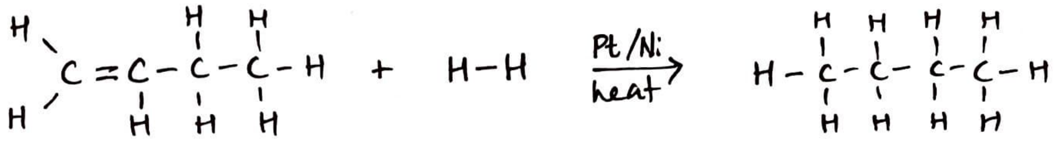
PRODUCTION OF ALKANES

1) HYDROGENATION OF ALKENES (ADDITION OF H_2)

$$\boxed{\text{alkene} + H_2(g) \xrightarrow[\text{heat}]{\text{finely divided Pt/Ni catalyst}} \text{alkane}}$$ – exothermic



2) CRACKING

$$\boxed{\text{long hydrocarbons} \xrightarrow[\text{heat}]{Al_2O_3\text{ catalyst}} \text{alkane} + \text{alkenes}}$$ – endothermic

$$C_{10}H_{22} \xrightarrow[\text{heat}]{Al_2O_3} C_8H_{18} + C_2H_4$$

REACTIONS OF ALKANES

1) COMBUSTION

a) Complete Combustion

$$\boxed{\text{alkane} + \text{oxygen} \longrightarrow \text{carbon dioxide} + \text{water}}$$

$$2C_8H_{18} + 25O_2 \longrightarrow 16CO_2 + 18H_2O$$

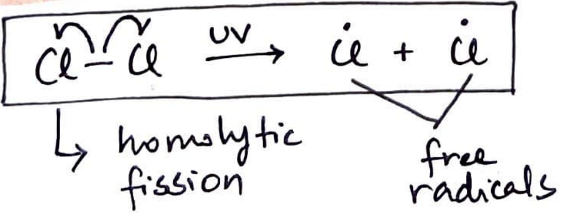
b) Incomplete Combustion

$$\boxed{\text{alkane} + \text{oxygen} \longrightarrow \text{carbon monoxide} + \text{water}}$$

$$2C_8H_{18} + 17O_2 \longrightarrow 16CO + 18H_2O$$

2) FREE-RADICAL SUBSTITUTION

(i) Initiation



*overall reaction:

$$CH_3CH_3 + Cl_2 \longrightarrow CH_3CH_2Cl + HCl$$

(ii) Propagation

$CH_3CH_3 + \dot{C}l \longrightarrow \dot{C}H_2CH_3 + HCl$

(homolytic fission of C-H bond; alkyl radical formed)

$\dot{C}H_2CH_3 + Cl_2 \longrightarrow CH_3CH_2Cl + \dot{C}l$

halogenoalkane (chloroethane)

(free radical formed, which repeats cycle)

Further substitution :

$CH_3CH_2Cl + \dot{C}l \longrightarrow \dot{C}H_2CH_2Cl + HCl$

$\dot{C}H_2CH_2Cl + Cl_2 \longrightarrow ClCH_2CH_2Cl + \dot{C}l$

(1,2-dichloroethane)

$ClCH_2CH_2Cl + \dot{C}l \longrightarrow ClCH_2\dot{C}HCl + HCl$

$ClCH_2\dot{C}HCl + Cl_2 \longrightarrow ClCH_2CHCl_2 + \dot{C}l$

(1,1,2-trichloroethane)

⋮

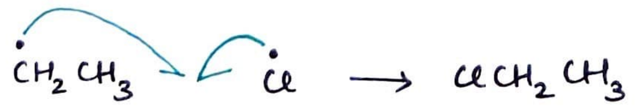
eventually C_2Cl_6 is formed

(iii) Termination

$\dot{C}H_2CH_3 + \dot{C}l \longrightarrow ClCH_2CH_3$

$\dot{C}H_2CH_3 + \dot{C}H_2CH_3 \longrightarrow CH_3CH_2CH_2CH_3$

$\dot{C}l + \dot{C}l \longrightarrow Cl_2$

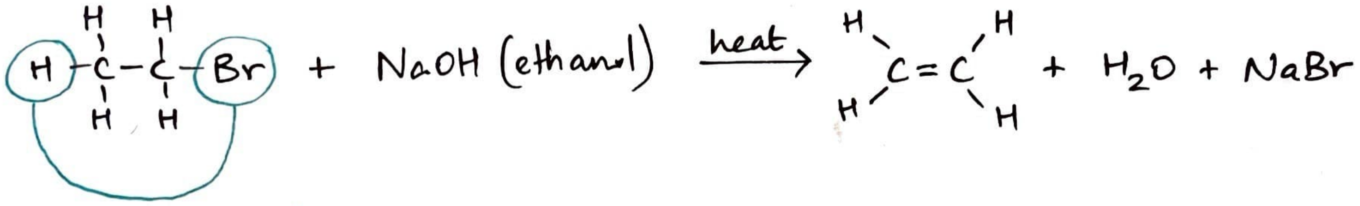


$\dot{C}H_2CH_3 \; \dot{C}l \longrightarrow ClCH_2CH_3$

PRODUCTION OF ALKENES

1) ELIMINATION (of hydrogen halide from halogenoalkane)

$$\boxed{\text{halogenoalkane} + \text{ethanolic NaOH} \xrightarrow{\text{heat}} \text{alkene} + H_2O + NaX}$$



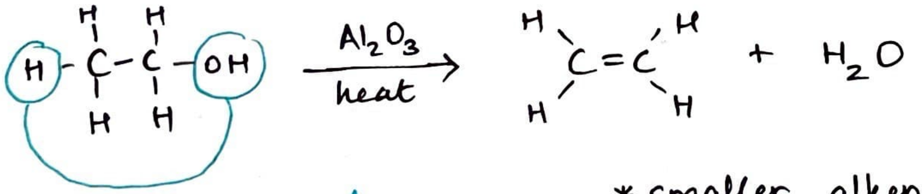
- HBr eliminated
- heterolytic bond breaking of C-Br bond ; Br takes both e^- & forms Br^-.
- ethanolic OH^- acts as a base & accepts H^+

  $H^+ + OH^- \rightarrow H_2O$
- Br^- combines w/ Na^+ to form NaBr

  $Na^+ + Br^- \longrightarrow NaBr$

2) DEHYDRATION (elimination of H_2O from alcohol)

$$\boxed{\underset{\text{(vapour)}}{\text{alcohol}} \xrightarrow[\text{heat}]{Al_2O_3\,/\,\text{conc. acid}\,/\,\text{pieces of porous pot}\,/\,\text{pumice}} \text{alkene} + H_2O}$$



- H_2O eliminated

  $H^+ + OH^- \rightarrow H_2O$

* smaller alkenes (ethene, propene, butene) = gases at room temp
∴ collected over water.

