Class 12 Boards 2022

CHEMISTRY

SHORT NOTES

MADE BY:

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Haloalkanes

Hydrogen atom in aliphatic hydrocarbons replaced by halogen.

R-X (X = F, Cl, Br, I)

Classification:

- Haloalkanes → 1° $R-CH_2-X$
  → 2° R_2-CH-X
  → 3° R_3-C-X

- **Allylic Halide**

$CH_2=CH-CH_2-X$

- **Benzyl Halide** **Vinyl Halide** **Aryl Halide**



Preparation

R-OH →
- $HX, ZnCl_2$ → $R-X + H_2O$
- Red P / X_2 → $R-X$ ($X = Br, I_2$)
- $+ PCl_5$ → $R-Cl + POCl_3 + HCl$
- $SOCl_2$ → $R-Cl + SO_2 + HCl$ (Best Method)
- $NaBr, H_2SO_4$ → $R-Br + NaHSO_4 + H_2O$

From Alkene

$R-CH=CH_2 + HX$ —Mark. Rule→ $R-\underset{X}{CH}-CH_3$

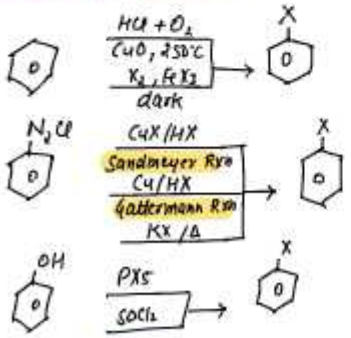
$R-CH=CH_2 + HBr$ —Benzoyl Peroxide, Anti-Markovnikov Rule→ $R-CH_2-\underset{Br}{CH_2}$

$H_2C=CH_2 + Br_2$ —CCl_4→ $BrCH_2-CH_2Br$ (Test of Unsaturation)

Halogenation:

$CH_3-CH_2-CH_3$ —$Cl_2, h\nu$→ $CH_3-\underset{Cl}{CH}-CH_3$ (major) + $CH_3-CH_2-CH_2-Cl$

Preparation of Haloarenes



Physical Properties

B.P ∝ Mol. Mass

B.P ∝ Surface Area

B.P ∝ 1/Branching

- B.Pt Order → R-I > R-Br > R-Cl > R-F
- M.Pt of p-isomer is more than that of ortho and meta due to symmetry.
- The **density** increases with increase in no. of carbon atoms, halogen atoms and atomic mass of the halogen atom.
- **Solubility** Although Haloalkanes are polar but they can not form Hydrogen bond with water molecule hence they are insoluble in water and soluble in Organic solvents.

Finkelstein Reaction

$R-X + NaI \xrightarrow[Acetone]{Dry} R-I + NaX$

Swarts Reaction

$R-X \xrightarrow{AgF, HgF, CoF \text{ or } SbF} R-F$

Chemical Properties

Elimination Reaction

$CH_3-\underset{Cl}{CH_2} \xrightarrow{alc.\ KOH} CH_2=CH_2 + KCl + H_2O$

Acc. to Saytzeff Rule

In elimination reaction, prefered alkeneo is one in which double bonded C-atom are more alkylated

$CH_3-\overset{\beta}{CH_2}-\underset{Br}{\overset{\alpha}{CH}}-\overset{\beta}{CH_3} \xrightarrow[KOH]{alc.} CH_3-CH=CH-CH_3$ (80%) + $CH_3-CH_2-CH=CH_2$ (20%)

R-X
- Aq. KOH → alcohol → High Polarity
- Alc. KOH → Alkene → low Polarity.

Reaction with Metal

$R-X + Mg \xrightarrow[Ether]{Dry} R-Mg-X$ Grignard Reagent

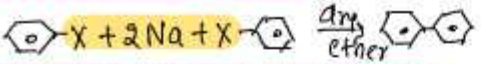
$CH_3-Cl + Mg \xrightarrow[Ether]{Dry} CH_3-MgCl$ Grignard Reagent

Grignard reagent are highly reactive and react with any source of proton to give Hydrocarbons

WURTZ REACTION

$R\text{-}X + 2Na + X\text{-}R \xrightarrow[\text{ether}]{\text{dry}} R\text{-}R + 2NaX$

FITTIG REACTION



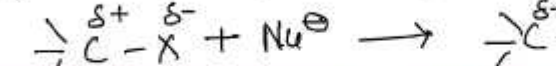
WURTZ FITTIG REACTION

Resonance in Haloarenes: (2)

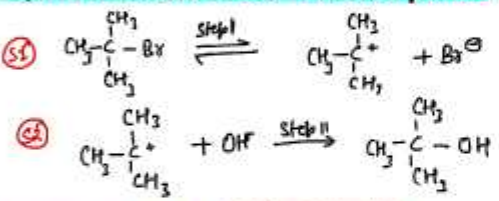
Aryl Halides are less reactive towards Nucleophilic substitution reaction because C-Cl bond acquire partial double bond due to resonance as a result the bond cleavage in Haloarenes is difficult than halo alkanes.

Nucleophilic Substitution Reaction:

when an atom or group of atom is replaced by nucleophile

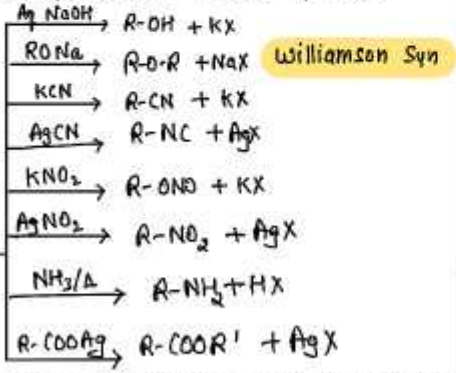


S_N1 (Unimolecular Nucleophilic)



Reactivity order: $3^\circ > 2^\circ > 1^\circ$

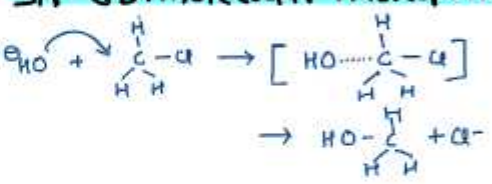
- Polar Protic solvent is used
- Racemisation takes place



KCN is predominantly ionic, the attachment takes place mainly through carbon atom and thus form cyanide

AgCN is covalent in nature nitrogen is free to donate the $e^\ominus$ pair forming isocyanide.

S_N2 (Bimolecular Nucleophilic)

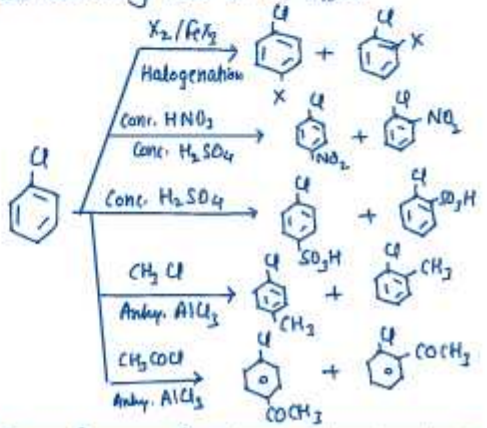


Reactivity Order: $1^\circ > 2^\circ > 3^\circ$

- Inversion of confi. takes place
- Nucleophile attacks from opp. side

Electrophilic Substitution Rxn

Halo group on benzene ring is ortho and para directing due to +R effect



Para isomer is the major product

Alcohol, Phenol and Ethers (7)

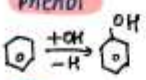
Alcohol

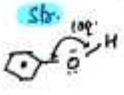
$R-H \xrightarrow[-H]{+OH} R-OH$

Str. 

due to lp-lp repulsion

Phenol



Str. 

due to double bond character and sp^2 hybridized

Ether

$R-O-R'$

Str. 

due to bulky alkyl group.

Types of Alcohol

1° $R-CH_2-OH$

2° $\begin{matrix} R \\ R \end{matrix}\!\!>\!CH-OH$

3° $\begin{matrix} R \\ R \\ R \end{matrix}\!\!>\!C-OH$

Allyl Alcohol $CH_2=CH-CH_2-OH$

Benzyl Alcohol 

Vinyl Alcohol $CH_2=CH-OH$

Methods of Preparation

$CH_3-Cl + aq.\ KOH \longrightarrow CH_3-OH + KCl$

From Carbonyl Compound

$CH_3-\overset{O}{\overset{\|}{C}}-H + H_2 \xrightarrow{Ni \text{ or } Pt} CH_3-CH_2-OH$

$CH_3-\overset{O}{\overset{\|}{C}}-CH_3 + H_2 \xrightarrow{Ni} CH_3-\overset{OH}{\overset{|}{C}}H-CH_3$

$R-\overset{O}{\overset{\|}{C}}-OH \xrightarrow[ii)\ H_2O]{i)\ LiAlH_4} R-CH_2-OH$

From Alkene:

Acid Catalysed Hydration

$\begin{matrix} H \\ H \end{matrix}\!\!>\!C=C\!<\!\begin{matrix} H \\ H \end{matrix} + H_2O \xrightarrow{H^+} CH_3-\overset{OH}{\overset{|}{C}}H_2$

Hydroboration-Oxidation Rxn

$CH_3-CH=CH_2 + (BH_3)_2 \longrightarrow (CH_3-CH_2-CH_2)_3B$

$\xrightarrow[OH^-]{H_2O_2,}$ $CH_3-CH_2-OH + H_2BO_2$

From Grignard Reagent:

$H-\overset{O}{\overset{\|}{C}}-H + CH_3MgBr \longrightarrow H-\overset{OMgBr}{\overset{|}{C}}-H \xrightarrow{H^+}$ $\quad CH_3$

$CH_3-CH_2OH + Mg\!<\!\begin{matrix} OH \\ Br \end{matrix}$

$HCHO \xrightarrow[ii)\ H_2O/H^+]{i)\ RMgX}$ 1° alcohol

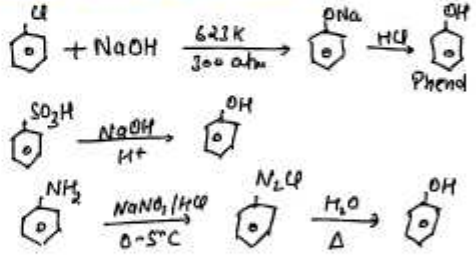
$RCHO \xrightarrow[ii)\ H_2O/H^+]{i)\ RMgX}$ 2° alcohol

$R-CO-R \xrightarrow[ii)\ H_2O/H^+]{i)\ RMgX}$ 3° Alcohol.

