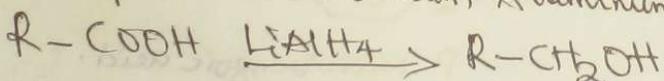
(a) Conversion into acid chloride



(b) Conversion onto esters

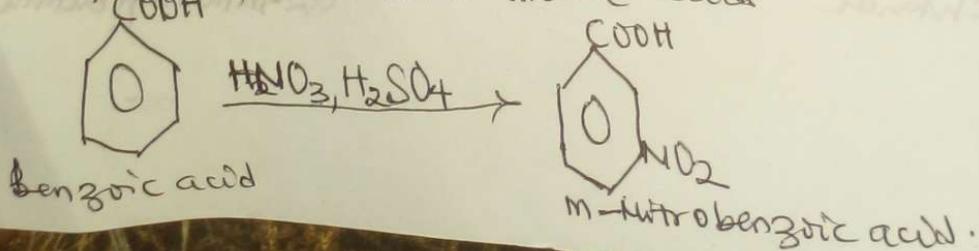


② **Friedel-Crafts:** Carboxylic acids can be reduced to alcohol by treating it with Lithium Aluminum hydride (LiAlH_4)



(3) Substitution in alkyl or aryl groups

Long substitution in aromatic acids
 COOH



USES OF CARBOXYLIC ACIDS

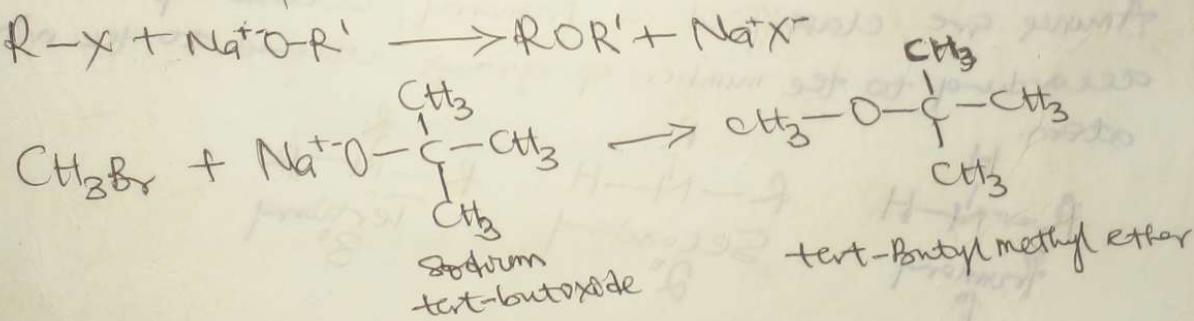
- (1) Higher fatty acids are used in the manufacturing of soap e.g. Stearic acid.
- (2) Carboxylic acids are used in foods, cold drinks etc e.g. Acetic acid is used as vinegar.
- (3) Carboxylic acids are used for the preparation of many drugs such as aspirin, phenacetin etc.
- (4) Acetic acid is used as coagulant in the manufacturing of rubber.
- (5) Acetic acid is also used in the manufacturing of various dye stuffs, perfumes and rayon.

ETHERS

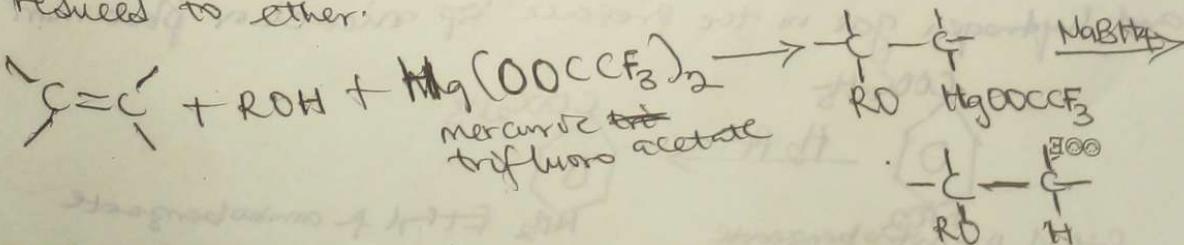
Ethers are compounds of the general formula $R-O-R'$, $Ar-O-R$, or $Ar-O-Ar$. (Ar is phenyl or some other aromatic group).