3) CRACKING

REACTIONS OF ALKENES

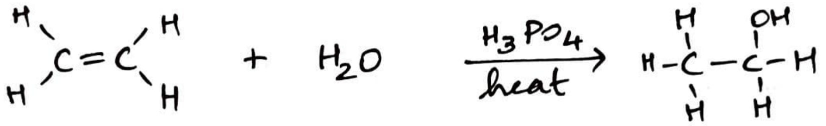
1) ELECTROPHILIC ADDITION – electrophile is added to double bond

a) Addition of H_2 (Hydrogenation)

$$\boxed{\text{alkene} + H_2 \xrightarrow[\text{heat}]{Pt/Ni} \text{alkane}}$$

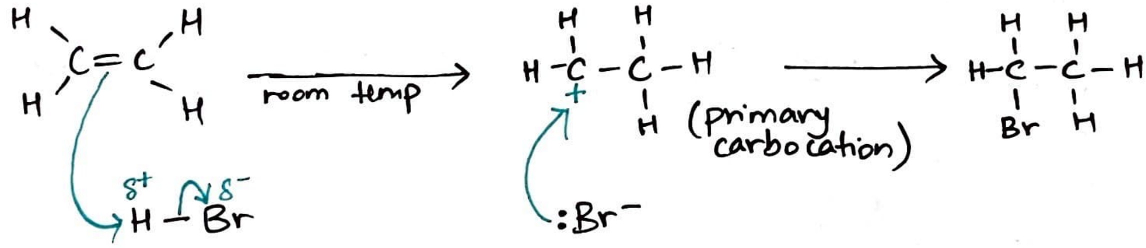
b) Addition of steam

$$\boxed{\text{alkene} + H_2O(g) \xrightarrow[\text{heat}]{H_3PO_4} \text{alcohol}}$$

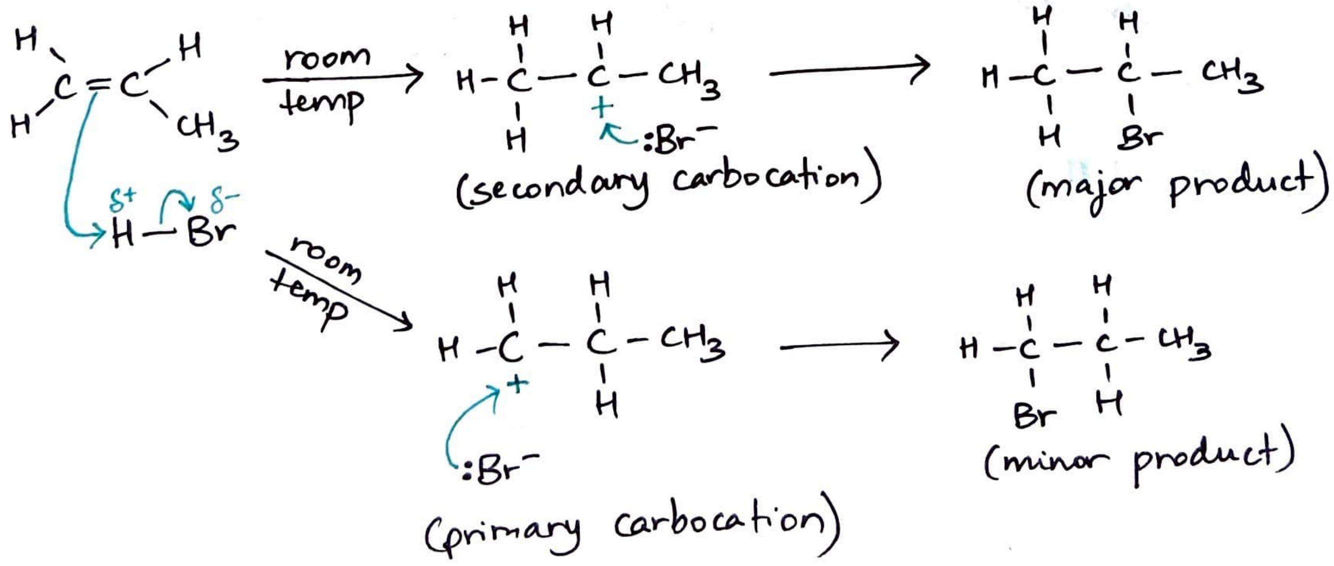


c) Addition of hydrogen halides (HX)

$$\boxed{\text{alkene} + HX(g) \xrightarrow{\text{room temp}} \text{halogenalkane (major product / minor product)}}$$

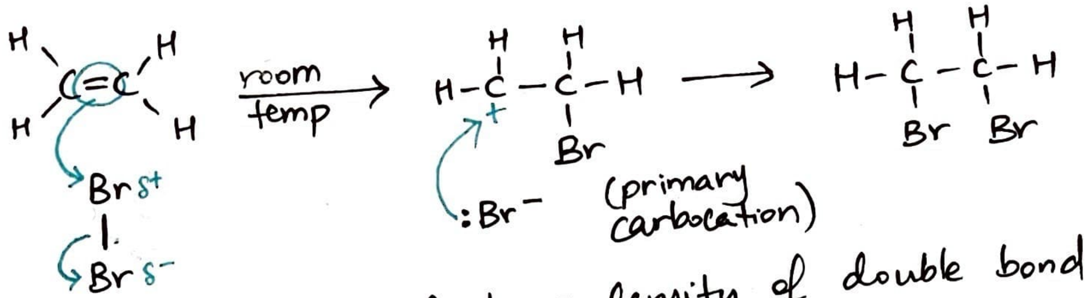


Markovnikov's rule: halogen ends up attached to most substituted C atom; applies to asymmetrical alkenes.



d) Addition of halogens

$$\text{alkene} + X_2 \xrightarrow{\text{room temp}} \text{halogenoalkane}$$



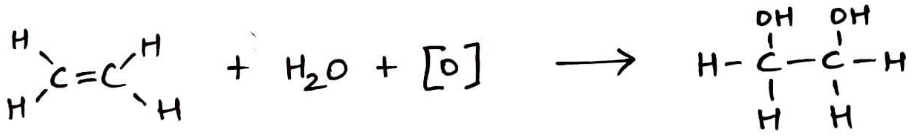
(induced dipole, as high e⁻ density of double bond repels e⁻ from the closest Br atom)

2) OXIDATION

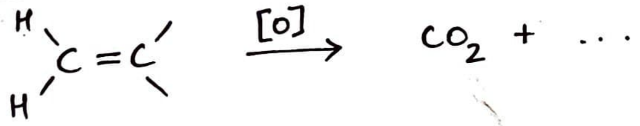
a) Cold, dil. $KMnO_4$

$$\text{alkene} \xrightarrow[(H_2O)]{\text{cold dil. } KMnO_4} \text{diol}$$

pale purple solution → colourless solution

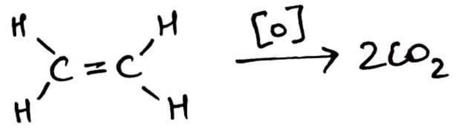


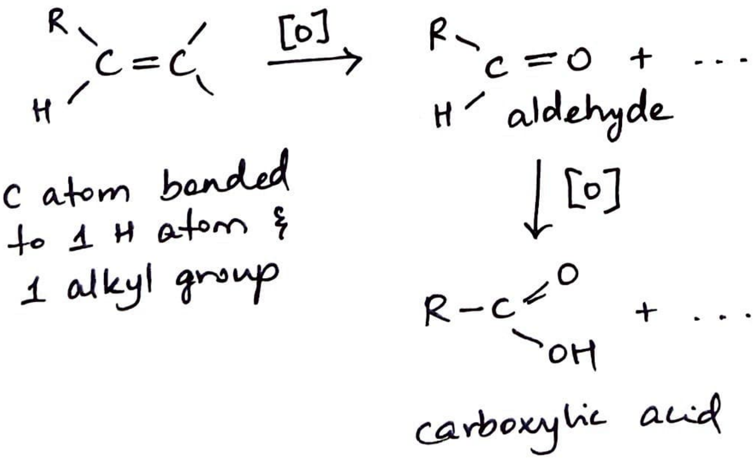
b) Hot, conc. $KMnO_4$



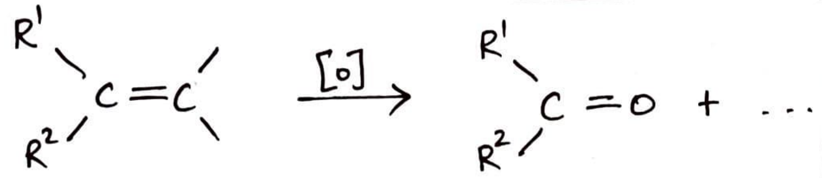
C atom bonded to 2H atoms

carbon dioxide



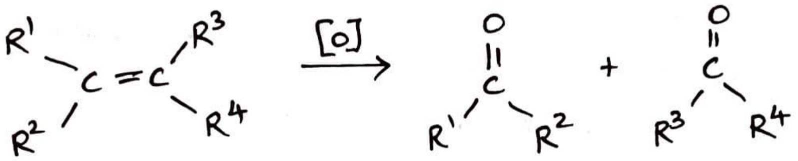


C atom bonded to 1 H atom & 1 alkyl group

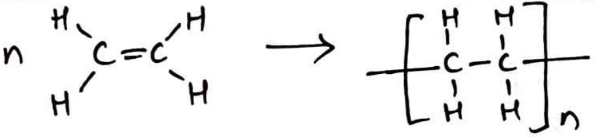


C atom bonded to 2 alkyl groups

ketone



3) ADDITION POLYMERISATION



↳ (repeating unit)