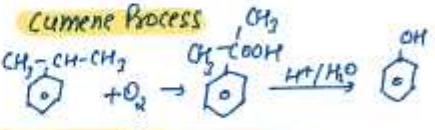
Lucas Test (Lucas Reagent $HCl + ZnCl_2$)

1° alcohol	2° alcohol	3° alcohol
$R-CH_2-OH + HCl \xrightarrow{ZnCl_2} R-CH_2-Cl + H_2O$	$R-\overset{R}{\overset{\|}{C}}H-OH + HCl \xrightarrow{ZnCl_2} R-\overset{R}{\overset{\|}{C}}H-Cl + H_2O$	$R-\overset{R}{\overset{\|}{\overset{R}{\overset{\|}{C}}}}-OH + HCl \xrightarrow{ZnCl_2} R-\overset{R}{\overset{\|}{\overset{R}{\overset{\|}{C}}}}-Cl + H_2O$
Turbidity appears on heating	Turbidity appears in 5 min.	Turbidity appears immediately

Preparation of Phenol



Cumene Process



Physical Properties

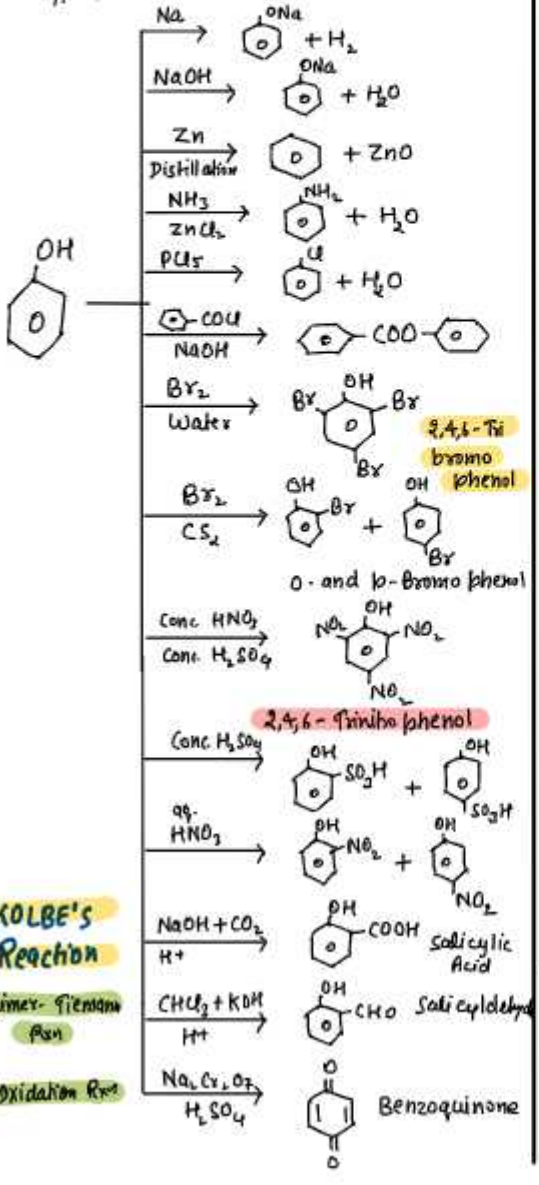
- Due to strong hydrogen bonding b/w molecules of alcohol, they have higher bpt as compared to molecules of alkane having same molecular mass.
- As molecular weight increases surface area also increases and there is increase in Van der Waal force. As a Result m.pt increases.

- The bpt of phenol increases with increase in no. of C-atoms.

Nature of Phenol:

order of acidity $\bigcirc$-OH > 1° > 2° > 3°

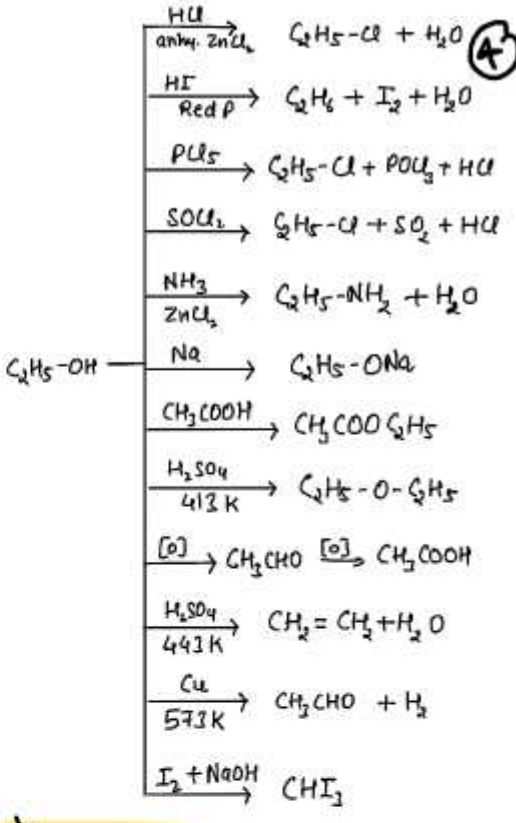
electron withdrawing group like $-NO_2$, $-X$, $-CHO$, $-COOH$ increase acidic strength due to $-I$ effect while electron donating group like $-R$, $-OR$ decrease acidic strength due to $+I$ effect



KOLBE'S Reaction

Reimer-Tiemann Rxn

Oxidation Rxn



Oxidation

1° alcohol $\xrightarrow{[O]}$ Aldehyde

2° alcohol $\xrightarrow{[O]}$ Ketone

3° Alcohol $\xrightarrow{[O]}$ No Rxn

Ethers $R-O-R'$ $C_nH_{2n+2}O$

Preparation

- Dehydration of Alcohol

$$2(C_2H_5-OH) \xrightarrow[413K]{\text{conc. } H_2SO_4} C_2H_5-O-C_2H_5$$

- $2(C_2H_5-Cl) + Ag_2O \xrightarrow{\Delta} C_2H_5-O-C_2H_5$

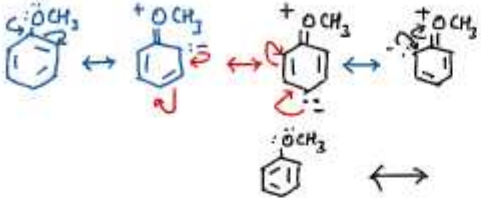
Williamson Synthesis (SN^2)

$R-X + Na-O-R' \longrightarrow R-O-R' + NaX$

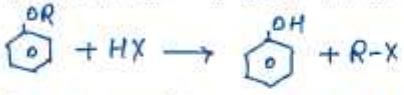
- If alkyl halide is 1° ether will form
- If alkyl halide is 3° alkene will form

Chemical Properties

- Ethers are less reactive than alcohols
- Alkoxy ion is ortho and para directing it activates the benzene ring towards electrophilic sub.

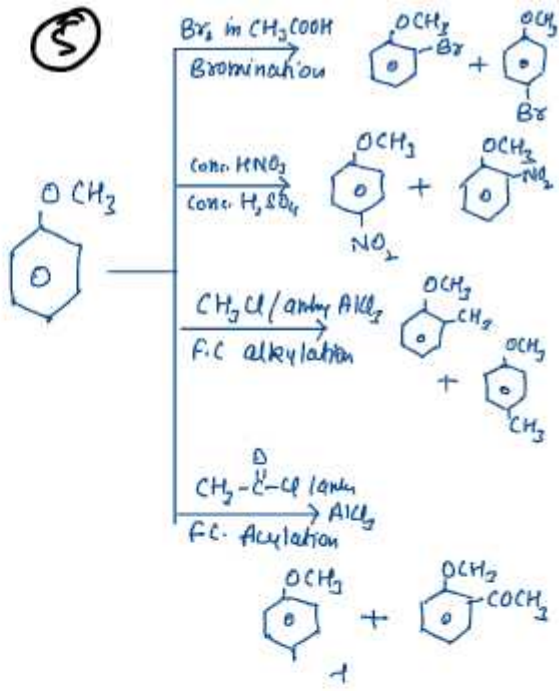


$$R\text{-}O\text{-}R + HX \longrightarrow R\text{-}OH + R\text{-}X$$



Order of reactivity $HI > HBr > HCl$

(5)



Polyhalogen Compounds

- Chloroform (Trichloromethane, $CHCl_3$)

$$CH_4 + 3Cl_2 \xrightarrow[\text{Controlled oxidation}]{\text{Sunlight}} CHCl_3 + 3HCl$$

- Iodoform (triiodoform, CHI_3)

$$CH_3COCH_3 + 3I_2 + 4NaOH \longrightarrow CHI_3\downarrow + 3NaI + CH_3COONa + 3H_2O$$

- Carbon Tetra Chloride [CCl_4]

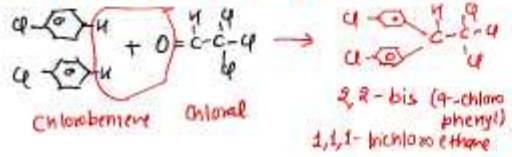
i) $CH_4 + 4Cl_2 \xrightarrow{\text{Sunlight}} CCl_4 + 4HCl$

ii) $CHCl_3 + Cl_2 \xrightarrow{h\nu} CCl_4 + 2HCl$

CCl_4 is a colourless, non-inflammable, poisonous liquid, soluble in alcohol and ether.

