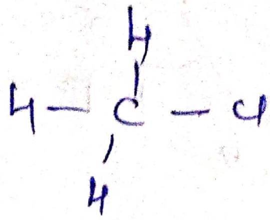
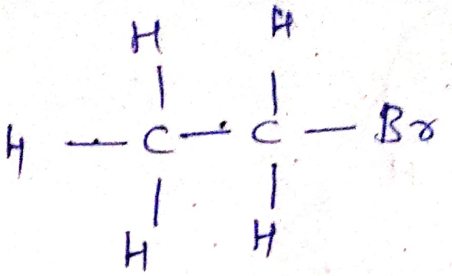
UNIT- III - ALKYLE HALIDES

→ There are the compound in which hallide is attached to the carbon.

e.g.

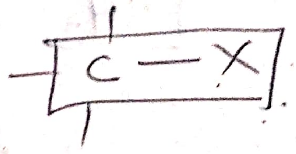


$H-\overset{H}{\underset{H}{C}}-Cl$



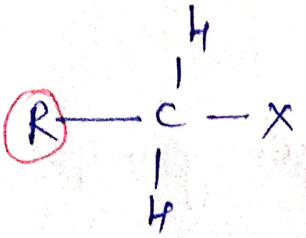
$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Br$

so general formula is $R-X$ or



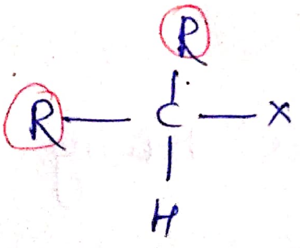
$X = Cl, Br, I, F$ etc..

⇒ They are classi-fied as primary, secondary & 3° depending on carbon atom at which they attached.



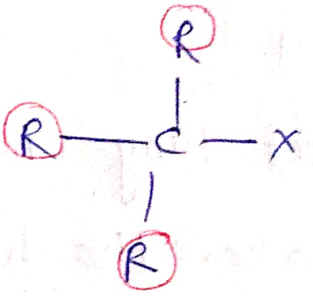
$R-\overset{H}{\underset{H}{C}}-X$

1° carbon



$R-\overset{R}{\underset{H}{C}}-X$

2° (Secondary)



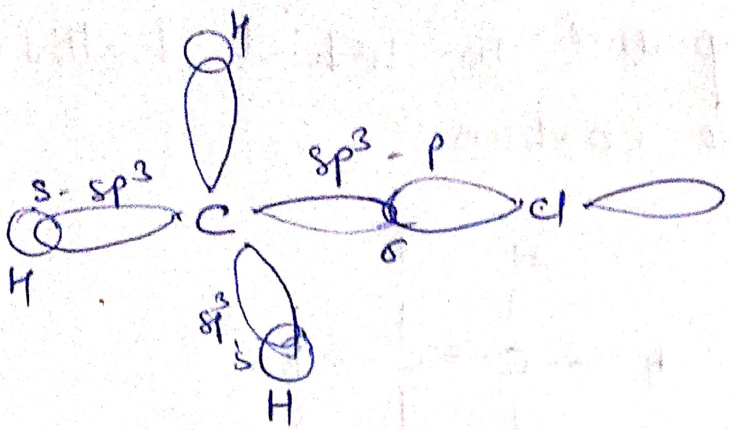
$R-\overset{R}{\underset{R}{C}}-X$

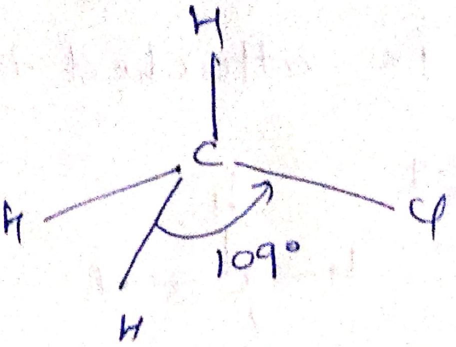
Tertiary (3°)

STRUCTURE

- for example CH_3Cl.
- The Carbon atom is sp^3 hybridized.

→ The C-Cl bond forms by overlapping of sp^3 orbital of Carbon & half filled ~~or~~ p-orbital of chlorine atom.





$$\boxed{CH_3-Cl}$$

Nomenclature

COMMON SYSTEM :

- Alkyl group name at first & then halogen atom.

eg. $CH_3Cl \longrightarrow$ Methyl chloride

$C_2H_5Cl \longrightarrow$ Ethyl chloride.

IUPAC

→ Select long chain of 'c' having halogen group

→ Number the hallogen.

→ Name the hallogen first as. chloro, floro, bromo.

$$\boxed{\text{position} + \text{hallogen} + \underset{(\text{no. of C})}{\text{Carbon chain}} + \text{Suffix}}$$

e.g. $\overset{3}{CH_3}-\overset{2}{CH_2}-\overset{1}{CH_2}-Br$: 1-bromo propane

$CH_3-\overset{Cl}{CH}-CH_3$: 2-chloro propane

Method of Preparation

① Halogination of alkane
② Addition of hallogen acid to alkene
③ Action of hallogen acid to alcohol
④ Action of phosphorus hallid to alcohol
⑤ Hallogen exchange reaction.

① Halogination of alkane

$$\underset{\text{(Methane)}}{CH_4} \xrightarrow[\text{UV light}]{Cl_2} \underset{\text{(Polyhalogen derivative)}}{CH_3Cl + CH_2Cl_2 + CHCl_3 + CCl_4}$$

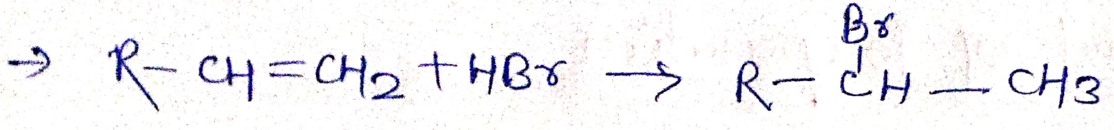
* This method is not used in lab as there is difficulty to seperate it.

② Addition of hallogen acid to Alkene

→ Halogen acid (HCl, HBr, HI) added to alkenes to give "alkyl halides"

→ It follow morkonikove rule except HBr, that follow Antimarkonikov rule, in presence of (R-O-O-R).

$$R-CH=CH-R + HX \longrightarrow \underset{\text{(Alkyl halide)}}{R-CH_2-\overset{X}{\overset{|}{C}}H-R}$$



$\Rightarrow R-CH=CH_2 + HBr \rightarrow R-\overset{\overset{Br}{|}}{C}H-CH_3$

(markonikov)

$\Rightarrow CH_3-CH=CH_2 + HBr \xrightarrow{Peroxide} CH_3-CH_2-CH_2Br$

(1-bromo propane)
(Antimarkonikov)

③ Action of hallogen Acid on Alcohols

$$R-\underline{OH + H}-X \rightarrow R-X + H_2O$$

e.g. $CH_3-CH_2-\boxed{OH + H}Cl \rightarrow CH_3-CH_2-Cl + H_2O$

④ Action of phosphorus Hallide on alcohols.