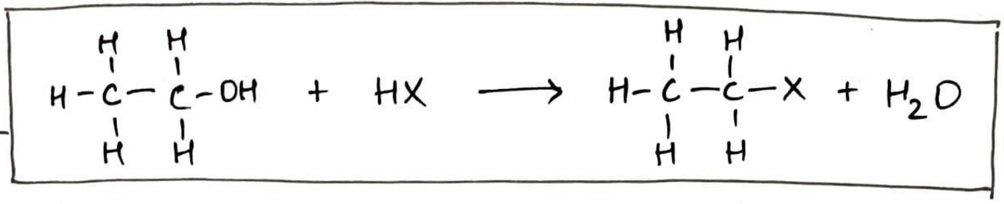
PRODUCTION OF HALOGENOALKANES

1) FREE-RADICAL SUBSTITUTION OF ALKANES

2) ELECTROPHILIC ADDITION (of hydrogen halides/halogens to alkenes)

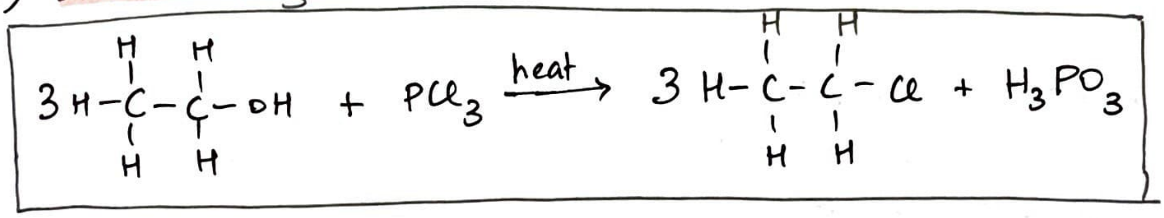
3) SUBSTITUTION OF ALCOHOLS

a) alcohol + HX (g)



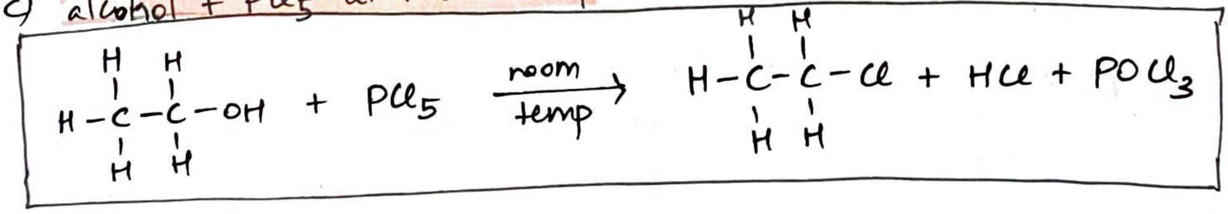
$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH + HX \longrightarrow H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-X + H_2O$$

b) alcohol + PCl_3 + heat



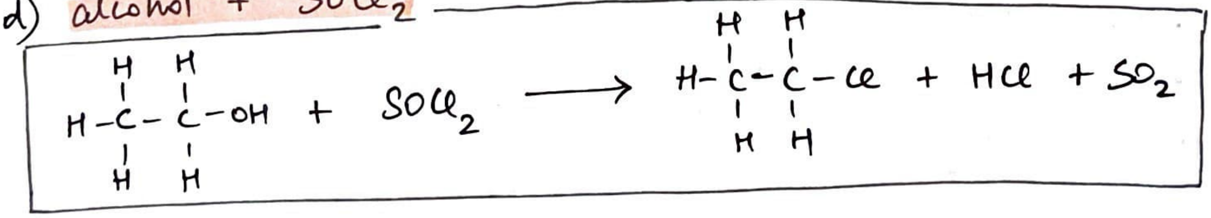
$$3\,H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH + PCl_3 \xrightarrow{heat} 3\,H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Cl + H_3PO_3$$

c) alcohol + PCl_5 at room temp

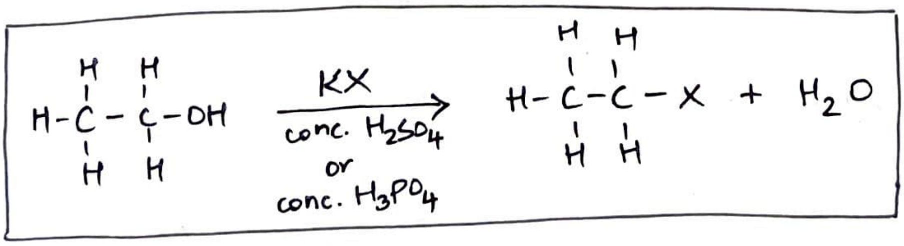


$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH + PCl_5 \xrightarrow[temp]{room} H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Cl + HCl + POCl_3$$

d) alcohol + $SOCl_2$



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH + SOCl_2 \longrightarrow H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Cl + HCl + SO_2$$



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-OH \xrightarrow[\text{conc. } H_2SO_4 \text{ or conc. } H_3PO_4]{KX} H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-X + H_2O$$

KCl + Conc. H_2SO_4

conc. H_3PO_4

REACTIONS OF HALOGENOALKANES

1) NUCLEOPHILIC SUBSTITUTION

– nucleophile attacks $\delta^+ C$ atom & replaces δ^- atom.

a) NaOH + heat

$$\boxed{\text{halogenoalkane} + NaOH\,(aq) \xrightarrow{heat} \text{alcohol} + NaX}$$

- OH^- ion = nucleophile
- OH^- replaces halogen

$CH_3CH_2Br + :OH^- \longrightarrow CH_3CH_2OH + :Br^-$

b) KCN in ethanol + heat

$$\boxed{\text{halogenoalkane} + KCN\,(\text{ethanol}) \xrightarrow[\text{under reflux}]{heat} \text{nitrile} + KX}$$

- CN^- = nucleophile
- CN^- ion replaces halogen
- an extra C atom is added to carbon chain

$CH_3CH_2Br + :CN^- \longrightarrow CH_3CH_2CN + :Br^-$

c) NH_3 in ethanol + heat under pressure

$$\boxed{\text{halogenoalkane} + \text{excess } NH_3\,(\text{ethanol}) \xrightarrow[\text{under pressure}]{heat} \text{primary amine} + HX}$$

- NH_3 = nucleophile
- amine grp (NH_2) replaces halogen
- ammonia should be in excess otherwise primary amine produced can act as nucleophile, attack another halogenoalkane molecule to form secondary amine.

$CH_3CH_2Br + NH_3 \longrightarrow CH_3CH_2NH_2 + HBr$

d) aq. $AgNO_3$ in ethanol

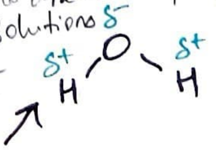
→ halogenoalkanes have diff rates of hydrolysis so this reaction is used ~~to~~ as a test to identify halogens in a halogenoalkane

$$\boxed{\text{halogenoalkane} + H_2O \xrightarrow[AgNO_3]{reflux} \text{alcohol} + HX}$$

– hydrolysis by measuring how long it takes for test tubes containing halogenoalkane & aq. $AgNO_3$ solutions to become opaque

- H_2O molecules in aq. $AgNO_3$ = nucleophiles
- H_2O replaces halogen

$C_2H_5Br + H_2O \xrightarrow{reflux} C_2H_5OH + HBr$



* slower than nucl. sub. reac. w/ aq. alkali as OH^- is a better nucleophile: carries full formal -ve charge. O atom in H_2O carries δ^- charge.