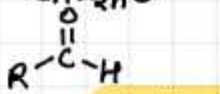
➤ Uses
- as a solvent for oils, fats, resins
- in dry cleaning
- as fire extinguisher

DDT (p,p'- Dichloro Diphenyl trichloro ethane)

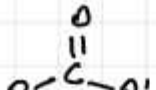


Aldehydes & Ketones

In Organic compounds containing carbon-oxygen double bond ($>C=O$) called carbonyl group. Their general formula is $C_nH_{2n}O$

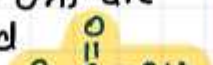


Aldehyde

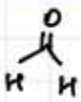


Ketone

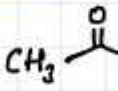
The carbonyl compound in which carbonyl group is bonded to an oxygen atom of hydroxyl group (C-OH) are known as caboxylic acid



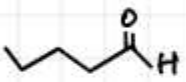
Nomenclature of Aldehyde



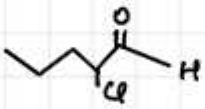
methanal



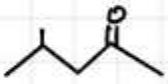
ethanal



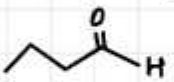
pentanal



2-Chloropentanal



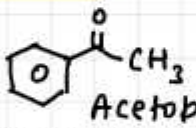
3-Methyl butanal



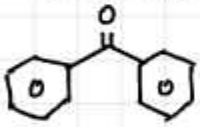
Butanal

Nomenclature of Ketones

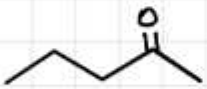
Propanone (Acetone)



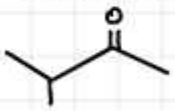
Acetophenone (methyl phenyl Ketone)



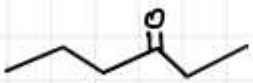
benzophenone



2-pentanone

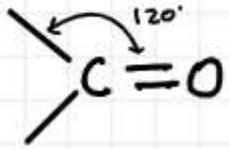


3-Methyl-2-butanone

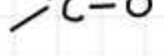


3-hexanone

STRUCTURE OF CARBONYL GROUP



1. C-sp^2 hybridization
2. Bond angle is 120°
3. 3σ bond, 1π bond
4. Carbon-Oxygen double bond consist 1σ & 1π



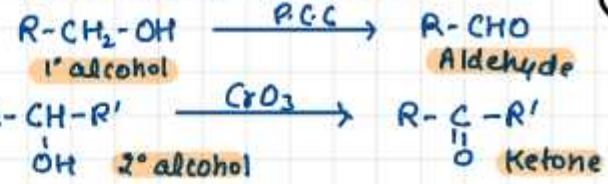
5. Carbon-oxygen bond is polar in Nature

6.) In Carbonyl gp C^+ is electrophilic O^- is Nucleophilic

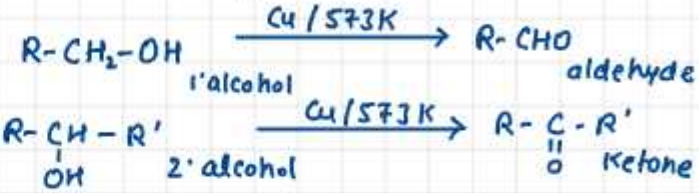
PREPARATION OF ALDEHYDES AND KETONES:

(6)

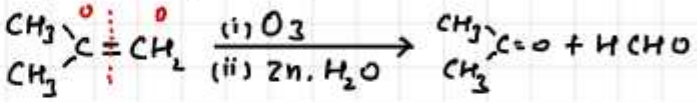
1.) By Oxidation of alcohols:



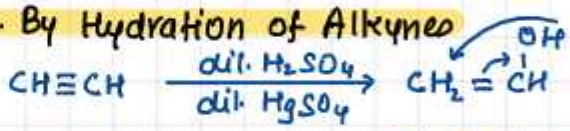
2. By Dehydrogenation of Alcohols



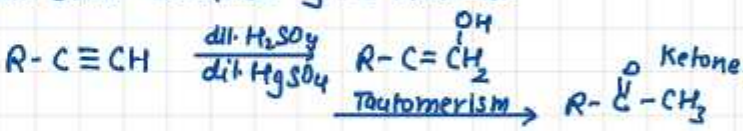
3. By Ozonolysis of Alkenes:



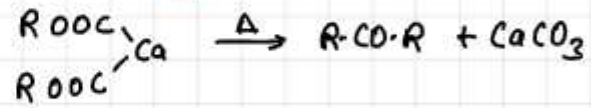
4. By Hydration of Alkynes



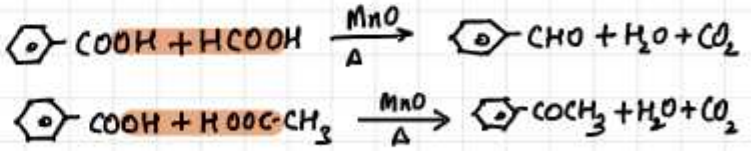
All other alkynes give ketones.



By Heating Ca Salt of Acid

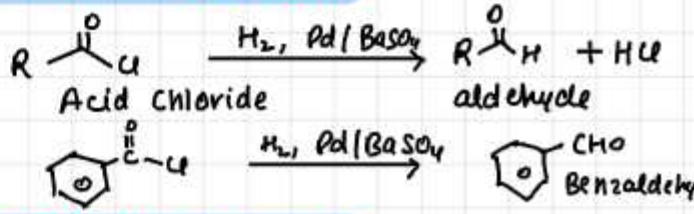


By Decarboxylation and Dehydration of Aromatic Acids

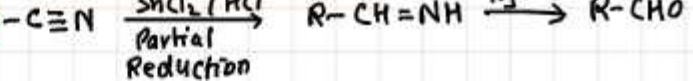


PREPARATION OF ALDEHYDE ONLY

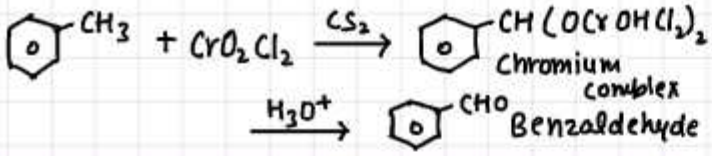
→ ROSENMUND REDUCTION:



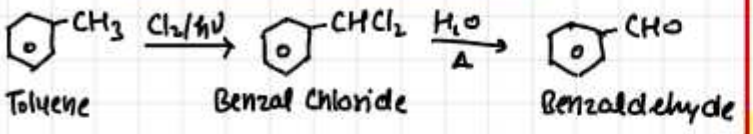
→ STEPHEN REDUCTION



ETARD REACTION:

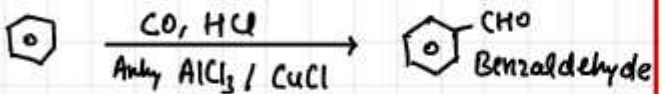


By Side Chain Chlorination of Methylbenzene followed by Hydrolysis:



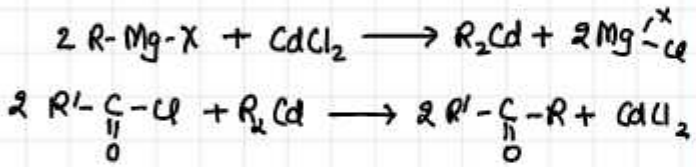
Commercial method to manufacture of Benzaldehyde

GATTERMAN - KOCH REACTION:

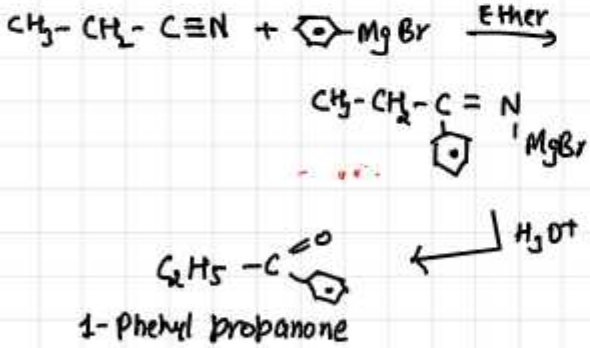


PREPARATION OF KETONES

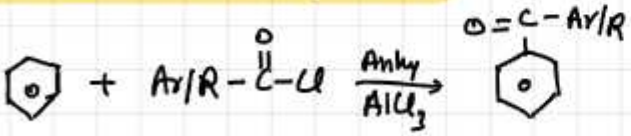
- From Acid Chloride



2.) From Nitriles:



3.) Friedal Craft Acylation



PHYSICAL PROPERTIES OF ALDEHYDE AND KETONE

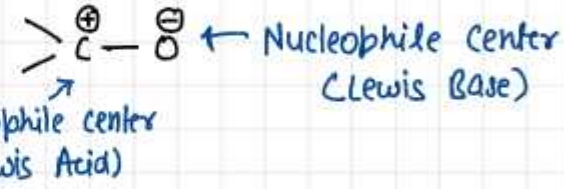
- Lower member of aldehyde and ketones upto C_{10} are colourless, volatile liquid while formaldehyde is a gas at ordinary temp. Higher members of both are solids with fruity odour.
- BPt of carbonyl compounds are higher than those of non-polar compounds, hydrocarbons and ethers due to dipole-dipole interactions but their bpt are lower than alcohols.