$$R-OH + PX_5 \longrightarrow R-X$$

$\Rightarrow 2C_2H_5OH + PCl_5 \longrightarrow 2C_2H_5Cl + POCl_3 + H_2O$

PHYSICAL PROPERTY OF ALKYLE HALIDE

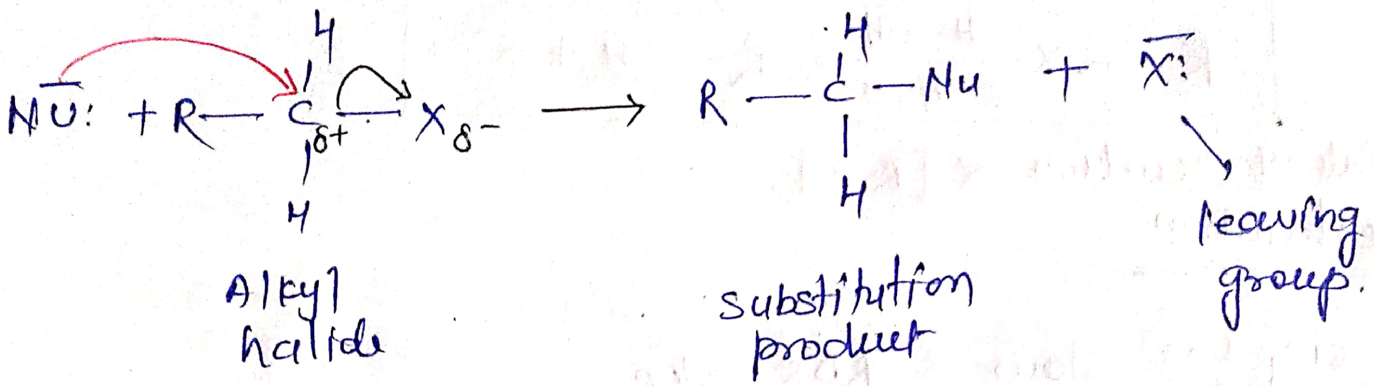
1) H_2O insoluble, soluble in Organic solvent.
2) Alkyl bromide & R-I are densor than H_2O
R-Cl & R-F are lighter than H_2O.

Chemical Property

(A) SUBSTITUTION REACTION

→ C- halogen bond in alkyl halide is "polar" due to of high electro-negativity of halogen atom relative to carbon.

→ 'C' is good target for nucleophilic attack.



Types of Substitution Reaction

SN'	SN2
* Unimolecular	• Bimolecular
* ~~single~~ 2 step reaction	• ~~2~~ Single step reaction.
* favoured by polar solvent	• favored by ~~Non~~-polar=Aproti
* It have ~~transition state~~ an intermediate carbonium ion.	• It have transition State
* Rate depends only on R–X conc.	• Rate depends on R–X + Nucleophil both.
• Reaction occurs c̄ weak base	• c̄ strong base
• Rate depends on $3° > 2° > 1° > CH_3-X$	• $1° > 2° > 3° > CH_3X$

SN1- Reaction

→ Unimolecular ~~sub~~ Nucleophilic substitution reaction.

→ It's rate determining step depends on 1 molecule.

→ first order reaction.

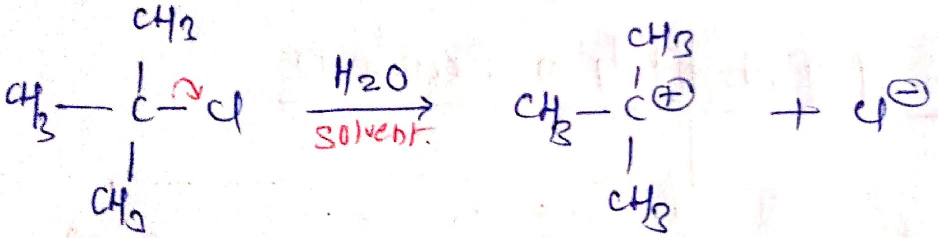
e.g. Hydrolysis of alkyl halide

$$\boxed{R-X \xrightarrow[-H_2O]{H-OH} R-OH + X^-}$$

* Rate of reaction ∝ [R-X]

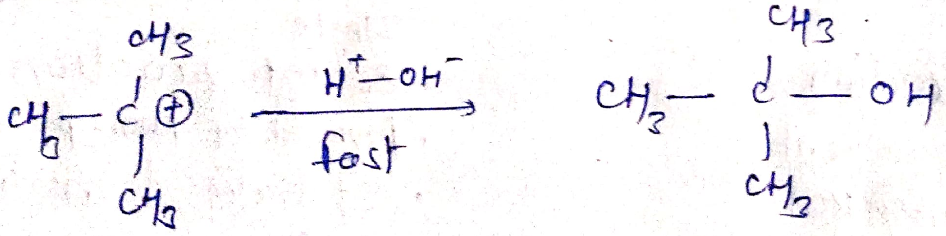
Mechanism

step 1: slow & RDS step.



$$CH_3-\overset{CH_3}{\underset{CH_3}{C}}-Cl \xrightarrow[\text{solvent}]{H_2O} CH_3-\overset{CH_3}{\underset{CH_3}{C}}{}^{\oplus} + Cl^{\ominus}$$

Step II



$$CH_3-\overset{CH_3}{\underset{CH_3}{C}}{}^{\oplus} \xrightarrow[\text{fast}]{H^+-OH^-} CH_3-\overset{CH_3}{\underset{CH_3}{C}}-OH$$

Reactivity order (carbocation)

3° > 2° > 1°

↓ more stable

→ less stable.

Property / factor of S_N1 Reaction

① **Unimolecular**

→ depends only on R–X

→ Rate of reaction ∝ [R–X] so follow first order kinetic.

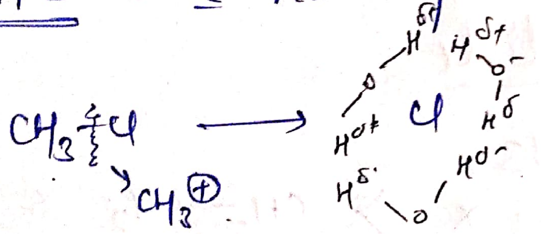
② **solvent** : Polar protic solvent

Polar = break R–X due to dielectric property.

R–X
(dielectric)
Prop. 80 of H_2O.

Protic → c have proton.

e.g.



due to protic property halide ion entrapped by H_2O molecule & it will not be free for reaction back to carbocation

③ **Exothermic reaction**

C–Cl & form C–O

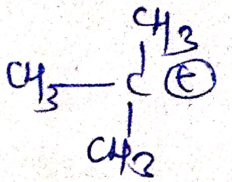
→ Energy of C–O bond is more compared to C–Cl

→ It is performed on Low temp.

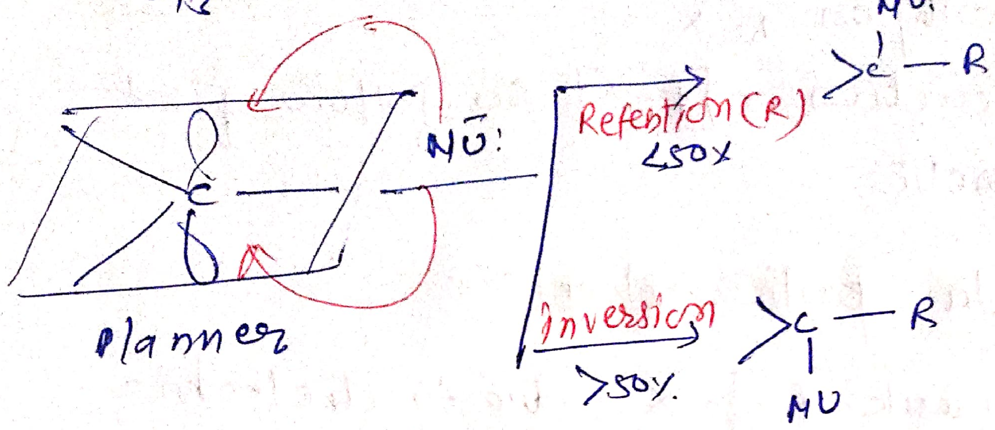
④ **carbocation will form**

$$CH_3-CH_2-Cl \xrightarrow{H_2O} CH_3CH_2^{\oplus} + Cl^-$$

⑤ Stereo chemistry of SN1



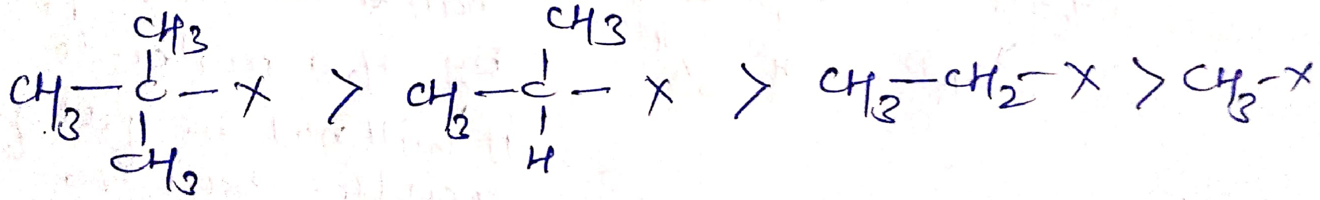
$CH_3-\underset{CH_3}{\overset{CH_3}{C}}^{\oplus} \longrightarrow$ sp^2 hybridization.