PREPARATION OF ETHERS

- (1) Williamson synthesis: Alkyl halide reacts with sodium alkoxide to form ether.



- (2) Alkoxymercuration-demercuration: Alkene reacts with alcohol in the presence of mercuric acetate to give an intermediate called alkoxymercury intermediate that is further reduced to ether.

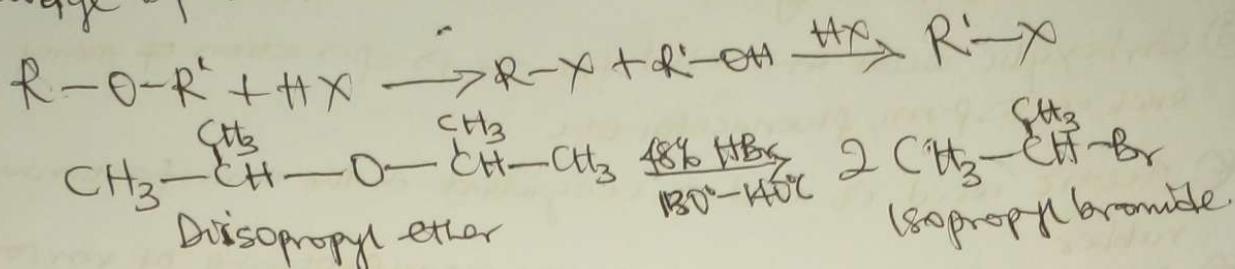


REACTIONS OF ETHERS

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REACTIONS OF ETHERS

Ether are comparatively unreactive compounds. The ether bond is quite stable toward bases, oxidizing agents and reducing agents. Ether undergoes just one kind of reaction which is cleavage by acids.



USES OF FILTERS

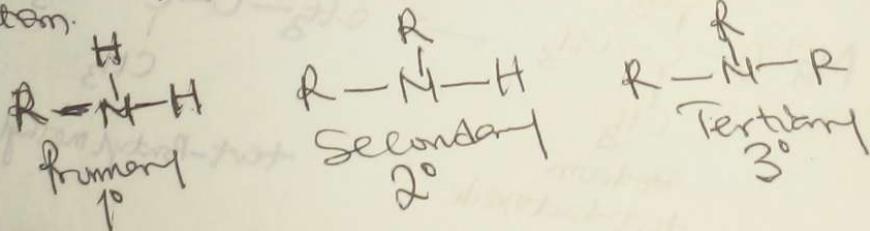
USES OF ETHERS
Ether eg diethyl ether is used as an anaesthetic during surgery.

AMINES

Amines are alkyl or aryl derivatives of NH_2 . They have a general formula RNH_2 , R_2NH , or R_3N , where R is any alkyl or aryl group.

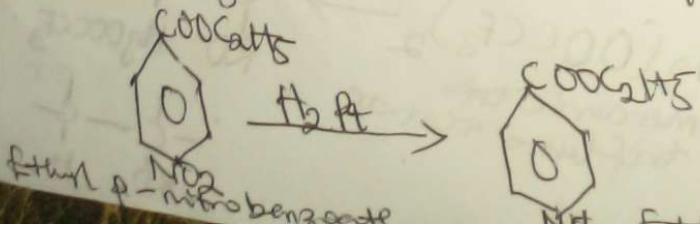
Classification

Amines are classified as primary, secondary or tertiary according to the number of groups attached to the nitrogen atom.