SOLUBILITY: Lower members of aldehyde and ketones are soluble in water because of H-Bond. The solubility of aldehyde and ketones decreases rapidly on increasing the length of alkyl chain. All aldehyde and ketones are fairly soluble in organic solvent.

CHEMICAL PROPERTIES

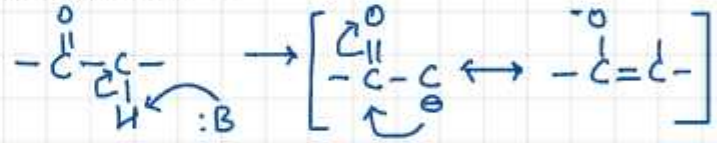
Polar Nature of Carbonyl Group →

The polarity of Carbonyl group arise due to high electronegativity of O-atom.



Acidity of α-Hydrogen Atom:

The strong electron withdrawing effect of carbonyl group and resonance stabilisation of conjugate base are responsible for the acidity of α-hydrogen atom.



NUCLEOPHILIC ADDITION REACTION

the reactivity of aldehyde is more than that of Ketones, due to

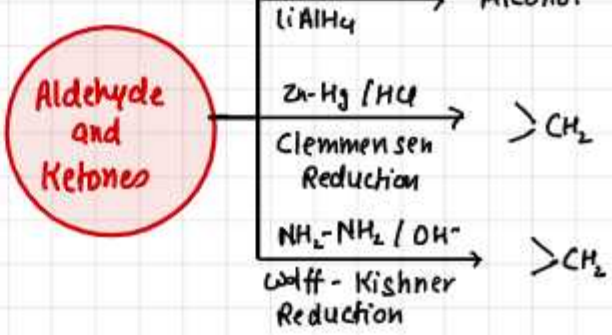
↳ Steric Reason

The attack of nucleophile on carbonyl carbon is hindered by the presence of large substituent on Ketones

↳ Electronic Reason

The presence of two alkyl group in Ketones the electrophilicity of carbonyl carbon more effectively than aldehyde.

REDUCTION



NUCLEOPHILIC ADDITION REACTION

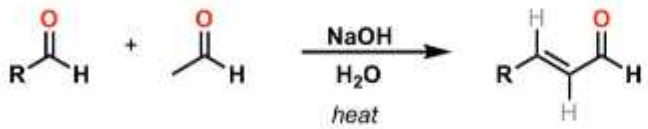
- HCN/OH^- → $>C<^{CN}_{OH}$ Cyanohydrin
- $NaHSO_3$ → $>C<^{SO_3Na}_{OH}$ Bisulphite addition product
- ROH / Dry HCl → $>C<^{OR}_{OH}$; ROH / Dry HCl → $>C<^{OR}_{OR}$ Acetal
- CH_2-OH, $CH-OH$ → $>C<^{O\,CH_2}_{O\,CH_2}$ Ketal
- H_2N-Z → $>C=N-Z$
  - Z = OH, $-NH_2$, $-C_6H_5-NH_2$

OXIDATION REACTION

- $K_2Cr_2O_7/H^+$ → R-COOH
- $2[Ag(NH_3)_2]^+$ (Tollens Test) → $2Ag\downarrow + RCOO^-$ {Only Aldehydes}
- $2Cu^{2+} + 5OH^-$ (Fehling's Test) → $Cu_2O\downarrow + RCOO^-$ {Only Aldehydes}
- NaOX (Haloform) → $CHX_3 + RCOO^-Na^+$ {methyl ketone and ethanal give this test}

REACTION DUE TO α-HYDROGEN

Aldol Condensation Reaction



CARBOXYLIC ACID (-C(=O)-OH)

The carboxyl group, consist of a carbonyl gp attached to a hydroxyl group

Aliphatic (R-COOH) or Aromatic (C_6H_5-COOH)

Their general formula is $C_nH_{2n}O_2$

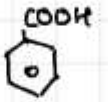
8

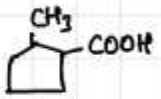
H-COOH
Methanoic Acid
(Formic Acid)

CH_3-COOH
Ethanoic Acid
(Acetic Acid)

CH_3-CH_2-COOH
Propanoic Acid

COOH
COOH
Oxalic Acid
(Ethane-1,2-dioic acid)

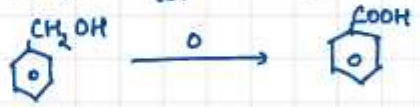

Benzoic Acid
(Benzene Carboxylic Acid)


2-Methyl cyclo pentene-1-carboxylic Acid.

METHODS OF PREPARATION:

From alcohol by Oxidation:

$CH_3CH_2OH \xrightarrow[(O)]{alc.\ KMnO_4} CH_3CHO \xrightarrow{(O)} CH_3COOH$



$CH_3-(CH_2)_6-OH \xrightarrow[H_2SO_4]{Cr_2O_3} CH_3-(CH_2)_5-COOH$

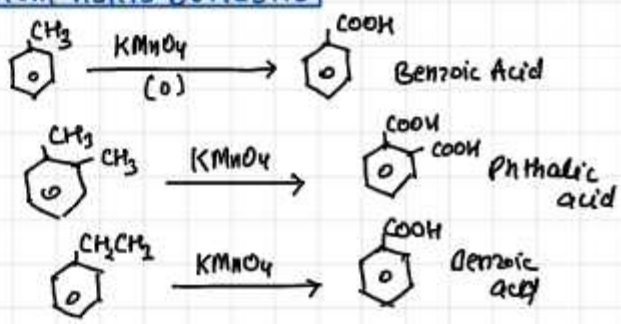
→ OXIDATION OF ALDEHYDE AND KETONE

$CH_3-CHO \xrightarrow[[O]]{KMnO_4} CH_3-COOH$

$CH_3-\overset{O}{\overset{\|}{C}}-CH_2-CH_3 \xrightarrow[[O]]{KMnO_4} CH_3COOH + CH_3COOH$

Oxidation of Ketones is done with difficulty acc. to PODOFF'S RULE i.e Ketonic group remain with smaller group.

FROM ALKYL BENZENE



HYDROLYSIS OF NITRILES

$R-CN + H_2O \xrightarrow{H^+/OH^-} RCONH_2 \xrightarrow{H_2O} R-COOH$ (Carboxylic Acid)

$CH_3-CH_2-CN + H_2O \longrightarrow CH_3-CH_2-CONH_2 \xrightarrow{H_2O} CH_3-CH_2COOH$

FROM GRIGNARD REAGENT

$O=C=O + CH_3-MgBr \longrightarrow O=C(CH_3)-O-MgBr \xrightarrow{H_2O} CH_3COOH + Mg(Br)(OH)$

FROM ACYL HALIDE

$R-COCl \xrightarrow{H_2O} RCOOH + HCl$

$CH_3COCl \xrightarrow{H_2O} CH_3COOH + HCl$

FROM ACID DERIVATIVE

$R-COZ \xrightarrow[\text{or dil NaOH}]{\text{dil HCl}} R-COOH$

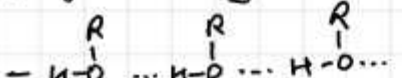
Ease of Hydrolysis

$RCOCl > (RCO)_2O > RCOOH > RCONH_2$

PHYSICAL PROPERTIES

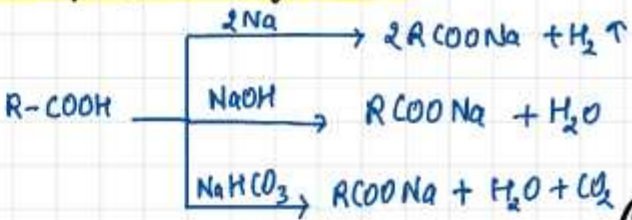
- Aliphatic carboxylic acids upto nine carbon atoms are colourless liquid at room temp with unpleasant odour. The higher acids are wax like solids.
- Due to presence of intermolecular forces the lower carboxyl acids are freely miscible with water But the solubility in water decreases gradually due to increase in size of alkyl gp.
- Stronger intermolecular forces increased the b.pt of monocarboxylic acids as compared to the alcohols of comparable molecular masses.

Hydrogen Bonding in Carboxylic Acid



Hydrogen Bonding in Alcohols

Acidity of Carboxylic Acid



- Carboxylic acids are stronger acids than alcohols and many simple phenols but weaker than mineral acids.
- Electron withdrawing group stabilises the carboxylate anion and strengthen the acid, whereas e⊖ donating group destabilised the carboxylate anion and weakens the acid.

