NCERT MIND MAP FOR 12TH BOARDS

- Subject - Chemistry
- Chapter – Alcohols, Phenols & Ethers

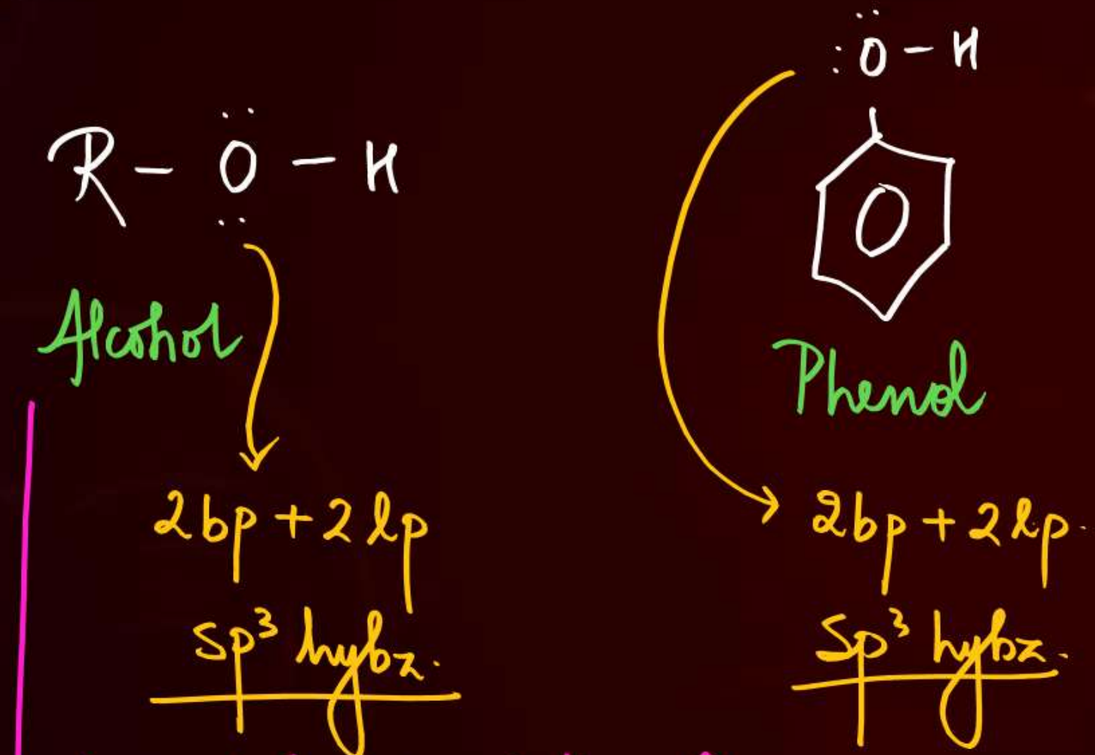
(One Shot)