PREPARATION OF AMINES

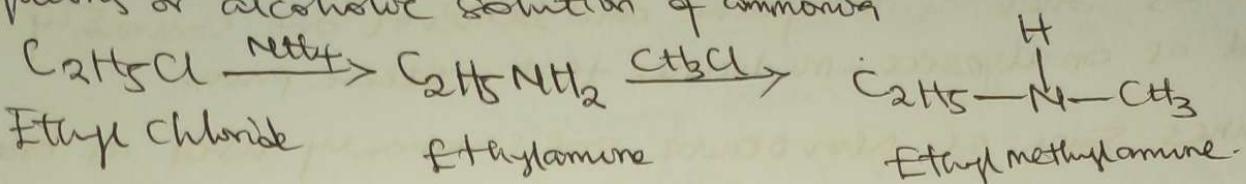
(1) Reduction of nitro Compounds: Amine is prepared by the reaction between a solution of the nitro compound in alcohol and hydrogen gas in the presence of nickel or platinum catalyst.



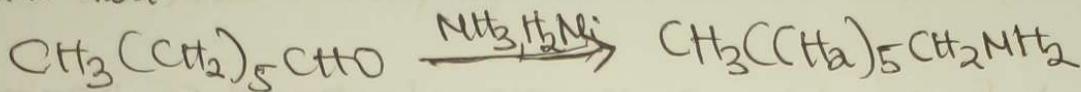
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Reactions of halides with ammonia or amines : Organic halogen compounds are converted into amines by treatment with aqueous or alcoholic solution of ammonia H

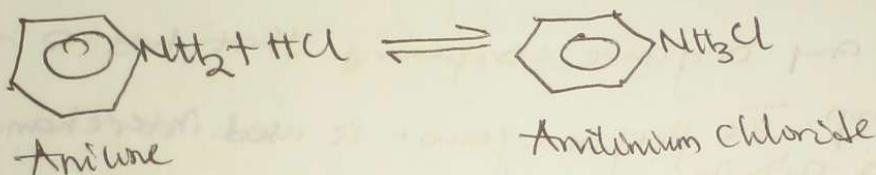


② Reductive amination: Many aldehydes and ketones are converted into amine by reductive amination i.e. reduction in the presence of ammonia.

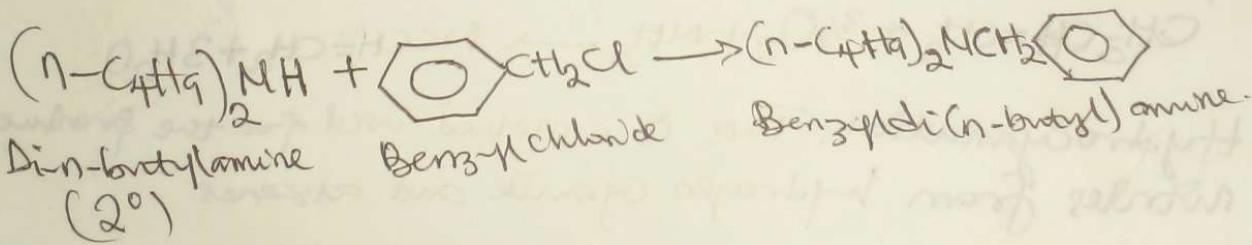


FRACTIONS

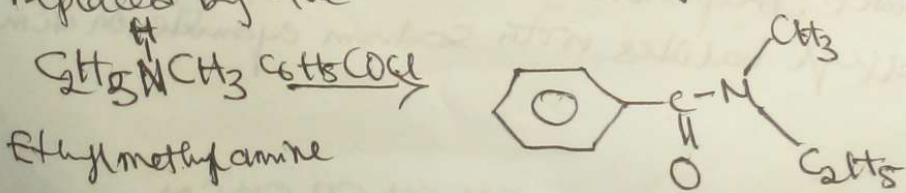
(1) Salt formation: Ammonium reacts with acids to form salt.