2) ELIMINATION

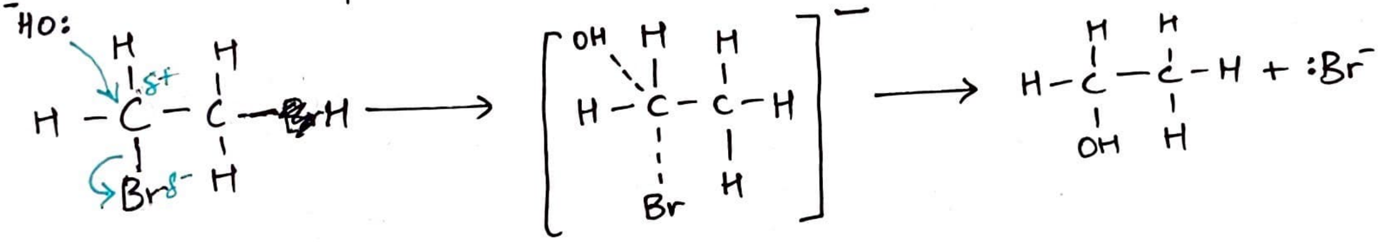
halogenoalkane + NaOH (~~aq~~) $\xrightarrow{heat}$ alkene + H_2O + NaX

ethanolic

S_N1 & S_N2

S_N2

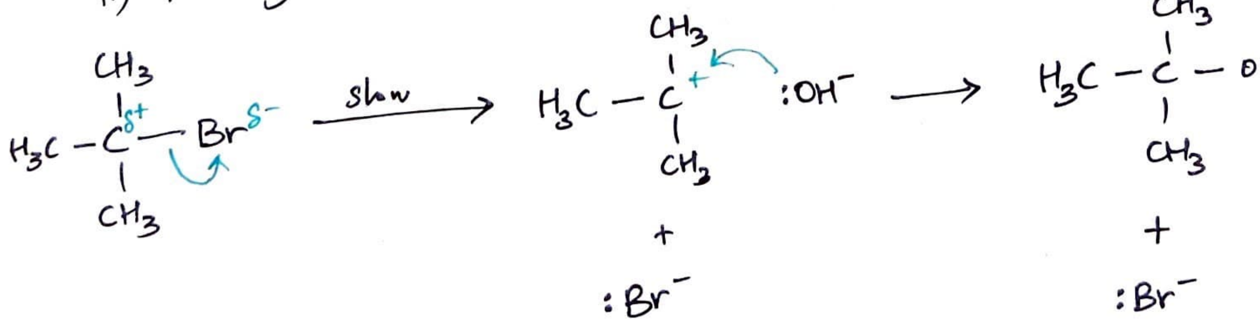
- primary halogenoalkanes
- rate depends on conc. of halogenoalkane & nucleophile ions
- one step:
  - → nucleophile donates e⁻ pair to δ+ carbon
  - → at same time C–X bond breaks by heterolytic fission & X^- formed



C–Br breaks
C–OH forms
intermediate

S_N1

- tertiary halogenoalkanes
- rate depends on conc. of halogenoalkane
- 2 steps:
  - i) C–X bond breaks heterolytically & halogen leaves as X^- (slow & rate-determining step); tertiary carbocation formed
  - ii) tertiary carbocation attacked by nucleophile.



PRODUCTION OF ALCOHOLS

1) ELECTROPHILIC ADDITION (of steam to alkene)

2) OXIDATION OF ALKENES

(using cold dil. $KMnO_4$)

→ forms diol (2 OH grps)

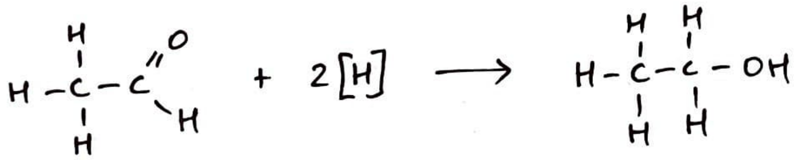
→ C=C double bond is not fully broken

3) NUCLEOPHILIC SUBSTITUTION (of halogenoalkanes w/ aq. NaOH and heat)

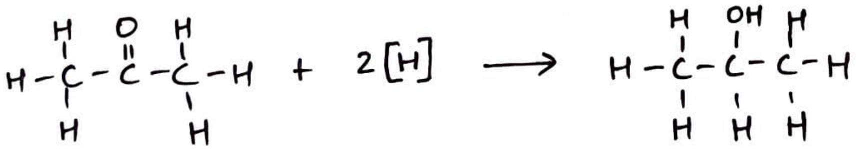
4) REDUCTION OF ALDEHYDES & KETONES

- reducing agent = $NaBH_4$ or $LiAlH_4$
- aldehydes → primary alcohols
- ketones → secondary alcohols

aldehyde + 2[H] → primary alcohol



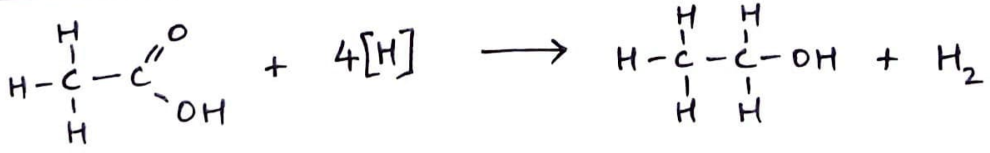
ketone + 2[H] → secondary alcohol



5) REDUCTION OF CARBOXYLIC ACIDS

- reducing agent = ~~$NaBH_4$ or~~ $LiAlH_4$

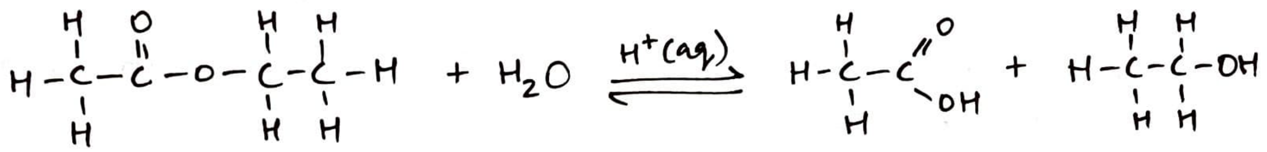
carboxylic acid + 4[H] → alcohol + H_2



6) HYDROLYSIS OF ESTER

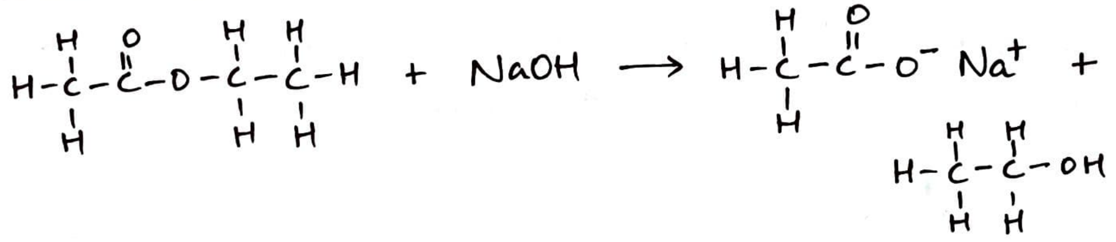
- dilute acid / alkali
- heat

$$\boxed{\text{ester} + H_2O \xrightleftharpoons{H^+(aq)} \text{carboxylic acid} + \text{alcohol}}$$



$$CH_3COOCH_2CH_3 + H_2O \xrightleftharpoons{H^+(aq)} CH_3COOH + CH_3CH_2OH$$

$$\boxed{\text{ester} + NaOH \longrightarrow \text{sodium alkanoate} + \text{alcohol}}$$



$$CH_3COOCH_2CH_3 + NaOH \longrightarrow CH_3COO^- Na^+ + CH_3CH_2OH$$

REACTIONS OF ALCOHOLS

1) COMBUSTION

- complete combustion when ignited.