→ Rxn involving cleavage of C-OH bond

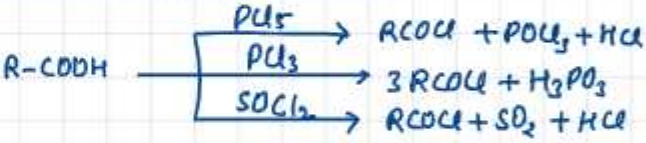
↳ **Formation of anhydride**

$2R-COOH \xrightarrow[\text{or } P_2O_5,\ \Delta]{H^+,\ \Delta} R-C(=O)-O-C(=O)-R$

↳ **Esterification:**

$R-COOH + R'OH \underset{}{\overset{H^+}{\rightleftharpoons}} RCOOR' + H_2O$

↳ **Rx with PCl_5, PCl_3 and $SOCl_2$:**



↳ **Rx with ammonia**

$RCOOH + NH_3 \longrightarrow RCOO^-NH_4^+ \xrightarrow[-H_2O]{\Delta} RCONH_2$

Rxn involving -COOH group

-Reduction

$RCOOH \xrightarrow[\text{(ii) } H_3O^+]{\text{(i) } LiAlH_4/\text{ether, or } B_2H_6} RCH_2OH$

• Decarboxylation

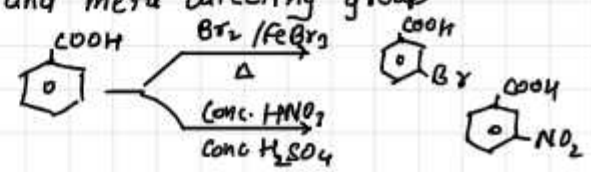
$RCOO^-Na^+ \xrightarrow[\Delta]{NaOH + CaO} R-H + Na_2CO_3$

↳ **H.V.Z Rxn (Hell Volhard Zelinsky Rxn)**

$CH_3-COOH \xrightarrow[\text{ii) } H_2O]{\text{i) } X_2/RedP} CX_3-COOH$

↳ **Electrophilic Ring Substitution**

Carboxyl group acts as a deactivating and meta directing group



They do not undergo Friedal Craft reaction because carboxyl group is deactivating group and catalyst $AlCl_3$ gets bonded to carboxyl group.

AMINES

Amines are considered as amino of hydrocarbons or alkyl derivatives of ammonia

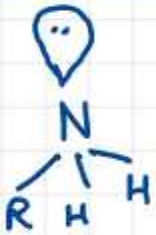
Aliphatic amino compounds are called amino alkanes and aromatic amines are called amino arenes eg CH_3NH_2, $C_2H_5NH_2$,

$R-NH_2$ Primary Amines (1°)

$R-NH-R$ Secondary amines (2°)

$R-\underset{\underset{R}{|}}{N}-R$ Tertiary Amines (3°

STRUCTURE OF AMINES:



Pyramidal shape of Amine

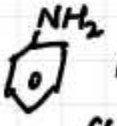
NOMENCLATURE

$CH_3-CH_2-CH_2-NH_2$ Propan-1-amine

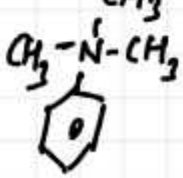
$CH_3-\underset{\underset{NH_2}{|}}{CH}-CH_3$ Propan-2-amine

$CH_3-CH_2-\underset{\underset{C_2H_5}{|}}{N}-C_4H_9$ N,N-Diethyl butan-1-amine

$CH_2=CH-CH_2-NH_2$ Prop-2-en-1-amine

 Aniline

 p-Bromo aniline

 N,N-Dimethyl benzenamine

$NH_2-(CH_2)_6-NH_2$

Hexane-1,6-diamine

Preparation of Amines:-

10

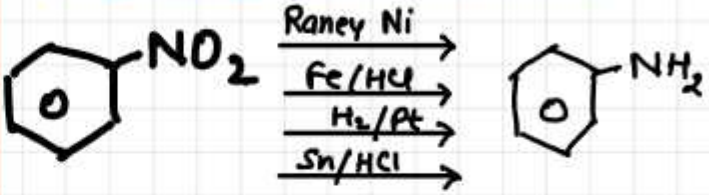
▶ Reduction of Alkyl Nitrile

$R-C\equiv N \xrightarrow{LiAlH_4} R-CH_2NH_2$

$R-C\equiv N \xrightarrow[Ethanol]{Na} RCH_2NH_2$

Rxn is used for ascent of amine

▶ Reduction of Nitroalkane:



Reduction with Fe/HCl is preferred

▶ Reduction of Amides:

$R-\overset{O}{\overset{\|}{C}}-NH_2 \xrightarrow{LiAlH_4} RCH_2NH_2 + H_2O$

Reduction of amides give amine with same number of carbons.

▶ Hofmann Ammonolysis Method:

$RX \xrightarrow[393\ K]{NH_3} \underset{(1°)}{R\ddot{N}H_2} \xrightarrow{RX} \underset{(2°)}{R_2\ddot{N}H} \xrightarrow{RX} \underset{(3°)}{R_3\ddot{N}} \xrightarrow{RX} (R_4N^+)X^-$

Order of reactivity → RI > RBr > RCl

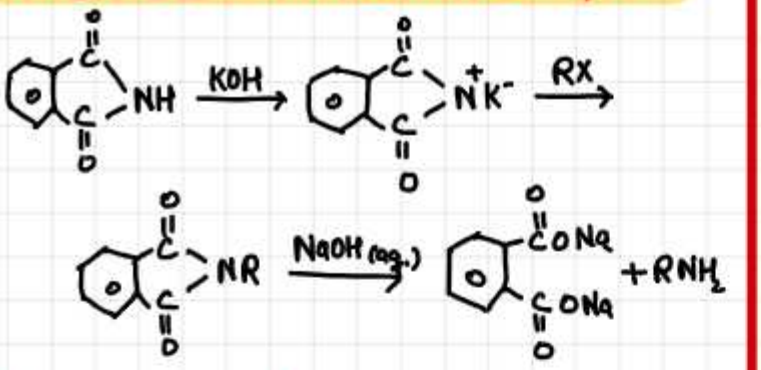
↳ 1° amine is obtained as major product when excess of NH_3 is taken

▶ HOFMAN BROMAMIDE DEGRADATION:

$RCONH_2 + Br_2 + 4NaOH \xrightarrow{\Delta} RNH_2 + 2NaBr + Na_2CO_3 + 2H_2O$

↳ Amines formed contains one carbon less than that present in the amide.

GABRIEL PHTHALIMIDE SYN.



↳ Only 1° amines can be synthesized by this method

↳ Aromatic 1° amines can not be prepared by this method as aryl halide do not undergo nucleophilic sub. Rxn with potassium phthalimide

PHYSICAL PROPERTIES :

PHYSICAL STATE ⇒ The lower aliphatic amines are gases with fishy odour, 1° amines with three or more carbon atoms are liquid and higher ones are solid.

COLOUR ⇒ Pure amines are colourless but develop colour on keeping in air for long time

SOLUBILITY ⇒ Lower amines are readily soluble in water, which decreases in water and increases in organic solvents with an increase in molecular weight.

BOILING POINT :

1° and 2° amines are engaged in intermolecular association due to Hydrogen bonding, while 3° amines do not have intermol-ecular association (due to absence of H-atoms

order of B.Pt of isomeric amines

$1° > 2° > 3°$

BASIC CHARACTER OF AMINES :

Larger the value of K_b or smaller the value of pK_b, stronger is the base

- Alkyl amines are stronger bases than NH_3
- Basic nature of aliphatic amines increases with increase in the number of alkyl groups i.e +I effect of alkyl group increases their basicity.

(11)

- order of basicity in gaseous phase...

$3° \text{ amine} > 2° \text{ amine} > 1° \text{ amine} > NH_3$

In aqueous phase, solvation effect and steric hindrance, besides inductive effect of alkyl group decid the basic strength of alkyl amines.

↳ when alkyl group is ethyl group

$(C_2H_5)_2NH > (C_2H_5)_3N > C_2H_5NH_2 > NH_3$

↳ when alkyl group is methyl group

$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$

▶ BASIC NATURE of aniline or aryl amine would be less than that of ammonia.

↳ less basicity of aniline as compared to NH_3 is attributed to -I effect of benzene ring and delocalisation of lone pair of N.

Note: ERG like $-OCH_3$, CH_3 increase basic strength whereas E.W.G like NO_2, SO_3H decrease basic strength.

CHEMICAL PROPERTIES OF AMINES

FOR ALIPHATIC AMINES

ALKYLATION

$$R\text{-}X + \underset{(1°)}{R'NH_2} \xrightarrow{-HX} \underset{(2°)}{R\text{-}NHR'} + RX \xrightarrow{-HX} \underset{(3°)}{R_2NR'} + R\text{-}X \longrightarrow \underset{\text{Quaternary ammonium salt}}{R_3N^+R'X}$$

- It yields a mixture of 1°, 2° and 3° amines and also quaternary ammonium salt.
- major product is obtained when amine is taken in excess.

ACYLATION

$R/Ar-\ddot{N}(H)-H \xrightarrow[(CH_3CO)_2O]{CH_3COCl \text{ or}} R/Ar-\ddot{N}(H)-C(=O)-CH_3$

Base

The reaction is carried out in presence of a base stronger than (e.g pyridine) which removes HCl so formed and shifts equilibrium to right side.