(2) Alkylation : Amine alkylation is a reaction between an alkyl halide and amine to produce a higher substituted amine.



③ Conversion into amides : Amines react with acids to form substituted amides compounds in which -H has been replaced by the $-NH_2$ or NH_3^+ group.



N-Ethyl-*N*-methylbenzamide

USES OF AMINES

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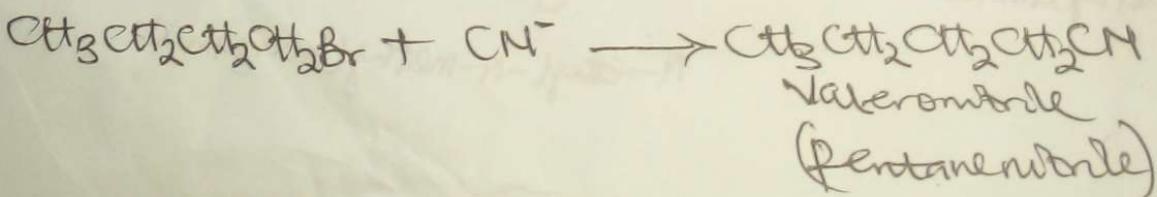
- ① Amines such as Morphine and Demerol are commonly used as analgesics - medicines that relieve pain.
 - ② Amines such as Novocaine are commonly used as anaesthetics.
 - ③ Tetramethyl ammonium iodide is used in the disinfection of drinking water.
 - ④ Many amines are used in industries for pest control and tanning of leather.
 - ⑤ Amine finds application in the manufacture of man-made fibres.

MITRELES

MINERALS

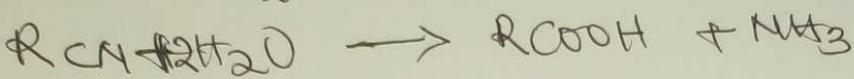
A nitrile is any organic compound that has a $\text{C}\equiv\text{N}$ function group. The prefix cyano- is used interchangeably with the term nitrile.

PREPARATION OF NITRILES

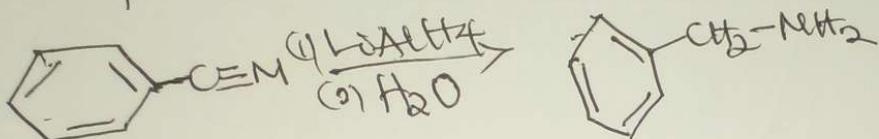


REACTIONS

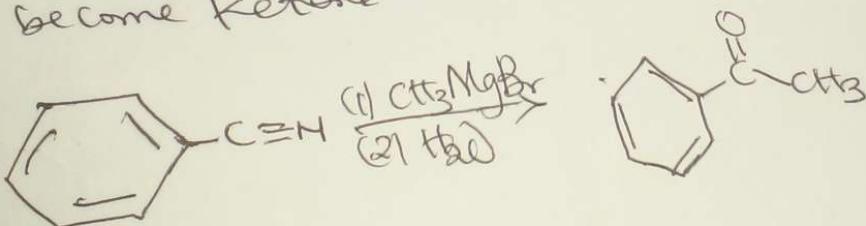
(1) Hydrolysis: Nitrile are hydrolyzed under acid or base treatment to carboxamide (RC(O)NH_2) and carboxylic acids & CO_2H



(2) Reduction: Nitrile can be reduced to amine by treating it with Lithium aluminium hydride (LiAlH_4)



(3) Reaction of nitriles with organometallic reagents: Grignard reagents can attack the electrophilic carbon in a nitrile to form an imine salt, which can be hydrolyzed to become ketone



USES

- (1) Nitrile are used in the manufacture of nitrile gloves.
- (2) They are used as an anti-diabetic drug which is used in the treatment of breast cancers.
- (3) The compound of nitrile called perphenazine is used as anti-psychotic.