$$\boxed{\text{alcohol} + \text{oxygen} \xrightarrow{\text{heat}} \text{carbon dioxide} + \text{water}}$$

$$CH_3CH_2OH + 3O_2 \xrightarrow{\text{heat}} 3H_2O + 2CO_2$$

2) SUBSTITUTION (to form halogenoalkanes)

- OH grp replaced by halogen

a) alcohol + HX

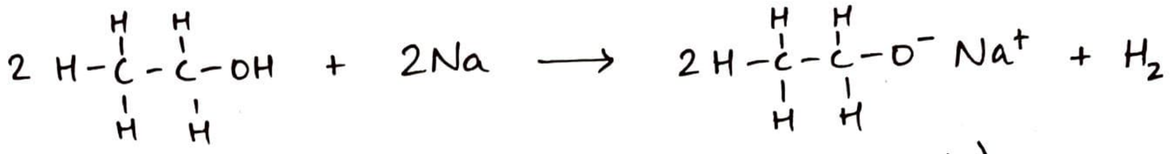
b) alcohol + PCl_3 + heat

c) alcohol + PCl_5 at room temp

d) alcohol + $SOCl_2$

3) REACTION WITH SODIUM - Na(s)

alcohol + sodium → sodium alkoxide + hydrogen



$$2\,\mathrm{CH_3CH_2OH} + 2\mathrm{Na} \longrightarrow 2\,\mathrm{CH_3CH_2O^-\,Na^+} + \mathrm{H_2}$$

(sodium ethoxide)

- when alcohol reacts w/ Na (reactive metal), O–H bond in OH grp breaks
- H_2 gas + basic compound (alkoxide) is formed, but reaction is less vigorous than Na + H_2O
- longer hydrocarbon chain in alcohol ⇒ less vigorous
- if excess alcohol is evaporated off, white crystalline solid of sodium alkoxide is left.

4) OXIDATION

- oxidising agents = acidified potassium dichromate (VI)

$K_2Cr_2O_7$ orange → green

$Cr_2O_7^{2-}$ Cr^{3+}

acidified potassium manganate (VII)

$KMnO_4$ purple → colourless

MnO_4^- Mn^{2+}

acidic medium

↓

H^+ ions

↓

for reduction of the oxidising agent

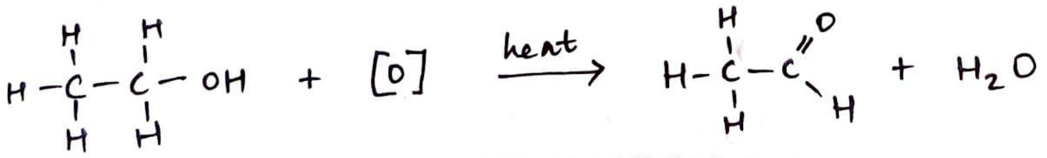
a) primary alcohols

primary alcohol $\xrightarrow{[O]}$ aldehyde $\xrightarrow{[O]}$ carboxylic acid

→ warm primary alcohol + oxidising agent

→ aldehyde formed has lower b.p than alcohol so distilled off as soon as its formed.

→ if not distilled off, further refluxing w/ excess oxidising agent will oxidise it to carb. acid.



$$\mathrm{CH_3CH_2OH} + [O] \xrightarrow{heat} \mathrm{CH_3CHO} + \mathrm{H_2O}$$

primary alcohol $\xrightarrow{distillation}$ aldehyde

primary alcohol $\xrightarrow{refluxing}$ carb. acid

b) secondary alcohols

secondary alcohol + [O] $\xrightarrow{heat}$ ketone + H_2O

$$CH_3CH(OH)CH_3 + [O] \xrightarrow{heat} CH_3COCH_3 + H_2O$$

→ ketone is formed under distillation

5) DEHYDRATION (elimination of H_2O) to form alkene

6) ESTERIFICATION (condensation reaction)

carboxylic acid + alcohol $\xrightarrow[\underbrace{H_2SO_4 \text{ or } H_3PO_4}_{\text{strong acid catalyst}}]{\text{heat under reflux}}$ ester + H_2O

reversible

$$C_2H_5OH + CH_3COOH \overset{H_2SO_4}{\rightleftharpoons} CH_3COOC_2H_5 + H_2O$$

CLASSIFYING & TESTING FOR ALCOHOLS

1) alcohol + acidified $K_2Cr_2O_7$ → classifying alcohols

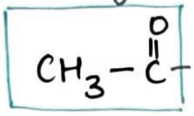
primary	green
secondary	green
tertiary	orange

2) Iodoform test for alcohols

- reagent = I_2 in NaOH (aq) ; I_2 (aq) + OH^- (aq) = alkaline solution of iodine
- condition = warm
- positive test = yellow ppt
  ↓
  CHI_3 = iodoform / tri-iodomethane

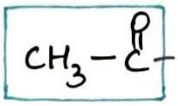
Compounds that give +ve result:

1) methyl ketones



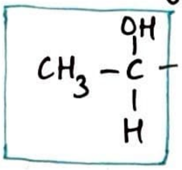
$CH_3-\overset{\overset{O}{\|}}{C}-R$

2) ethanal



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

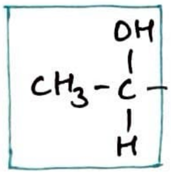
3) secondary alcohol that has CH_3 grp w/ C-atom that has -OH grp attached to it.



$CH_3-\underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}}-R$

→ this secondary alcohol will oxidise to a methyl ketone

4) ethanol



$CH_3-\underset{\underset{H}{|}}{\overset{\overset{OH}{|}}{C}}-H$

→ ethanol is oxidised to ethanal

$$\underset{\text{(methyl ketone)}}{RCOCH_3} \xrightarrow{I_2,\ NaOH(aq)} RCOCI_3 \xrightarrow{NaOH(aq)} \underset{\text{(sodium salt)}}{RCOO^-Na^+} + \underset{\text{(iodoform)}}{CHI_3}$$

Step 1: HALOGENATION

→ all 3 H atoms in CH_3 grp are replaced for I atoms, forming $-CI_3$

Step 2: HYDROLYSIS

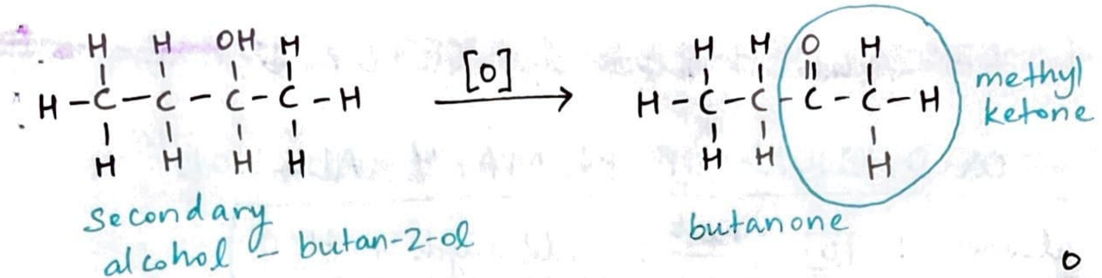
→ the intermediate compound is hydrolysed by alkaline solution, forming sodium salt + iodoform (yellow ppt)