So form a mixture called "Racemic mixture")

FACTORS AFFECTING RATE OF SN1

① Nature of alkyl hallide

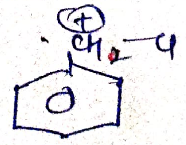


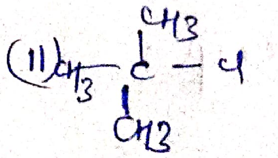
$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-X > CH_3-\underset{H}{\overset{CH_3}{C}}-X > CH_3-CH_2-X > CH_3-X$

3° > 2° > 1°
(Stable)

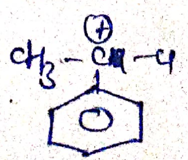
→ 3° will give more reaction as compared to 2° & 1°

e.g. which one is more stable

(I)


(II)


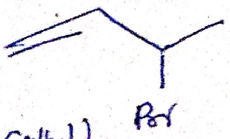
$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-Cl$

(III)


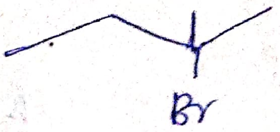
(IV) $CH_2=CH-\overset{\oplus}{CH_2}-Cl$

$\xrightarrow{}$ 3°
(III) > II > I > IV
↓
2° & resonance

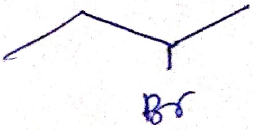
e.g. Stability

ⓐ 

(allyl)

ⓑ 

(3°c)

ⓒ 

(2°c)

(d.) All.

(so) $\boxed{3^\circ > \text{Allyl} > 2^\circ}$

② Nature of leaving group

→ Rate of reaction ↑ which group easily leave.

$\boxed{R-I > R-Br > R-Cl > R-F}$

③ Nature of Solvent

solvent → SN1 = polar-Protic
SN2 : Non-polar / Polar-aprotic

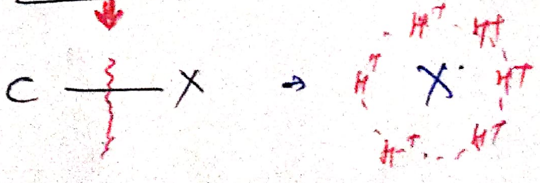
solvent have dielectric property

1) H_2O — 80
2) C_2H_5OH — 35
3) CH_3COOH — 5

↑ dielectric property reduce the force b/w C—X.