BENZOYLATION

$R-NH_2 + C_6H_5COCl \longrightarrow R-NHCO-C_6H_5 + HCl$

CARBYLAMINE REACTION:

$R-NH_2 + CHCl_3 + 3KOH \xrightarrow{\Delta} R-NC + 3KCl + 3H_2O$

Secondary and tertiary amines do not show this reaction.
It is used as a test for **1° AMINES**

REACTION WITH NITROUS ACID:

$R-NH_2 + HONO \longrightarrow R-OH + N_2\uparrow + HCl$

REACTION WITH ARYL SULPHONYL CHLORIDE $C_6H_5-SO_2Cl$ HINSBERG REAGENT

1°
$RNH_2 + C_6H_5SO_2Cl \xrightarrow[-HCl]{} C_6H_5SO_2NH-R$
Soluble in alkali

2°
$R_2NH + C_6H_5SO_2Cl \xrightarrow[-HCl]{} C_6H_5SO_2NR_2$

3°
$R_3N + C_6H_5SO_2Cl \longrightarrow$ No Reaction

Reaction is used to distinguish b/w three classes of amines 1°, 2° and 3° amines

AROMATIC AMINES

- $-NH_2$ group is ortho and para directing and powerful activating group.
- Activating effect of $-NH_2$ group in aniline can be controlled by protecting the $-NH_2$ group by acetylation with acetic anhydride and then carrying out the desired substitution Rxn

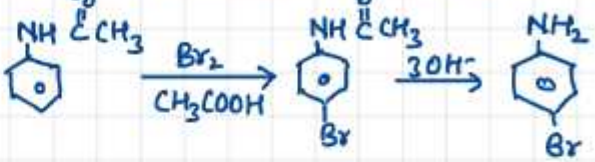
$C_6H_5-NH_2$ (Aniline) $\xrightarrow[\text{Pyridine}]{(CH_3CO)_2O} C_6H_5-NH-CO-CH_3$ (Acetanilide)

BROMINATION

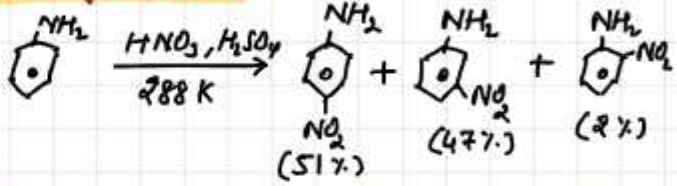
(12)

$C_6H_5NH_2 + 3Br_2 \xrightarrow{H_2O} 2,4,6\text{-tribromoaniline} + 3HBr$

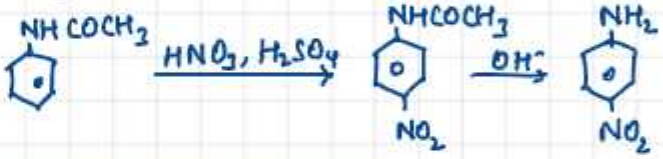
↳ To get monosubstituted derivative



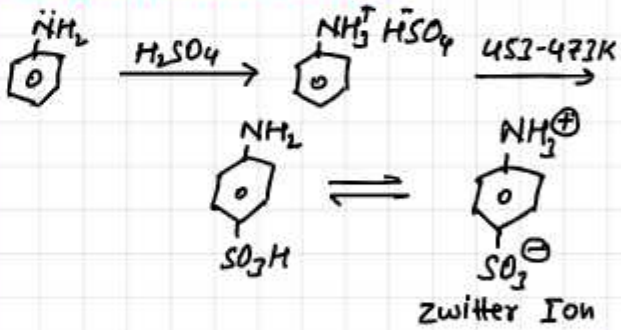
NITRATION



To get mono substituted para derivative



SULPHONATION:



p-aminobenzene sulphonic acid is the major product because distance b/w $-NH_2$ and SO_3H is maximum.

↳ Sulphanilic acid exist in ZWITTER ION FORM.

DIAZONIUM SALT-

Diazonium salts are written as $RN_2^+X^-$ where

R = aryl group

X^- ion can be Cl^-, Br^-, HSO_4^- and BF_4^-

N_2^+ group is called diazonium salt

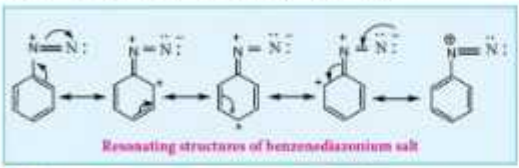
Eg

benzene diazonium chloride

benzene diazonium hydrogen sulphate

STABILITY OF DIAZONIUM SALT

Arenediazonium salts are more stable than the alkyl diazonium salts. This can be accounted on the basis of +R effect.



Resonating structures of benzenediazonium salt

Preparation (Diazotization Rxn -)

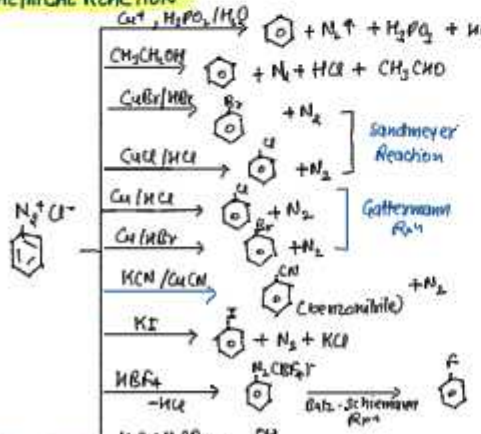
Diazonium salts are prepared and used only in an aqueous solution because in solid state they explode

PHYSICAL PROPERTIES

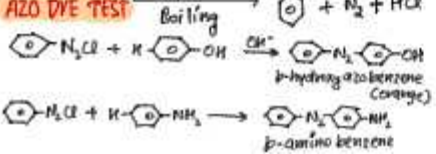
Benzene diazonium chloride is a colourless crystalline solid and is readily soluble in water. It is stable in cold water but reacts with water when warmed. It also decomposes easily in the dry state.

- Benzene diazonium fluoroborate is water insoluble and stable at room temperature.

CHEMICAL REACTION-



AZO DYE TEST



MOST EXPECTED TOPICS

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Haloalkanes and Haloarenes

- NOMENCLATURE
- S_N1 & S_N2
- β-elimination & Saytzeff Rule
- M.R & A.M.R
- Name. Rxn

Alcohol, Phenol and Ethers

↳ Mechanism → Hydration of Alkene; Dehydration of alcohol to alkene; Dehydration of alcohol to ether

Name Rxn → Kolbes Rxn, Reimer Tiemann Rxn, Acidic Property, Oxidation Property, Williamson Synthesis

Aldehyde, Ketones and Carboxylic Acid

→ Cannizzaro, Aldol, Cross Aldol, HVZ Rxn

→ Acidic Character of Carboxylic Acid.

Reduction – Stephen's Red^n, Wolff Kishner Red^n, Clemmensen Red^n Rosenmund Red

AMINES

→ Basic Strength of Amines

→ Hoffmann Bromamide Degradation, CARBYL AMINE Rxn

→ Properties of Diazonium Salt

BIO MOLECULES

→ Chemical properties of Glucose, Denaturation of protein,

→ Fibrous protein and Globular Proteins.

→ DNA and RNA

Biomolecules

Introduction: Biomolecules are the organic compound which form the basis of life i.e they build up the living system and responsible for their growth and maintence

The sequence that relates biomolecule to living organism is

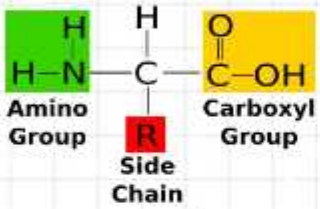
Biomolecules ⟶ Organelles → cells → Tissues → Organs → living organism

→ Living systems are made up of various complex biomolecules like carbohydrate, proteins, nucleic acids, lipids etc. Proteins and carbohydrates are essential constituents of our food.

→ In addition, some simple molecules like vitamins and mineral salts also play an important role in the function of organism.

Amino Acids & Proteins

The compounds containing amino group (-NH_2) and carboxylic group (-COOH) are called amino acids.



where R= H, alkyl or aryl group

→ except glycine (H_2N-CH_2-COOH), others are optically active in nature.

* **Classification of amino acids ⇒**

⇒ α, β, γ - amino acids depending upon the position of $-NH_2$ with respect to -COOH group.

→ Neutral, having one $-NH_2$ and one -COOH group.
e.g $NH_2-CH(H)-COOH$ (glycine)

→ Acidic, having one $-NH_2$ and two -COOH group.
e.g $HOOC-CH_2-CH(NH_2)-COOH$ (Aspartic Acid)

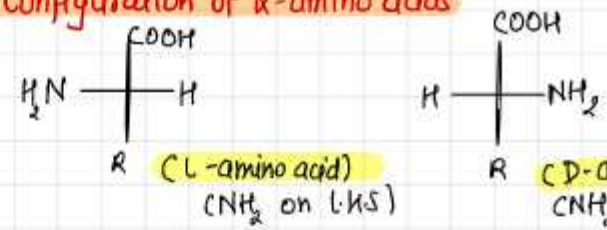
→ Basic, having two or more $-NH_2$ and one -COOH group.
e.g $H_2N-(CH_2)_4-CH(NH_2)-COOH$ (Lysine)

* **Essential and Non-Essential Amino Acids:**

Those amino acids which can be synthesized by our body are known as non-essential amino acids while which can't be synthesized by our body so must be supplied through our diet are called essential amino acids.

Essential	Conditionally Non-Essential	Non-Essential
Histidine	Arginine	Alanine
Isoleucine	Asparagine	Asparatate
Leucine	Glutamine	Cysteine
Methionine	Glycine	Glutamate

· Configuration of α-amino acids



→ Naturally occuring α-amino acids are L-amino acids D-amino acids occur in some antibiotics and bacterial cell walls.