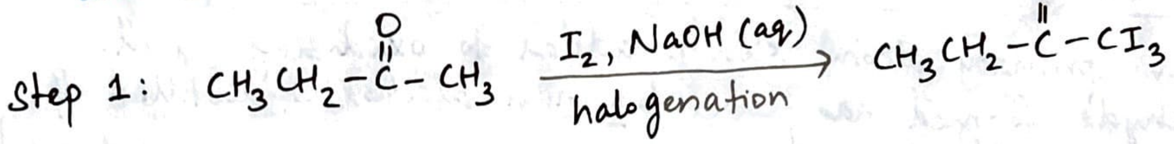
Reaction is used to deduce position of a secondary alcohol:

→ if OH grp is on C atom nxt to CH_3 grp, it is oxidised to methyl ketone

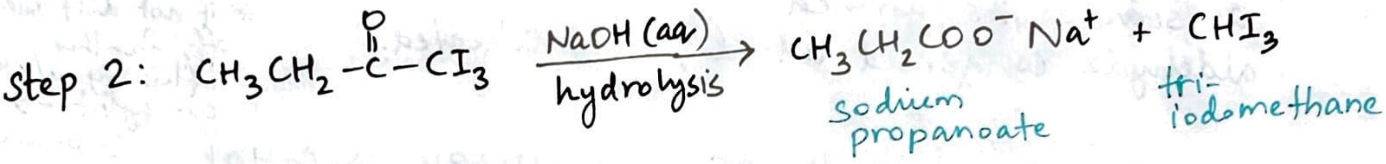
→ methyl ketone is halogenated & hydrolysed to form sodium salt + yellow ppt.

→ if no yellow ppt, secondary alcohol is NOT on a C atom nxt to methyl grp.





Step 1: $CH_3CH_2-\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow[\text{halogenation}]{I_2,\ NaOH\ (aq)} CH_3CH_2-\overset{O}{\overset{\|}{C}}-CI_3$



Step 2: $CH_3CH_2-\overset{O}{\overset{\|}{C}}-CI_3 \xrightarrow[\text{hydrolysis}]{NaOH\ (aq)} CH_3CH_2COO^-Na^+ + CHI_3$

sodium propanoate

tri-iodomethane

PRODUCTION OF ALDEHYDES & KETONES

1) ALDEHYDE – OXIDATION OF PRIMARY ALCOHOL

$$\boxed{\text{primary alcohol} + [O] \xrightarrow{\text{heat}} \text{aldehyde} + H_2O}$$

- warm primary alcohol slowly added to oxidising agent.
- aldehyde formed has lower b.p than alcohol ∴ distilled off as soon as it's formed.
- aldehyde condensed into liquid & collected.

* if not distilled off, further refluxing w/ excess ox. agent → carb. acid.

2) KETONE – OXIDATION OF SECONDARY ALCOHOL

$$\boxed{\text{secondary alcohol} + [O] \xrightarrow{\text{heat}} \text{ketone} + H_2O}$$

- warm secondary alcohol slowly added to oxidising agent.
- ketone formed; doesn't need to be immediately distilled off as it cannot be further oxidised.

oxidising agents

acidified $K_2Cr_2O_7$	acidified $KMnO_4$
· potassium dichromate (VI) acidified w/ dil. H_2SO_4	· potassium manganate (VII) acidified w/ dil. H_2SO_4
· orange → green ($Cr_2O_7^{2-}$) (Cr^{3+}) by reduction	· purple → colourless (MnO_4^-) (Mn^{2+}) by reduction

REACTIONS OF ALDEHYDES & KETONES

1) REDUCTION

- reducing agents: $NaBH_4$, $LiAlH_4$
- aldehydes → primary alcohols
- ketones → secondary alcohols

aldehyde + 2[H] → primary alcohol	
ketone + 2[H] → secondary alcohol	

2) NUCLEOPHILIC ADDITION WITH HCN

- nucleophile : cyanide ion (CN^-)
- nucleophile is added across C=O bond

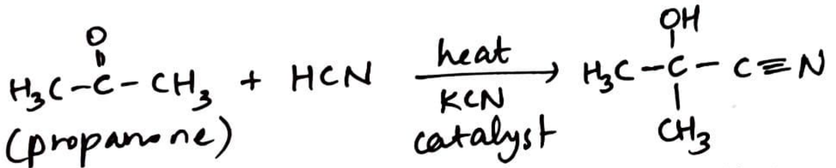
aldehyde / ketone + HCN $\xrightarrow[\text{KCN catalyst}]{\text{heat}}$ hydroxynitrile

$$H_3C-\overset{O}{\overset{\|}{C}}-H + HCN \xrightarrow[\text{KCN catalyst}]{\text{heat}} H_3C-\overset{OH}{\underset{H}{C}}-C\equiv N$$

(ethanal)

(2-hydroxypropanenitrile)

* hydroxynitrile = nitrile containing hydroxy (-OH) group



$$H_3C-\overset{O}{\overset{\|}{C}}-CH_3 + HCN \xrightarrow[\text{KCN catalyst}]{\text{heat}} H_3C-\overset{OH}{\underset{CH_3}{C}}-C\equiv N$$

(propanone)

(2-methyl-2-hydroxypropanenitrile)

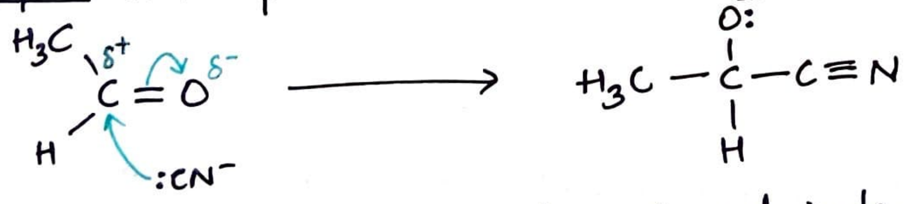
* nucleophilic addition of HCN to aldehyde = chiral hydroxynitrile <u>always</u>

nucleophilic addition of HCN to ketone = chiral hydroxynitrile <u>maybe</u>

Reaction mechanism

- carbonyl (C=O) grp is polarised.
- O atom more electronegative than C atom ∵ draws e^- density.
- C atom has δ^+ & O atom has δ^- charge.
- ∴ carbonyl C atom is susceptible to nucleophilic attack.

<u>step 1</u>: nucleophilic attack

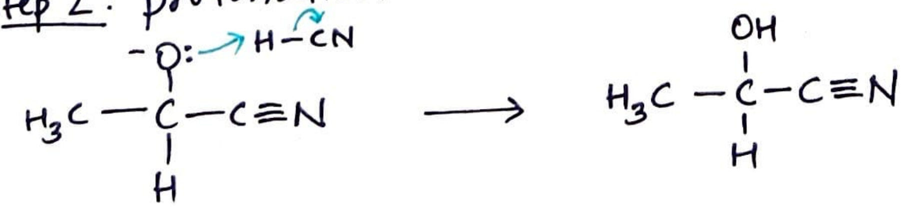


(CN⁻ ion attacks carbonyl C atom)

(-ve charged intermediate)

* -ve charge on CN⁻ ion is on C atom NOT on N atom!!

<u>step 2</u>: protonation



→ -ve charged O atom in -ve reactive intermediate quickly reacts w/ aq H^+ (from HCN/ H_2O/ dil. acid) to form 2-hydroxynitrile

TESTS FOR CARBONYL COMPOUNDS

1) 2,4-DNPH (2,4-dinitrophenylhydrazine)

- positive result : deep-orange ppt with aldehydes & ketones
- 2,4-DNPH + (C=O) grp = condensation reaction
- ppt formed can be purified by recrystallisation; mp of ppt is measured & compared to literature values to find out which specific aldehyde / ketone.

NOTE : carb. acids & esters give -ve result.

2) FEHLING'S SOLUTION

- oxidising agent.
- alkaline solution containing Cu^{2+} ions = oxidising agent.