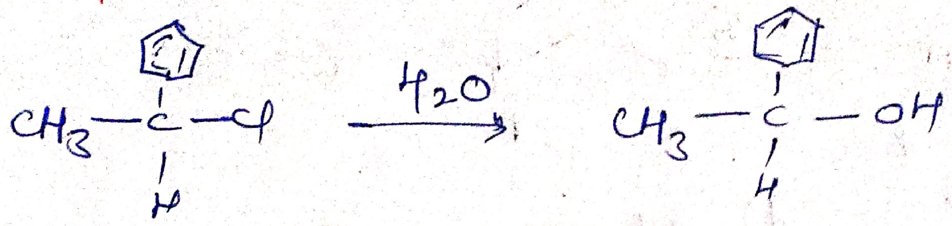
Polar

Protic



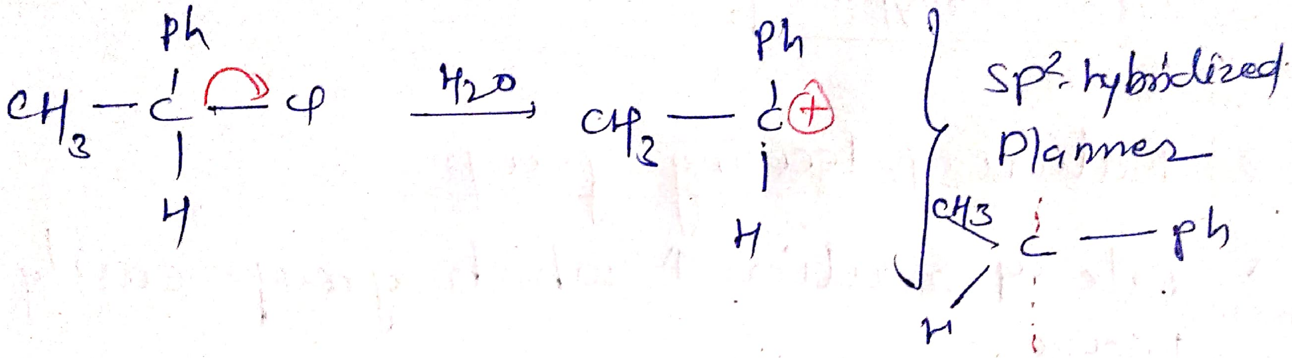
Ex of SN1

①

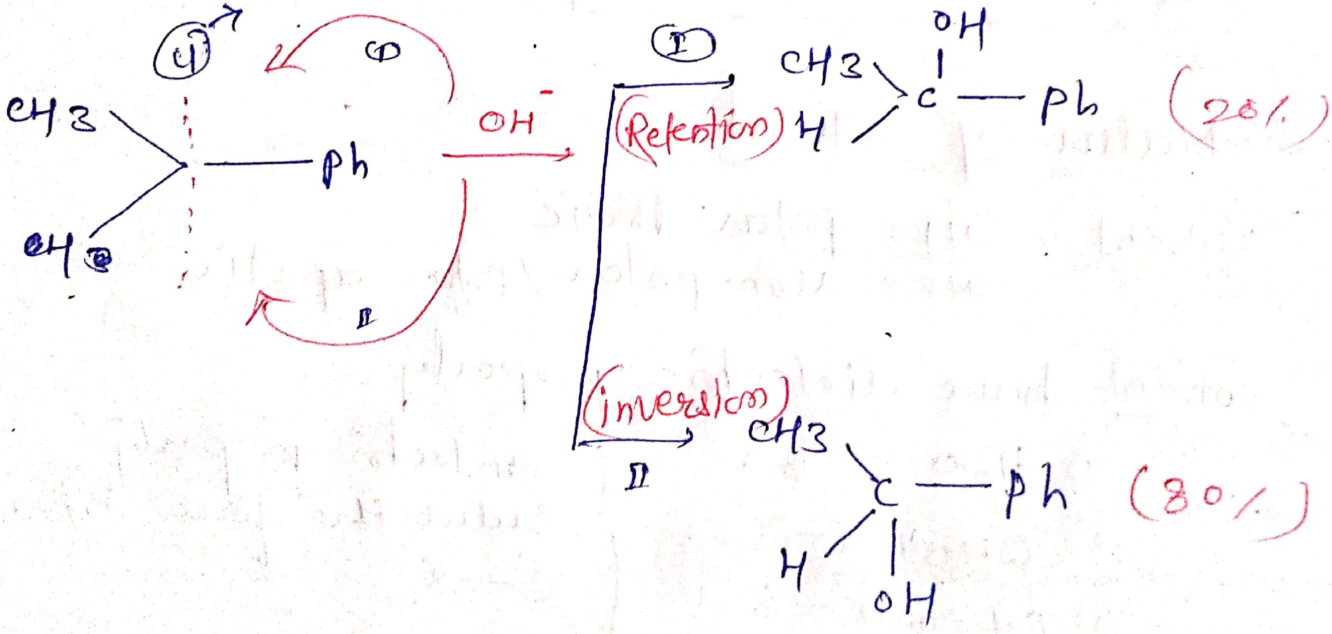


Mechanism

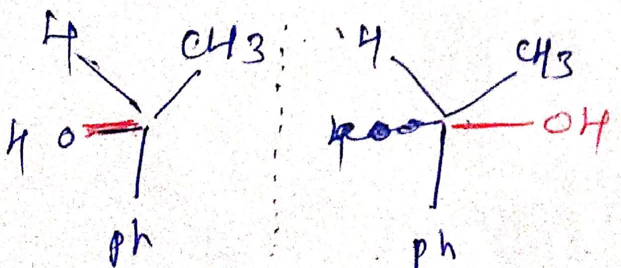
Step 1 : formation of carbocation



Step 2: Attack of Nucleophile (OH⁻)



⇒ Both are enantiomer also as form mirror image



S_N2 Reaction

(Substitution Nucleophilic, Bimolecular)

→ No carbocation will form.

→ e.g.

$$CH_3-\overset{-}{X} + \overset{+}{K}\overset{-}{O}H \xrightarrow[\text{Solvent}]{\text{Polar aprotic}} CH_3-OH + KX$$

$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$ (Acetone)

→ In this a transition state will form

→ single step reaction

→ follow 2° kinetic, $\boxed{\text{Rate} \propto [R-X]\,[Nu^-]}$

→ Reactivity order is $\boxed{1° > 2° > 3°}$

Reaction

$$CH_3-X + KOH \xrightarrow[CH_3-\underset{O}{\underset{\|}{C}}-CH_3 \text{ (solvent)}]{\text{Polar Aprotic Solvent}} CH_3-OH + KX$$

solvents

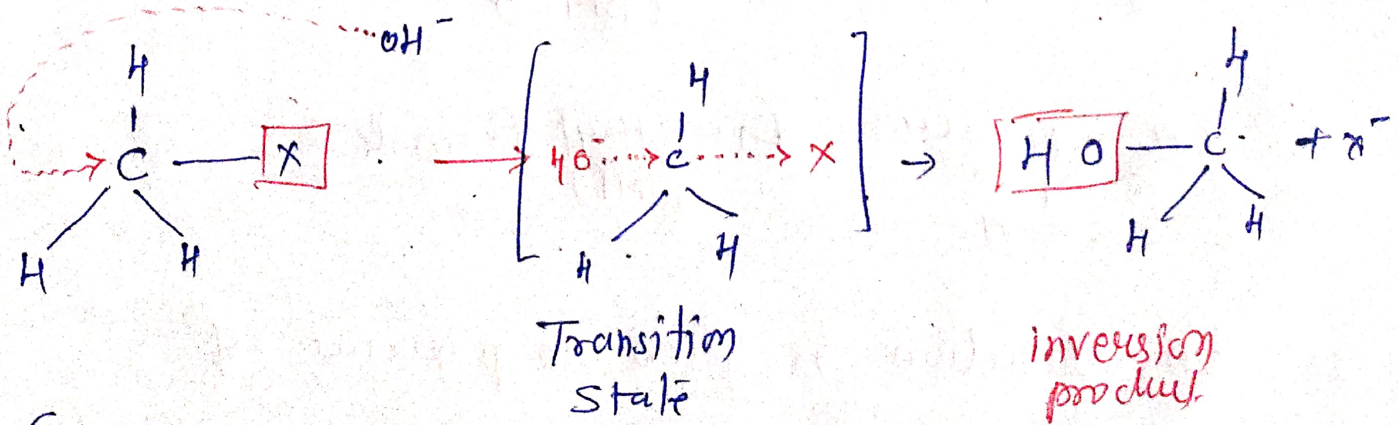
$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$ (aceton)

$CH_3-\overset{O}{\overset{\|}{S}}-CH_3$ dimethyl sulfo oxide (DMSO)

$CH_3-\underset{}{\overset{O=C-H}{N}}-CH_3$ dimethyl formide DMF

Mechanism

In S_N2, Nu^- will attack from backside on 'C' of alkyl hallide → & further form a transition state & further give $\boxed{\text{inversion}}$ product



(Rear side attack of OH⁻)

Property of S_N2

① single step reaction

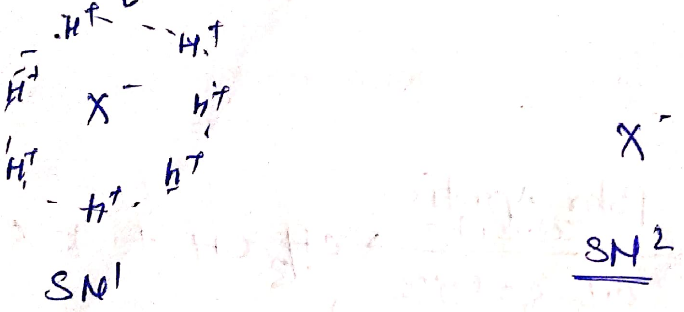
② No. carbocation formation, instead of that transition state is formed.

③ Solvent

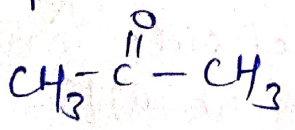
→ Polar-aprotic solvent e.g. $CH_3-\overset{O}{\overset{||}{C}}-CH_3$

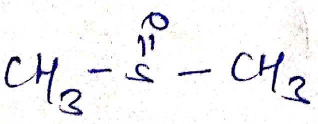
→ $C \overset{\downarrow}{-\!\wr\!-} X$

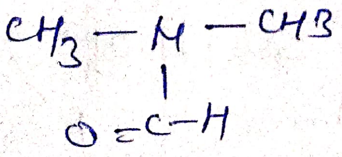
→ here no. proton is present so halide ion remain free to react $\bar{c}$ K^+.



Eg. of solvent

1)

$CH_3-\overset{O}{\overset{||}{C}}-CH_3$ - Acetone

2)

$CH_3-\overset{O}{\overset{||}{S}}-CH_3$ Dimethyl sulfoxide (DMSO)

③

$CH_3-\underset{O=C-H}{\underset{|}{N}}-CH_3$ Dimethyl formide (DMF)

so S_N2 reaction is given in presence of above solvent.

Stereochemistry of S_N2

→ In S_N2 only inversion product will form.

Factor Affecting to S_N2 reaction

① Nature of alkyl halide

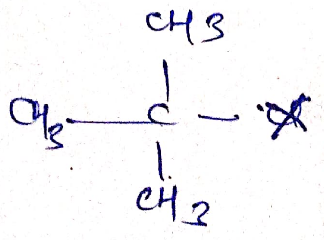
$$\text{Rate of reaction} \propto \frac{1}{\text{steric hinderance}}$$

* steric hinderance : Presence of ligands surrounding the given atom in molecule.

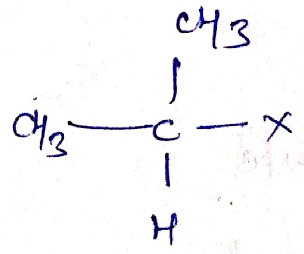
→ It prevent the reaction.

→ more Ligand ∝ more hinderence.

→ so In 3° halide steric hindrance is more there for NU will not easily attack in 3°.



$CH_3-\overset{CH_3}{\underset{CH_3}{C}}-X$



$CH_3-\overset{CH_3}{\underset{H}{C}}-X$

CH_3-CH_2-X CH_3-X

3° < 2° < 1° < methyle

so in substitution 2, rear attack is not possible in 3°. therefore in Methyl or 1° have is more chances for S_N2 reaction.