Zwitter ion: when a proton is migrated from carboxyl group to amino group, a dual ion is formed and this dual ion is called zwitter ion

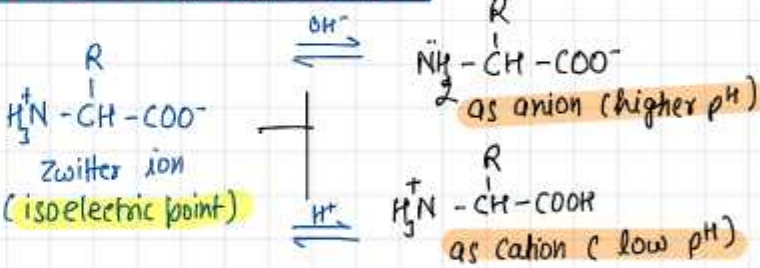
Isoelectric Point (p^I)

Zwitter ion, which is electrically neutral can only exist at a specific pH, that pH is called isoelectric point which is different for all amino acids.

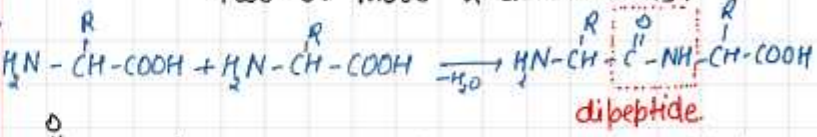
e.g p^I of Leucine pH = 6.0

p^I of Arginine pH = 10.8.

Structure of amino acids:



* **Peptide** ⇒ peptides are condensation products of two or more α-amino acids.



$-\overset{O}{\overset{\|}{C}}-NH-$ is known as peptide linkage or peptide bond.

→ 2 molecules of α-amino acid form dipeptide.
3 molecules of α-amino acid form tripeptide.

→ Dipeptide has only one peptide bond.
Tripeptide has only two peptide bond.

Polypeptide: Condensation products of many amino acid (≃ 10000) is known as polypeptide and those polypeptide which have molecular mass above than 10000 u are called proteins.

Proteins They are linear polymers of α-amino acid.

Str. of Proteins:

1.) Primary Structure: It simply reveals the sequence of amino acids.

2.) Secondary Structure: α-helix str. maintained by H-Bond or β-pleated sheet str. when R is small group.

3.) Tertiary Structure: The folding and superimposition of polypeptide chains forms a compact globular shape, termed as tertiary str.
It is stabilised by covalent, ionic, H-Bond and disulphide bonds.

4.) Quaternary Structure: The precise arrangement of constituents.

Classification on the Basis of Hydrolysis

Simple Protein: which give only α-amino acid upon hydrolysis e.g albumin

Conjugated Protein: These proteins give α-amino acid and non protein part, called prosthetic group

Protein	Prosthetic Group
Metalloproteins	Metal ions (Zn^{2+}, Fe^{2+}, Cu^{2+})
Haemoproteins	Haeme group
Glycoproteins	Carbohydrates
Lipoproteins	Lipid
Nucleoproteins	Nucleic acid (DNA, RNA)

Derived Proteins

These are obtained by partial hydrolysis of simple or conjugated Proteins.

[Proteins → Proteoses → Peptones → Polypeptides]

On the Basis of Molecular Shape

Fibrous Protein | Globular Protein

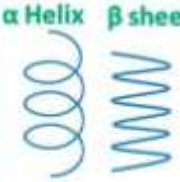
Primary str. of Proteins:

Proteins may have one or more polypeptide chains
→ each polypeptide in a protein has amino acids linked with each other in a specific sequence and it is this sequence of amino acids that is said to be the 1° str. of that protein

Any change in this 1° str. i.e the sequence of amino acid creats a different protein

Secondary Structure of Proteins:

The secondary str. of proteins refers to the shape in which a long polypeptide chain can exist.
They are found to exist in two different types of str.



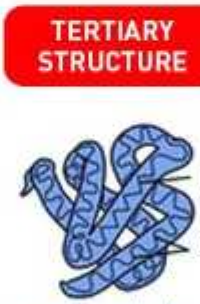
α-helix str.: most common ways in which a polype-ptide chain form all possible H-Bond by twisting into a right handed screw (helix) with the -NH- group of each amino acid residue

β-pleated sheet str.: In this str. all peptide chains are stretched out to nearly maximum extension and then laid side by side are held together by intermolecular H-Bond.

Tertiary str. of Proteins:

The tertiary str. of proteins represents overall folding of polypeptide chains i.e further folding of the secondary structure
It gives rise to 2 major molecular shapes i.e Fibrous and Globular

The main forces which stabilize the 2° and 3° str. of proteins are H-Bonds, disulphide linkage, Van der Waal and electrostatic forces of attraction.



Quaternary str. of Proteins

Some of the proteins are composed of two or more polypeptide chains referred to as sub-units
The spatial arrange-ment of these subunits with respect to each other is known as quaternary structure

Denaturation of Proteins

The process that changes the 3-D str. of native protein is called denaturation of proteins.
It can be caused by change in pH, change in temp. addition of electrolyte, addition of solvent like water, alcohol, acetone.

Nucleic Acids:

These are the polymers which are prepared by Nucleotide also known as polynucleotide

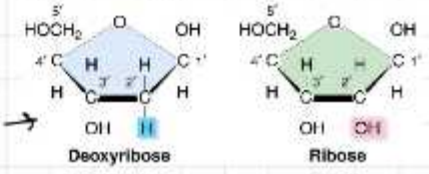
a nucleotide contain....

*) Pentose Sugar *) Nitrogenous Base *) Phosphate group.

Pentose Sugar:

5 carbon sugar either ribose or deoxy ribose

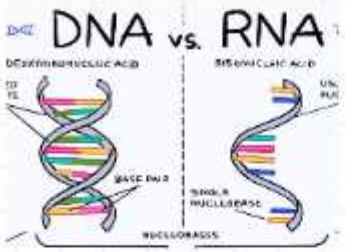
(not contain oxygen at 2nd position →



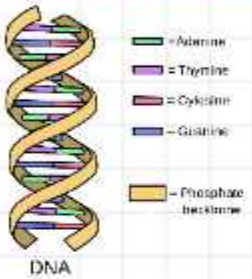
Nitrogeneous Base

Purine	Pyrimidine
→ Adenine	→ Thymine
→ Guanine	→ Uracil
	→ Cytosine

Two H-Bonds are present between A & T (A=T) while three hydrogen bonds are present between C & G (C≡G)



Structure of D.N.A



It consist of two polynucleotide chains, each chain form a right handed helical spiral with ten based in one turn of the spiral

The two chains coil to double helix and run in opposite direction. These are held together by H-Bonding.

Types of RNA

1.) Messanger RNA (M-RNA) It is produced in the nucleus and carries information for the synthesis of protein.

2.) Transfer RNA It is found in cytoplasm. Its function is to collect amino acids from cytoplasm for protein synthesis.

3.) Ribosomal RNA (R-RNA) This provide site for protein synthesis

Functions of Nucleic Acid

- Direct the synthesis of protein
- Transfer the genetic informations.

Replication :- It is a process in which a molecule can duplicate.

Template It means pattern, in the process of replication of DNA, the parent strand serves as template.

Gene The portion of DNA carrying information about a specific protein is called gene.

Genetic Code: The relation between the amino acid and the the nucleotide triplet is called genetic code.

Codons The nucleotide bases in RNA function in group of three (triplet) in coding amino acid. These based triplets are called codons.

Vitamins

The organic compounds other than carbohydrates, proteins and fats which are required in the diet in small amount to perform specific biological functions, maintain normal health, growth and nutrition are called vitamins

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Classification on the basis of Solubility

Fat Soluble Vitamins Vitamins A, D, E, K are soluble in fat and oils but insoluble in water. They are stored in liver and adipose (fat storing) tissues.

Water Soluble Vitamins - B group vitamins and C are soluble in water. Water soluble vitamins must be supplied regularly in diet because they are readily excreted in urine and can not be stored in our body (except Vitamin B_{12})

→ Vitamin K is responsible for coagulation of blood.

Sl. No.	Name of Vitamins	Sources	Deficiency diseases
1.	Vitamin A	Fish liver oil, carrots, butter and milk	Xerophthalmia (hardening of cornea of eye) Night blindness
2.	Vitamin B_1 (Thiamine)	Yeast, milk, green vegetables and cereals	Beri beri (loss of appetite, retarded growth)
3.	Vitamin B_2 (Riboflavin)	Milk, eggwhite, liver, kidney	Cheilosis (fissuring at corners of mouth and lips), digestive disorders and burning sensation of the skin.
4.	Vitamin B_6 (Pyridoxine)	Yeast, milk, egg yolk, cereals and grams	Convulsions
5.	Vitamin B_{12}	Meat, fish, egg and curd	Pernicious anaemia (RBC deficient in haemaglobin)
6.	Vitamin C (Ascorbic acid)	Citrus fruits, amla and green leafy vegetables	Scurvy (bleeding gums)
7.	Vitamin D	Exposure to sunlight, fish and egg yolk	Rickets (bone deformities in children) and osteomalacia (soft bones and joint pain in adults)

ENZYMES

Enzymes are biocatalyst, almost all the enzymes are globular proteins. They are generally named after the compound or class of compound upon which they work

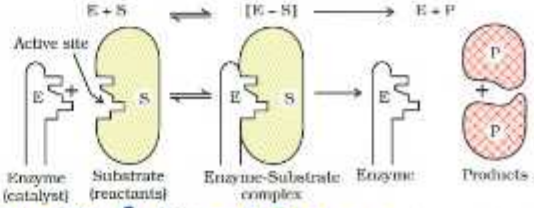
eg the enzyme that catalyse hydrolysis of maltose into glucose is named as maltase

$$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

Some Common Example

Substrate	Name	Product
Urea	Urease	$CO_2 + NH_3$
Maltose	Maltase	Glucose
Sucrose	Invertase	Glucose + Fructose
Starch	Amylase	Maltose
Proteins	Trypsin	Amino Acids

Mechanism Of Enzyme Action -



Characteristic feature of Enzyme:

- **Rate of Reaction :** They increase the rate of reaction upto 10^6 to 10^7 times.