- positive result : clear blue solution → red ppt with aldehyde.
- aldehyde + Fehling's solution + heat = redox reaction
  - → aldehyde oxidised to carb. acid
  - → Cu^{2+} ions reduced to Cu^{+} ions
  - → opaque red ppt = copper (I) oxide (Cu_2O)
  - → in alkaline conditions, carb acid neutralised to carboxylate ion ($COOH$ loses proton to become COO^-)
  - → COO^- will form a salt w/ +ve metal ion. eg. $COO^- Na^+$

NOTE : ketones give -ve result ∵ can't be oxidised.

3) TOLLENS' REAGENT

- oxidising agent.
- aq. alkaline solution of silver nitrate in excess ammonia solution : ammoniacal silver nitrate solution.

- positive result : silver mirror with aldehyde.
- aldehyde + Tollen's reagent + heat = redox reaction
  - → aldehyde oxidised to carb. acid
  - → Ag^+ ions reduced to Ag atoms
  - → In alkaline conditions, carb. acid → carboxylete ion → salt.

4.) IODOFORM TEST

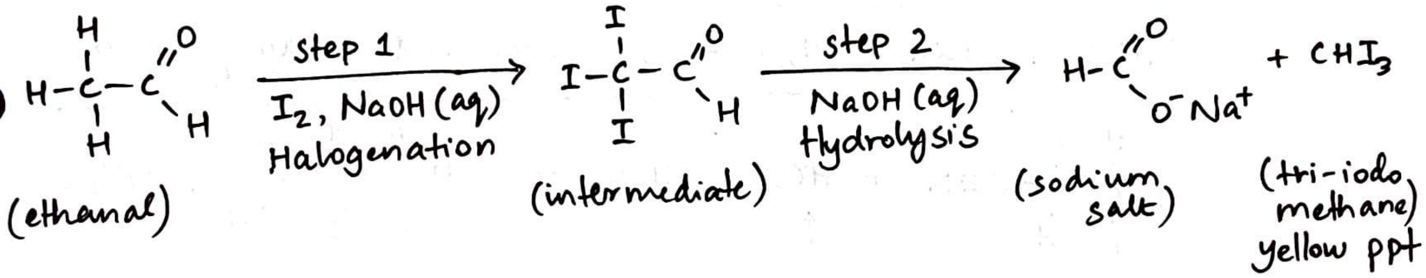
- positive result : yellow ppt w/ methyl ketones & ethanal

  compounds w/ CH_3CO- grp

reagent + alkaline solution of iodine + heat

step 1: halogenation (all 3 H atom in $-CH_3$ grp replaced with I atoms = $-CI_3$)

step 2: hydrolysis (intermediate compound hydrolysed by alkaline solution to form sodium salt + yellow ppt)



PRODUCTION OF CARBOXYLIC ACIDS

1) OXIDATION OF PRIMARY ALCOHOLS & ALDEHYDES

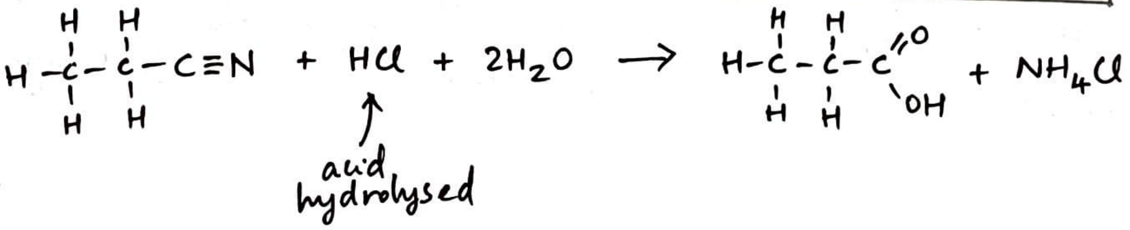
- oxidising agents: acidified $K_2Cr_2O_7$ / acidified $KMnO_4$
- reflux

primary alcohol $\xrightarrow{[O]}$ aldehyde $\xrightarrow{[O]}$ carb. acid

2) HYDROLYSIS OF NITRILES

a) using dilute acid

nitrile + acid + $H_2O \longrightarrow$ carb. acid + ammonium salt

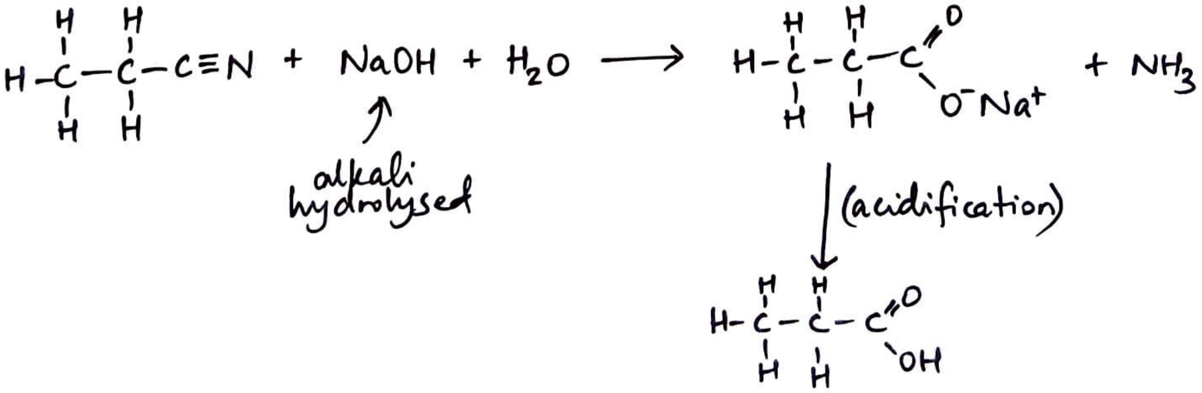


b) using dilute alkali + acidification

nitrile + alkali + $H_2O \longrightarrow$ sodium carboxylate salt + NH_3

$\downarrow$ acidification

carboxylic acid



3) HYDROLYSIS OF ESTERS

a) using dilute acid

ester + $H_2O \overset{H^+(aq)}{\rightleftharpoons}$ carb. acid + alcohol

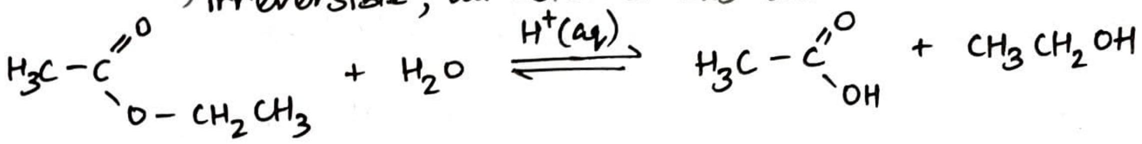
↳ reversible reaction where equilibrium established

b) using dilute alkali + acidification

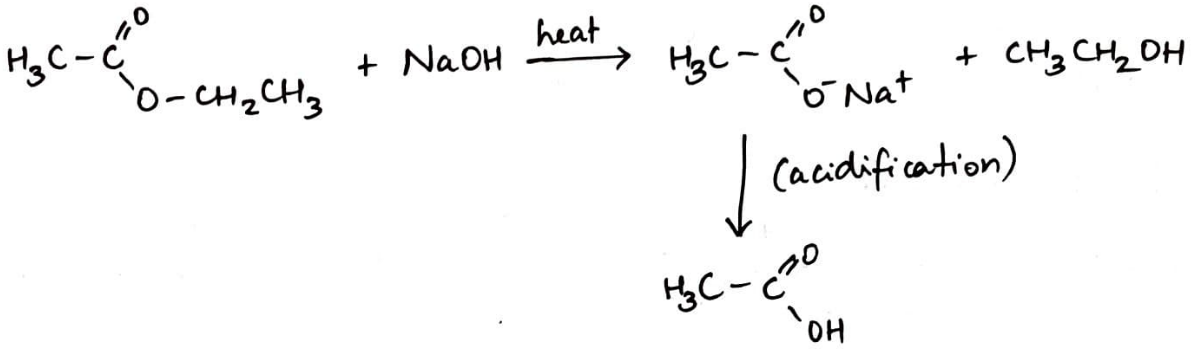
$$\text{ester} + \text{alkali} \xrightarrow{\text{heat}} \underset{\text{salt}}{\text{sodium carboxylate}} + \text{alcohol}$$

$$\text{sodium carboxylate salt} \xrightarrow{\text{(acidification)}} \text{carb. acid}$$