(II) Stability of transition state

$\overset{\delta-}{Nu} \cdots\cdots \overset{\delta+}{C} \cdots\cdots \overset{\delta-}{X}$

if c is bonded ē more electron withdrawing group then stability of compound will ↑.

stability ↑ → Rate of S_N2 ↑ > steric hinderance.

e.g. a) $CH_3-\overset{O}{\overset{\|}{C}}-CH_2-Cl$

b) CH_3-Cl (Me)

c) CH_3-CH_2-Cl (1°)

d) $(CH_3)_2CH-Cl$ (2°)

} order of stability = ?

here (a) have electron withdrawing group dominate to stability by 10,000 time.

so

Ans: $\boxed{a > b > c > d}$

(III) Nature of Nucleophile

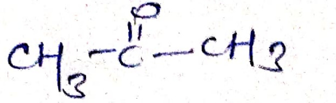
$$Rate = k[R-X][Nu]$$

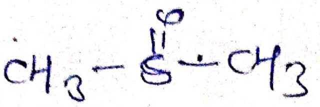
Higher the conⁿ of NU ⟶ more S_N2 reaction.

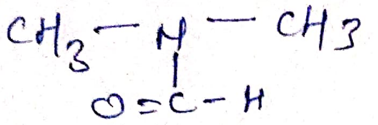
e.g. $\left[OH^-, CN^-, \underset{\text{Phenoxide ion}}{O^--ph}, \overset{\text{thione}}{SH^-}, S^--ph, I^{\ominus} \right]$ strong nucleophile.

(IV) Nature of solvent

→ Polar - Aprotic

e.g. 
$CH_3-\overset{O}{\overset{\|}{C}}-CH_3$ Acetone

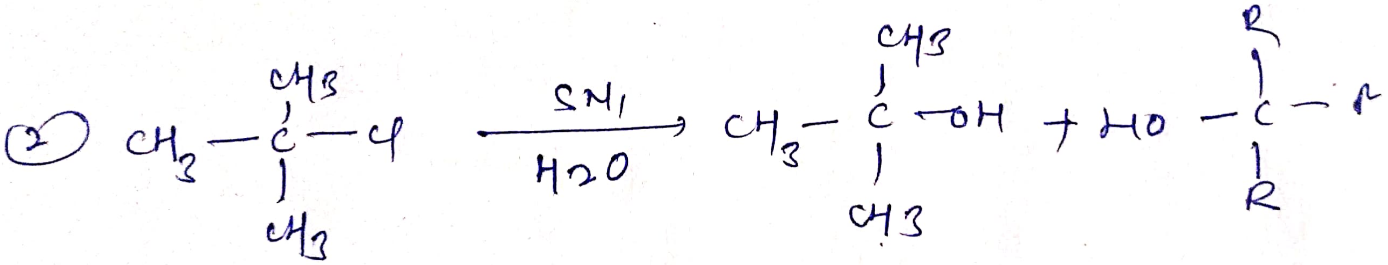

$CH_3-\overset{O}{\overset{\|}{S}}-CH_3$ DMSO

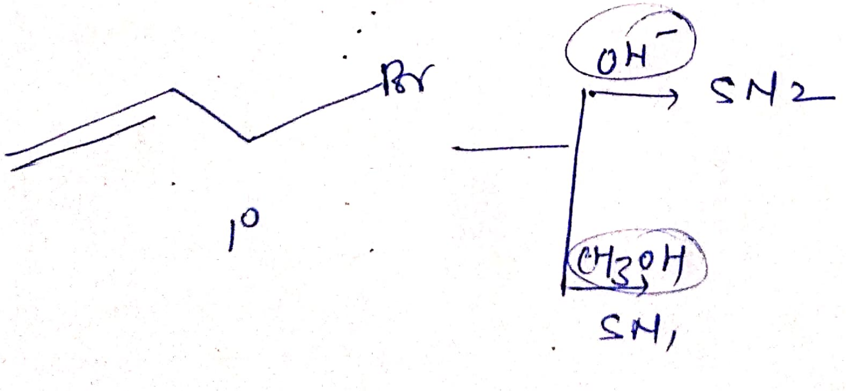

$CH_3-\underset{O=C-H}{\underset{|}{N}}-CH_3$ DMF

---

e.g. Excercise

① $CH_3-Br \xrightarrow[OH^{\ominus}]{S_N2} CH_3-OH$ $HO-CH_3$


② $CH_3-\overset{CH_3}{\underset{CH_3}{C}}-Cl \xrightarrow[H_2O]{S_N1} CH_3-\overset{CH_3}{\underset{CH_3}{C}}-OH + HO-\overset{R}{\underset{R}{C}}-R$

③ 

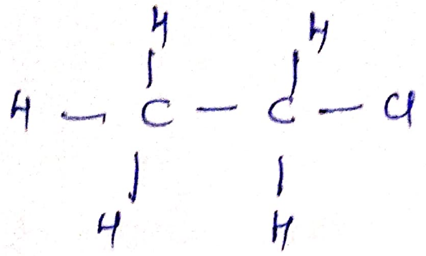
④

Structure and Uses of ethylchloride

→ General formula → C_2H_5Cl

→ Comm. Name : chloroethane,/ monochloroethane.

→ It's a colourless, flammable gas or refrigerated Liquid with a fainty sweet odour.



$$H-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-\overset{\displaystyle H}{\underset{\displaystyle H}{C}}-Cl$$

→ Ethyl carbon atoms are sp^3 hybridized.

⇒ formation of ethyl group

$$H_3C-CH_3 \xrightarrow[\text{of H from } 1^\circ]{\text{Removal}} CH_3-CH_2-$$

(Ethane) (Ethyle)

⇒ Preparation

$$\boxed{C_2H_4 + HCl \longrightarrow C_2H_5Cl}$$

⇒ Uses

1) Used as refrigerant, an aerosol spray propellant.

2) Used as anaesthetics

3) In industry used to make ethyl cellulose from cellulose

4) Act as CNS deprassant.

→ Used for temporary relief of minor sports injury.

→ E.C. is a cooling substance that is applied to skin

→ It is used to prevent pain caused by injection and minor surgical procedure.

Side effect

→ cutaneous sensitization may occurs.

→ It is a toxin for Liver & kidney on long exposure.

⇒ Precaution

→ Flamable :- Don't use in presence of flame.

→ Do not spray in eyes.

CHLOROFORM! ($CHCl_3$)

→ It is one carbon compound.

→ It is a methane in c̄ 3-H is replaced by Cl^-.

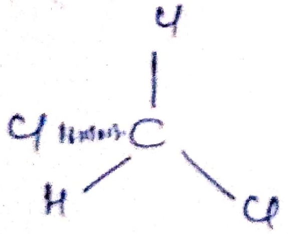
→ Initially it is employed as ideal anaesthetics.

→ first prepared in 1831.

⇒ Properties of $CHCl_3$

1) colourless.
2) Sweet smelling
3) Non-inflamable
4) Boiling point → 61.2°c
5) insoluble in H_2O

Structure



⇒ chemical property of chloroform

a) Reaction c̄ NaOH

$$CHCl_3 + 4NaOH \longrightarrow HCOONa + 3NaCl + 2H_2O$$

↓

(Sodi formate)

b) oxidation of $CHCl_3$

$$2CHCl_3 + O_2 \longrightarrow 2COCl_2 + 2HCl$$

↓

(Phosgene)

Uses of $CHCl_3$

1) Used as anaesthetics, primarily during root canal procedure in dentistry.
2) Utilized in production of R-22 freon refrigerant.
3) used as indirect food additive in food packaging material for adhesive component.