- **Specific Nature** - Urease catalyse the hydrolysis of urea and not methyl urea, so these are specific in nature.
- **Optimum Temperature** - It is active at 20-30°C
- **pH of medium** - It is about 7, for pepsin 1.8-2.2, for trypsin 7.5-8.3
- **Concentration** - Dilute solutions are more effective
- **Amount of enzyme** - Very small amount can accelerate the reaction
- **Enzyme Inhibitors** - These compound inhibit the enzyme action, with the help of such compounds, the reaction can be controlled.

HARMONES

These are the chemical substance which are produced by endocrine (ductless) glands in the body. Harmones acts as chemical messengers.

Some examples of ductless (endocrine) glands are thyroid, pituitary, adrenal, pancreas, testes and ovaries.

Harmones are divided into three types:
(i) Steroids (ii) Proteins (iii) Amines

Name of endocrine gland	Hormones secreted
Testis	Testosterone
Ovary	Estrogen
Adrenal	Adrenaline
Thyroid glands	Thyroxin
Pituitary gland	FSH
Pancreas	Insulin

Carbohydrates

These are optically active poly hydroxy aldehyde / ketones or the substance which give these on hydrolysis are called carbohydrates.

General formula $C_x(H_2O)_y$

Classification on the basis of Hydrolysis

- **Monosaccharides** - can not be hydrolysed further e.g glucose, fructose
- **Oligo Saccharides** - give 2-10 molecules of monosaccharides e.g Glucose, Fructose
- **Polysaccharides** - give large no. of monosaccharides e.g Starch, Cellulose.

• Preparation of Glucose:

From Sucrose

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{H^+} \underset{\text{glucose}}{C_6H_{12}O_6} + \underset{\text{fructose}}{C_6H_{12}O_6}$$

From Starch

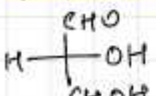
$$(C_6H_{10}O_5)_n + nH_2O \xrightarrow{H^+} n\,C_6H_{12}O_6 \text{ glucose}$$

Structure

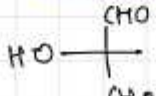
CHO ← one aldehyde group
(CHOH)$_4$ ← four 2° alcohol
CH$_2$OH ← one 1° alcohol

Str.

D-Glyceraldehyde



L-Glyceraldehyde



(D) means OH in R.H.S (L) means OH in L.H.S

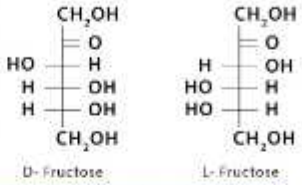
Str. of Glucose

Str. of fructose:

{The C_1 is known as anomeric carbon and these compounds are called anomers}

Fischer Projection

Fructose



Six membered cyclic ring

Five membered Cyclic ring

Reducing Sugar

- Free Aldehydic or Ketonic group
- Reduce Fehling Soln or Tollen's Reagent
- e.g Maltose & Fructose

Non Reducing Sugar

- Do not have any free aldehydic or ketonic group.
- Do not reduce tollens Reagent and Fehling Soln
- e.g Sucrose

Chemical Properties of Glucose

•) (CHOH)$_4$(CHO)(CH$_2$OH) $\xrightarrow{\text{Acetic Anhydride}}$ (CH(O-CO-CH$_3$))$_4$(CH$_2$-O-CO-CH$_3$)

Glucose Penta acetate

•) (CHOH)$_4$(CHO)(CH$_2$OH) + [O] $\xrightarrow[H_2O]{Br_2}$ (CHOH)$_4$(COOH)(CH$_2$OH)

Gluconic acid

•) (CHOH)$_4$(CHO)(CH$_2$OH) $\xrightarrow{HNO_3}$ (CHOH)$_4$(COOH)(CH$_2$OH)

Saccharic acid

•) (CHOH)$_4$(CHO)(CH$_2$OH) $\xrightarrow[\Delta]{HI}$ (CH$_2$)$_4$(CH$_3$)(CH$_3$)

n-Hexane

•) (CHOH)$_4$(CHO)(CH$_2$OH) $\xrightarrow{HN\text{-}OH}$ (CHOH)$_4$(CH=N-OH)(CH$_2$OH)

Glucoxine

•) (CHOH)$_4$(CHO)(CH$_2$OH) $\xrightarrow{HCN}$ (CHOH)$_4$(CH(OH)-CN)(CH$_2$OH)

Glucose Cyano hydrin

Mutarotation when either of the two forms of glucose is dissolved in water, there is a spontaneous change in specific rotation till the equilibrium value of +52.5°. This is known as mutarotation.

α-D(+) Glucose $\rightleftharpoons$ Equilibrium mixture $\rightleftharpoons$ β-D(+) Glucose
+111.5° +19.5°

Importance of Carbohydrate

- Carbohydrates are essential for life in both plants and animals
- They are major portion of our food.
- Carbohydrates are used as storage molecule as starch in plants and glycogen in animals.
- Cell wall of bacteria and plants is made up of cellulose
- Honey has been used for a long time as an instant source of energy.

Epimers Monosaccharides differing in configuration at a carbon other than anomeric carbon are called epimers e.g glucose and galactose differ in configuration at C4, hence called epimers.

Sugars and Non-Sugars

- monosaccharides and Oligosaccharides having sweet taste, soluble in water are known as **Sugars**
- Polysacchides which are insoluble in water and not sweet in taste are known as **non-sugars**

DISACCHARIDES AND POLYSACCHARIDES-

CARBOHYDRATES	Hydrolysis Product	Linkage	Reducing Property
Sucrose (Disaccharide)	α-D Glucose & β-D Fructose	C-1(Glucose) & C-2 (Fructose)	Non-Reducing
Maltose (Disaccharide)	α-D-Glucose	C-1 Glucose & C-4 Glucose	Reducing
Lactose (Disaccharide)	β-D-Galactose & β-D-Glucose	C-1 (Galactose) & C-4 (Glucose)	Reducing
Cellulose (Polysaccharide)	β-D-Glucose	C-1 (Glucose) & C-4 (Glucose)	Non-Reducing
Glycogen (Polysaccharide)	α-D-Glucose	C-1 (Glucose) & C-4 (Glucose)	Non-Reducing

MUTAROTATION

When glucose is dissolved in water, then its specific rotation changes into an equilibrium value. This spontaneous change in specific rotation of an optically active substance to an equilibrium value is called **mutarotation**

The two anomers of glucose i.e α-D glucose & β-D Glucose in solution changes their specific rotation to an equilibrium value which is the rotation of a straight chain str.

α-D Glucose $\rightleftharpoons$ Open chain str. $\rightleftharpoons$ β-D-Glucose
(Sp. rotation = +110°) (Sp. rotation = +52.5°) (Specific rotation = +19.2°)

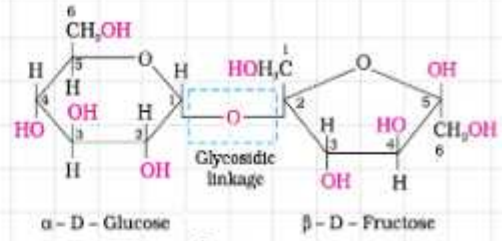
DISACCHARIDES

Disaccharides are the carbohydrates which on hydrolysis with dilute acids or with enzyme give two molecules of either same or different monosaccharide

The two monosaccharides are joined together by an oxide linkage formed by loss of a water molecule This is actually an ether group and is called glycosidic linkage

SUCROSE

α-D-Glucose + β-D-Glucose



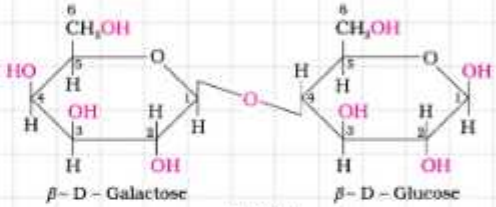
Sucrose

MALTOSE

β-D-Galactose + β-D Glucose

LACTOSE

β-D-Galactose + β-D-Glucose



Lactose

INVERSION OF SUCROSE -

Sucrose on dextro-rotatory but on hydrolysis either with dilute acid or with enzyme invertase, the solution is changed into laevo-rotatory solution.

As dextro rotatory sucrose is changed to laevo rotatory solution after hydrolysis. The sucrose is called "**invert sugar**"

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{\text{dil. HCl}} \underset{\text{D(+)-Glucose}\ +52.5°}{C_6H_{12}O_6} + \underset{\text{D(-)-fructose}\ -92.4°}{C_6H_{12}O_6}$$

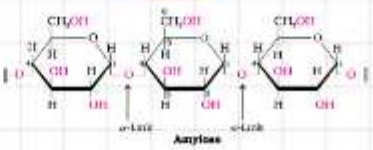
+66.5°

Since the laevo rotation of fructose (-92.4°) is more than dextro rotation of glucose (+52.5°), the mixture is laevo rotatory.

Polysaccharides

Starch it is a polymer of α-glucose units and it consist two components - Amylose and Amylopectin

Amylose



Amylopectin