↳ irreversible ; all ester breaks down.



$$H_3C-COOCH_2CH_3 + H_2O \underset{}{\overset{H^+(aq)}{\rightleftharpoons}} H_3C-COOH + CH_3CH_2OH$$

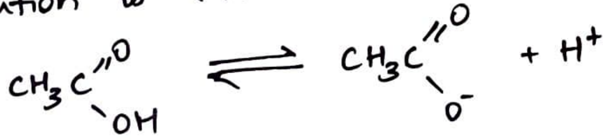


$$H_3C-COOCH_2CH_3 + NaOH \xrightarrow{\text{heat}} H_3C-COO^-Na^+ + CH_3CH_2OH$$

$$H_3C-COO^-Na^+ \xrightarrow{\text{(acidification)}} H_3C-COOH$$

REACTIONS OF CARBOXYLIC ACIDS

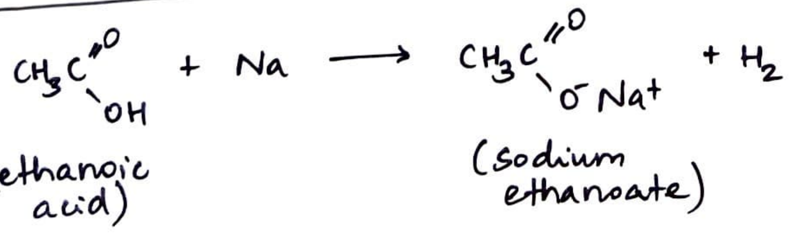
- → weak acids; don't completely dissociate in H_2O
- → position of equilibrium lies to left & H^+ conc. is much smaller than carb. acid conc.
- → pH of solution is <7.



$$CH_3COOH \rightleftharpoons CH_3COO^- + H^+$$

1) REDOX REACTIONS WITH REACTIVE METALS

$$\boxed{\text{carb. acid} + \text{metal} \longrightarrow \text{salt} + H_2}$$

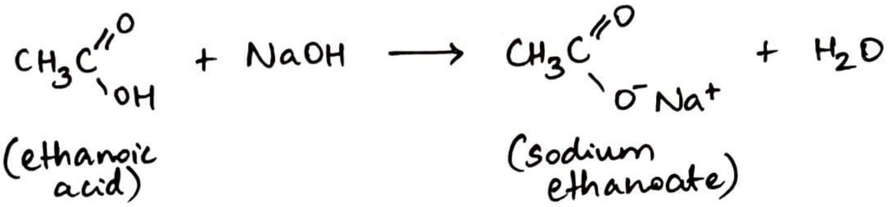


$$CH_3COOH + Na \longrightarrow CH_3COO^-Na^+ + H_2$$

(ethanoic acid) (sodium ethanoate)

2) NEUTRALISATION REACTIONS WITH ALKALIS

carb. acid + alkali → salt + water

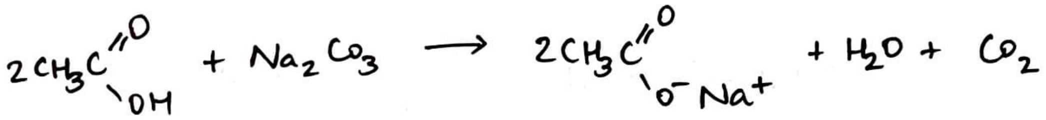


$$CH_3COOH + NaOH \longrightarrow CH_3COO^-Na^+ + H_2O$$

(ethanoic acid) (sodium ethanoate)

3) ACID-BASE REACTIONS WITH CARBONATES

carb. acid + metal carbonate → salt + H_2O + CO_2



$$2CH_3COOH + Na_2CO_3 \longrightarrow 2CH_3COO^-Na^+ + H_2O + CO_2$$

4) ESTERIFICATION

carb. acid + alcohol $\xrightarrow[\text{catalyst}]{H_2SO_4}$ ester + H_2O

catalyst: conc. H_2SO_4

5) REDUCTION

carb. acid + 4[H] → alcohol + H_2O

reducing agent : $LiAlH_4$ only

PRODUCTION OF ESTERS

1) ESTERIFICATION

REACTIONS OF ESTERS

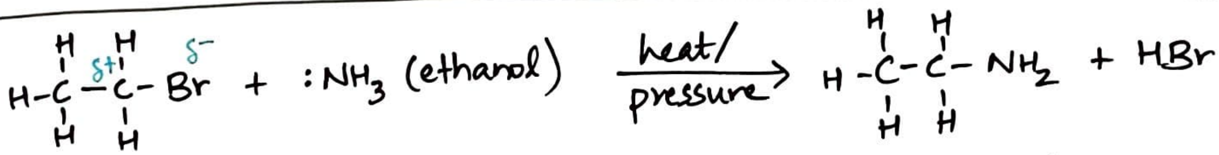
1) HYDROLYSIS

a) using dilute acid + heat under reflux (reversible)
b) using dilute alkali + heat under reflux (irreversible)

PRODUCTION OF AMINES

1) NUCLEOPHILIC SUBSTITUTION OF HALOGENOALKANES

$$\boxed{\text{halogenoalkane} + \text{ethanolic ammonia} \xrightarrow[\text{under pressure}]{\text{heat}} \text{amine} + \text{hydrogen halide}}$$



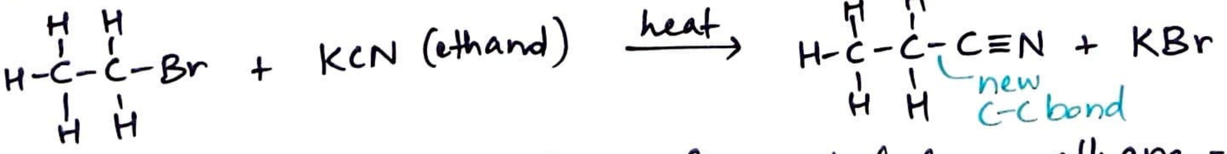
$$H-\overset{H}{\underset{H}{C}}-\overset{\delta+\ H}{\underset{H}{C}}-\overset{\delta-}{Br} + :NH_3 \text{ (ethanol)} \xrightarrow[\text{pressure}]{\text{heat/}} H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-NH_2 + HBr$$

- halogen atom more electronegative than C atom ∴ draws e⁻ density. $C = \delta^+$ & $X = \delta^-$ charge
- lone pair of e⁻ on N in NH_3 = nucleophile ; it attacks δ^+ C.
- C-X bond broken & halogen substituted by $-NH_2$ grp.

PRODUCTION OF NITRILES

1) NUCLEOPHILIC SUBSTITUTION OF HALOGENOALKANES

$$\boxed{\text{halogenoalkane} + \text{KCN (ethanol)} \xrightarrow[\text{under reflux}]{\text{heat}} \text{nitrile} + \text{hydrogen halide}}$$



$$H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-Br + \text{KCN (ethanol)} \xrightarrow{\text{heat}} H-\overset{H}{\underset{H}{C}}-\overset{H}{\underset{H}{C}}-C\equiv N + KBr$$

new C-C bond

* KCN(ethanol) heated under reflux w/ halogenoalkane = nitrile
KCN (aq) heated under reflux w/ halogenoalkane = alcohol

PRODUCTION OF HYDROXYNITRILES :

1) NUCLEOPHILIC ADDITION OF ALDEHYDES & KETONES :

REACTIONS OF NITRILES

1) HYDROLYSIS
   - a) using dil. acid
   - b) using dil. alkali + acidification

NOTE : formation of nitriles adds an extra C atom; hydrolysis of nitriles doesn't change no. of C atoms.