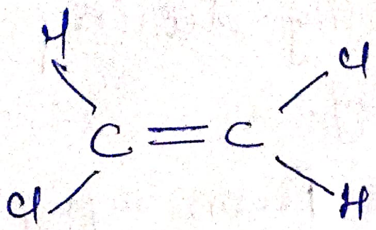
Side effect

1) Progressive central nervous system depression.
2) chronic exposure leads to defect in blood, liver and kidney.

Trichloroethylene

- first prepared in 1864.
- Man-made compound
- formula ⟶ C_2HCl_3
- It can be released into environment by evaporation from adhesive glue, paint, coatings and other chemical during their production.
- IUPAC → Trichloroethane

structure , C_2HCl_3



(1, 2, trichloro ethane)

chemical property of C_2HCl_3

⇒ Oxidation

→ It goes to combustion reaction forming CO_2, H_2O & Cl^-.

$$4C_2HCl_3 + 9O_2 \longrightarrow 8CO_2 + 2H_2O + 6Cl_2$$

Uses

1) Used in anaesthesia for it's analgesic property.

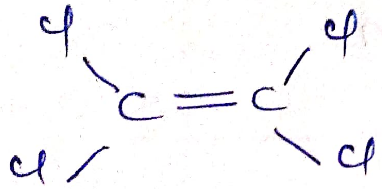
2) Used as solvent to remove greese from fabricated metal parts & some textiles

3) Ingrdeint in adhesive pain remover, type-writer correction fluid etc.

Tetrachloroethylene

- → Volatile chlorinated organic hydrocarbon
- → widely used as a solvent.
- → chemical formula → C_2Cl_4
- → Introduced in 1925

structure C_2Cl_4.



1, 2 tetra chloro ~~ethylen~~ ethene.

Property

- ⇒ odour → Ethereal odour / sweat odour.
- ⇒ Appercnce → Colourless volatil Liquid
- ⇒ Solubility → Soluble in H_2O.
- ⇒ Non-inflamable
- ⇒ Liquid at room temperature

chemical property

① C_2Cl_4 dissolved in H_2O to form dichloromethane & O_2.

$$C_2Cl_4 + 2H_2O \longrightarrow 2CH_2Cl_2 + O_2 \qquad \text{——①}$$

②

$$4NaOH + C_2Cl_4 \longrightarrow \underbrace{2HCO_2H}_{\text{formic acid}} + 4NaCl.$$

Uses

1> Used as a cleaning solvent
2) Chemical precursor for fluoro carbons
3) It act as an anthelmintics for treatment of hookworm Infestation.
4) Used in transformers.
5) Used as paint remover, ink, adhesive formulation.
6) cooling gas in aerosol formation.

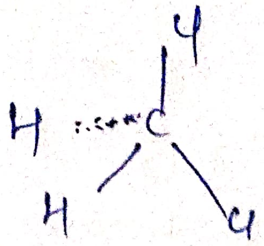
Dichloromethane

→ Also called methylene chloride.
→ Source :- Naturally from Volcano, macro algae
→ Majority is due to industrial emmission.
→ formula : → $\boxed{CH_2Cl_2}$

Property

→ colourless liquid
→ sweat, penetrating ether like smell
→ volatile in nature
→ Generally non combustible, but combustible on higher temp.
→ It may produce toxic ~~flam~~ fumes.

Structure



Uses

1) As solvent in food technology.
2) Used in aerosol formation.
3) Used as degreasing agent.
4) Used in electronic manufacturing.

Tetrachloromethane, (CCl_4)

→ Carbon tetrachloride also k/as tetrachloromethane.

→ CCl_4

→ Under standard condition it is colourless liquid.

Properties

→ colourless

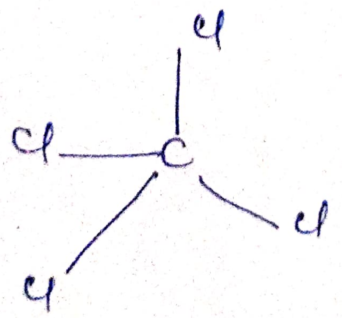
→ sweat odour

→ M.P. = −22.93°C

→ Soluble in H_2O

→ It can be crystalizes in a monoclinic crystal lattice.

Structure



Uses

1) As a chlorine source in a reaction k/as "Appel Reac"

2) Used in proton NMR Spectroscopy.

* **Appel reaction**: Reaction in c alcohol convert into alkyl chloride using "tri-phenyl phosphine"

Iodoform

→ It is also k/as tri-iodo-methane.

→ chemical formula → CHI_3

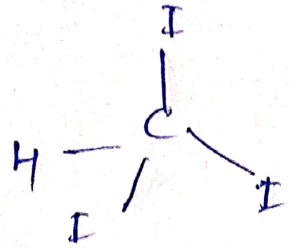
→ It's highly inflamable

→ It's volatile

→ m.p. = 121°c

→ It is ~~an~~ a skin friendly chemical.

Structure



(carbon tri-iodide)

Uses

1) Antiseptic to treat minor conditions.
2) Used in disinfectant products.
3) Sterilization of surgical instrument
4) It help removing ear hair for dogs & cats.
5) Used in hospitals.

Alcohols

→ Alcohol is any organic compound in c̲ the hydroxyl functional group (–OH) is bound to a saturated carbon atom.

Qualitative test

→ These test are used to identify the presence of alcohol. in a particular solution.

⇒ following types of test.

① Sodium metal test
② Ester test
③ Ceric ammonium nitrate test
④ Acetyl chloride test
⑤ Iodoform test.

① Sodium metal test

→ Alcohol react c̄ dry Na metal & liberate H_2 gas that can be observed in form of effervescence.

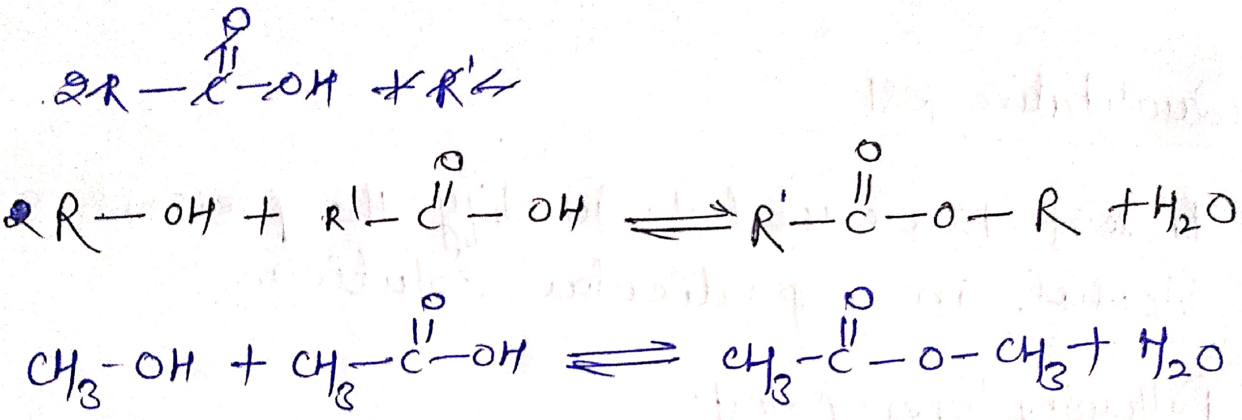
$$2R-OH + 2Na \longrightarrow 2R-O^-Na^+ + H_2\uparrow$$

$$2CH_3OH + 2Na \longrightarrow 2CH_3-O^-Na^+ + H_2\uparrow$$

(Sod. methoxide)

② Ester test

- → Alcohol react c̄ – COOH to form fruity smelling compound called "ester".
- → This reaction is called esterification.
- → catalysed by conⁿ H_2SO_4



~~$2R-\overset{O}{\overset{||}{C}}-OH + R'$~~

$$2R-OH + R'-\overset{O}{\overset{||}{C}}-OH \rightleftharpoons R'-\overset{O}{\overset{||}{C}}-O-R + H_2O$$

$$CH_3-OH + CH_3-\overset{O}{\overset{||}{C}}-OH \rightleftharpoons CH_3-\overset{O}{\overset{||}{C}}-O-CH_3 + H_2O$$

(Methyl acetalate)

③ ceric Ammonium nitrate test

Alcohols react c̄ ceric ammonium nitrate to form a red coloured Alkoksy cerium compound.

$$2R-OH + (NH_4)_2Ce(NO_3)_6 \longrightarrow (R-OH)_2Ce(NO_3)_4 + 2NH_4NO_3$$

Alcohol — ceric amm. nitrate — Alkoksy cerium compound IV (Pink/red coloured)

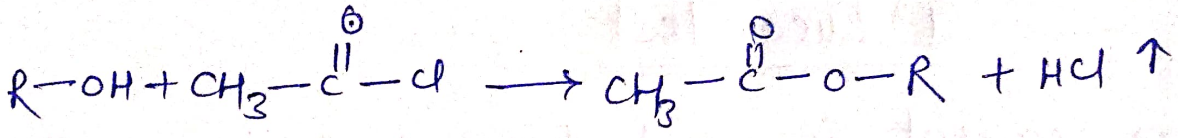
$$2CH_3-OH + (NH_4)_2Ce(NO_3)_6 \longrightarrow (CH_3OH)_2Ce(NO_3)_4 + 2NH_4NO_3$$

methyl alcohol — methoxy cerium(IV) compound

④ Acetyl chloride test

* Alcohol react c̄ acetyl chloride to form ester and give out HCl gas.

* HCl gas when react c̄ NH_4OH give white fumes.



$$R-OH + CH_3-\overset{O}{\overset{\|}{C}}-Cl \longrightarrow CH_3-\overset{O}{\overset{\|}{C}}-O-R + HCl\uparrow$$

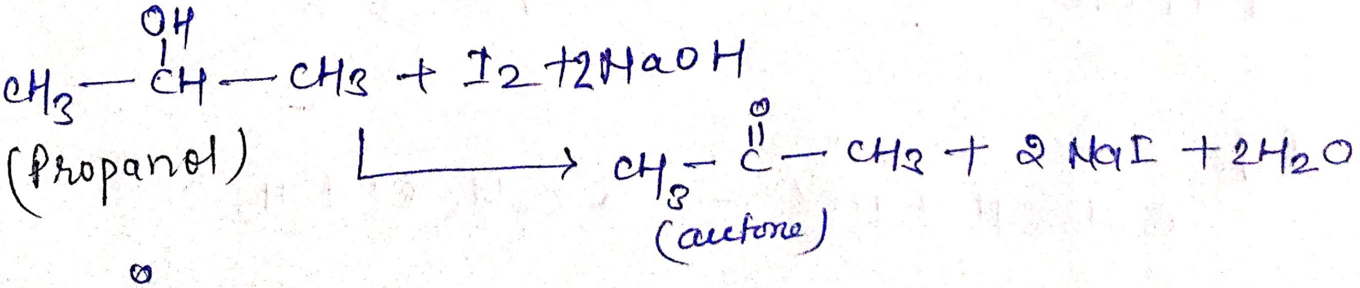
alcohol Acetyl chloride Ester Hydrogen chloride gas

$$HCl + NH_4OH \longrightarrow \underset{\substack{\downarrow \\ \text{white fumes}}}{\underline{NH_4Cl}} + H_2O$$

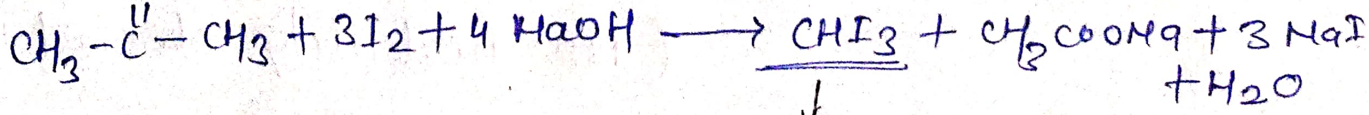
⑤ Iodoform test

- This test is given by acetaldehyde, all methyl ketones & all alcohol containing $CH_3\cdot CH-OH$ group.

→ when alcohol react c̄/warmed c̄ NaOH solution and iodine → A yellow precipitate forms.



$$\underset{\text{(Propanol)}}{CH_3-\overset{OH}{\overset{|}{C}H}-CH_3} + I_2 + 2NaOH \longrightarrow \underset{\text{(acetone)}}{CH_3-\overset{O}{\overset{\|}{C}}-CH_3} + 2NaI + 2H_2O$$



$$\underset{\text{Acetone}}{CH_3-\overset{O}{\overset{\|}{C}}-CH_3} + 3I_2 + 4NaOH \longrightarrow \underset{\substack{\downarrow \\ \text{iodoform}}}{\underline{CHI_3}} + CH_3COONa + 3NaI + H_2O$$

Test to differentiate Primary, secondary and tertiary alcohol.

① Lucas test

② Victor Meyer test

① Lucas test

→ Lucas reagent is anhydrous $ZnCl_2$ in conⁿ hydrochloric acid.

→ It is based on the difference in reactivity of alcohol c̄ hydrogen hallide.

→ It follows the S_N1 reaction.

① Test for Primary Alcohol

→ when Lucas reagent is added to 1° alcohol, there is no change observed in the solution, rather it remain colourless.

→ The solution is then heated for 30-45 minute and an oily layer is formed.

e.g.

$$C_2H_5\text{-}OH + HCl \longrightarrow C_2H_5\text{-}Cl + H_2O$$

(No turbidity observed)

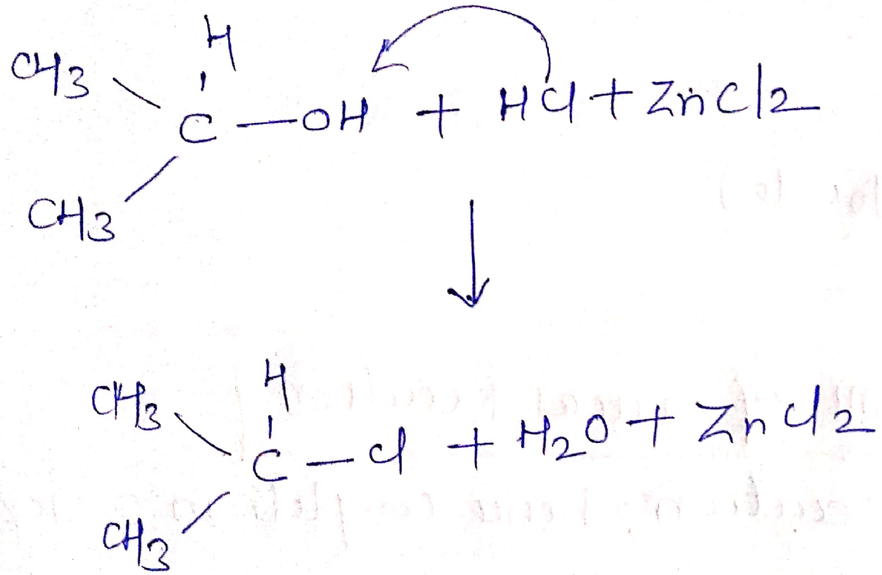
② Test for Secondary alcohol

2° alcohol + Lucas reagent

↓

1) oily layer is formed in 3-4 minutes.
2) Turbidity is observed.

$(CH_3)_2CHOH$ — 2° Alc.



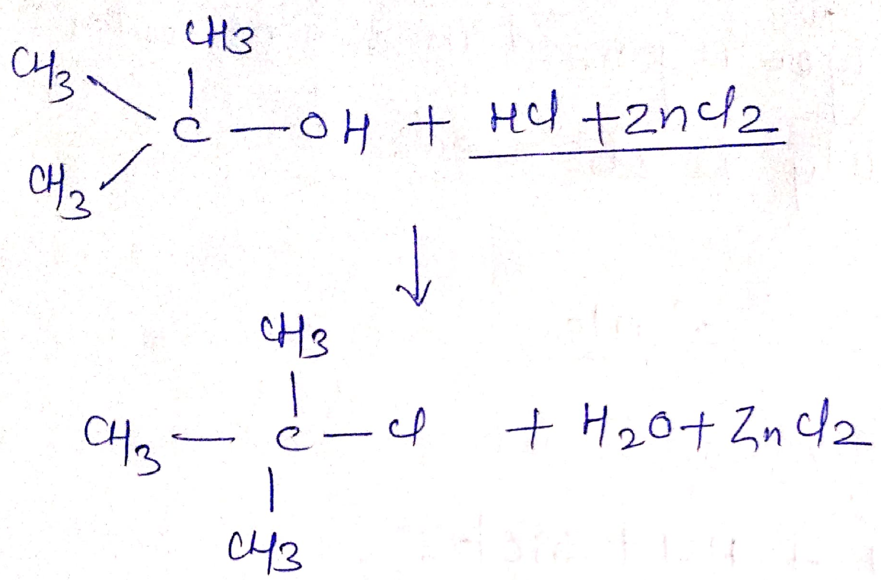
$$(CH_3)_2CH-OH + HCl + ZnCl_2 \longrightarrow (CH_3)_2CH-Cl + H_2O + ZnCl_2$$

(Propyl chloride)

* Propyl chloride is responsible for turbidity in solⁿ.

③ Test for tertiary alcohols

→ 3° alcohol quickly form an oily layer & turbidity is also observed.



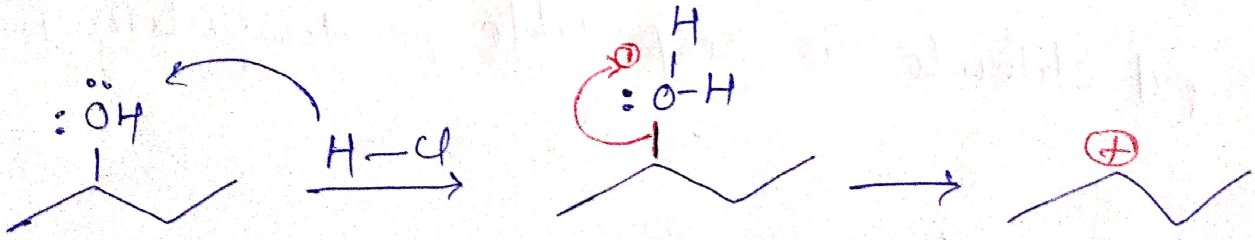
$$\begin{array}{c} CH_3 \\ CH_3-\overset{|}{C}-OH \\ CH_3 \end{array} + \underline{HCl + ZnCl_2} \downarrow \begin{array}{c} CH_3 \\ | \\ CH_3-C-Cl \\ | \\ CH_3 \end{array} + H_2O + ZnCl_2$$

(butyl chloride)

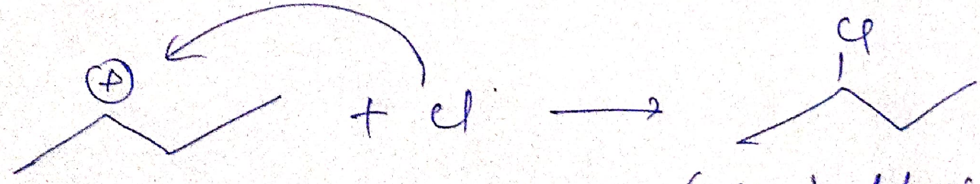
Mechanism of Lucas Reaction

* It follow S_N1 reaction; hence complete in 2 steps.

(I) Protonation of hydroxyl group & ~~formation of~~



(II) Attack of Cl on Carbocation.



(alkyl chloride)

Observation

Type of alcohol	observation
Primary	No change in solⁿ. upon heating an oily layer is formed.
Secondary.	solution turn turbid, oily layer formed (3-5 min)
Tertiary	Turbid solution, oily layer is formed.

* Rate of reaction is according to Carbocation stability

$\boxed{3° > 2° > 1° \text{ alcohol}}$

Victor Meyer test

→ In this method 1°, 2°, 3° alcohol are subjected to series of chemical analysis. & colour of resulting solution is observed.

Steps

1) Alc. is treated c̄ I_2 in presence of red-phosphorus to obtain Indol alkane.

2) Indol alkane react c̄ alc. $AgNO_3$ to obtained nitro-alkane.

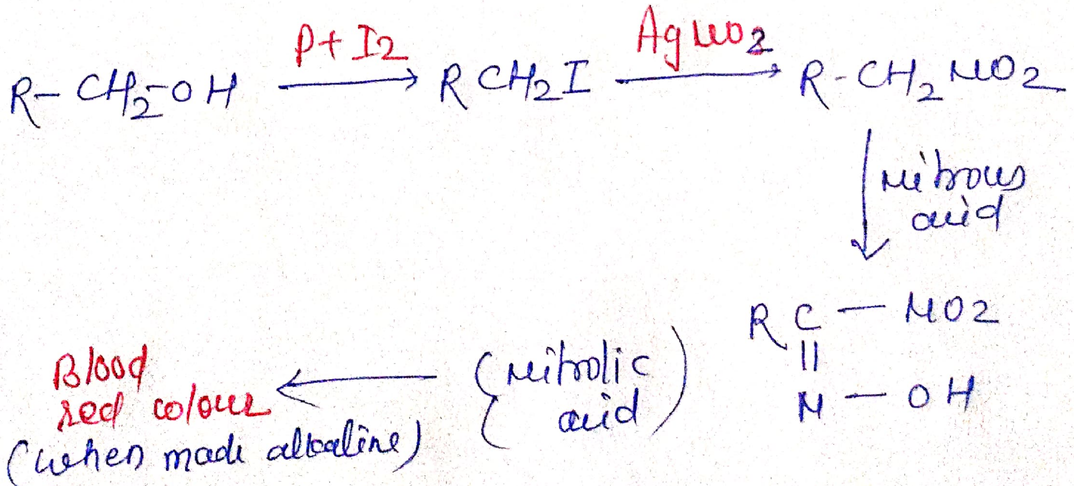
3) Nitro-alkane is treated c̄ Nitrous acid ($NaNO_2 + HCl$) & resulting sol^n made alkaline.

4) Colour observed

   a) Primary alcohol → Red blood colour
   b) Secondary alcohol → blue colour
   c) Tertiary alcohol → No. colour.

Reactions

1) Primary alcohol



$$R-CH_2-OH \xrightarrow{P+I_2} RCH_2I \xrightarrow{AgNO_2} R-CH_2NO_2 \xrightarrow{\text{nitrous acid}} \underset{\substack{\| \\ N-OH}}{RC}-NO_2 \;(\text{nitrolic acid}) \longrightarrow \text{Blood red colour (when made alkaline)}$$

Secondary

$$\begin{tikzcd}
R-CHOH \arrow[r, "P+I_2"] & R_2CHI \arrow[r, "AgNO_2"] & R_2CHNO_2 \arrow[d, "HNO_2"] \\
\text{Blue colour } \bar{c} \text{ alkali} & & \underset{\substack{| \\ NO}}{R_2C}-NO_2 \arrow[ll]
\end{tikzcd}$$

(Pseudo nitrol)

Tertiary

$$\begin{tikzcd}
R_3C-OH \arrow[r, "P+I_2"] & R_3CI \arrow[r, "AgNO_2"] & R_3CNO_2 \arrow[d] \\
 & & (\text{no reaction})
\end{tikzcd}$$