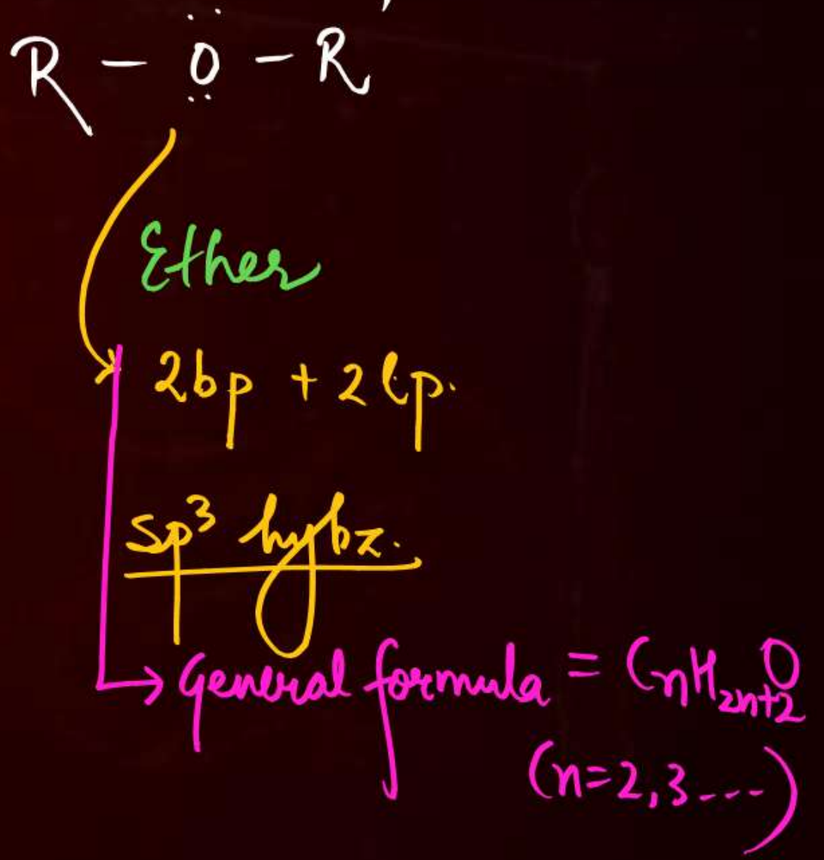
By- Ashima Gupta Ma'am

Today's Targets

1. Classification, Nomenclature
2. MOP of Alcohols & Phenols
3. Physical Properties
4. Chemical Properties
5. Ethers

Introduction





Classification

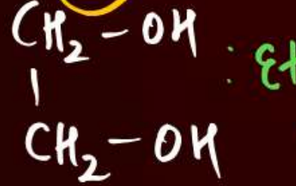
(1) On the basis of no. of -OH groups :

Monohydric

e.g. CH_3-OH

C_2H_5-OH

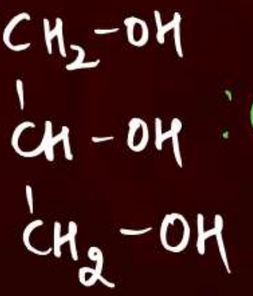
Dihydric



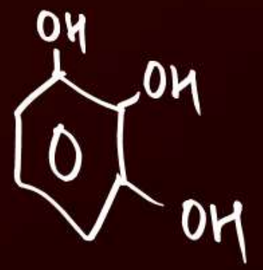
: Ethylene glycol

: Catechol

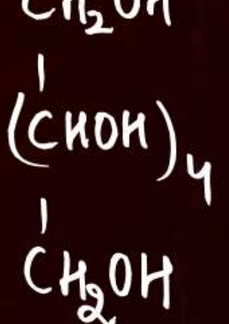
Trihydric



: Glycerol



Polyhydric



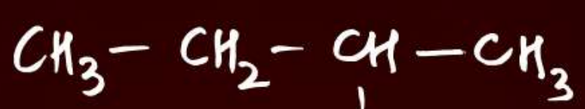
Sorbitol or Mannitol

(2) On the basis of $Csp^3 - OH$:

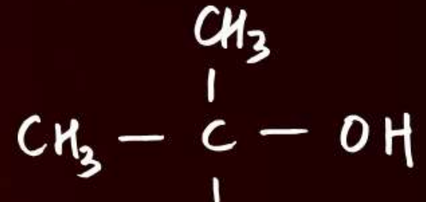
(a) 1°, 2° & 3° alcohols :

$C_4H_{10}O$:

(1° alcohol)

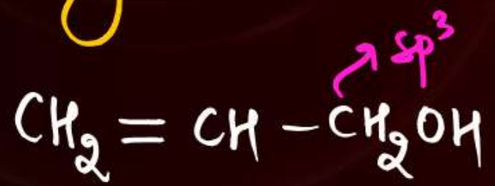


(2° alcohol)

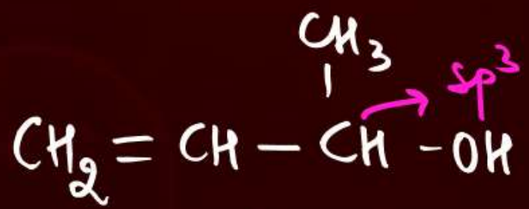


(3° alcohol)

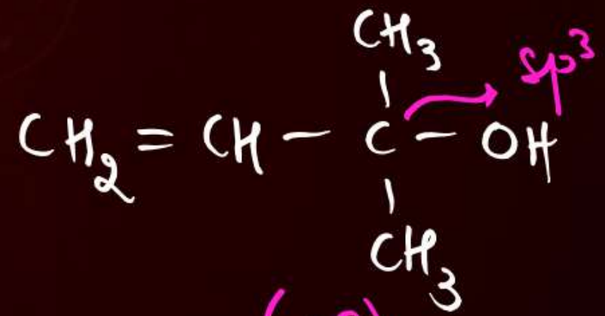
(b) Allylic alcohols :



(1°)



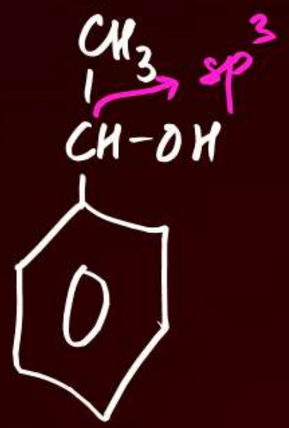
(2°)



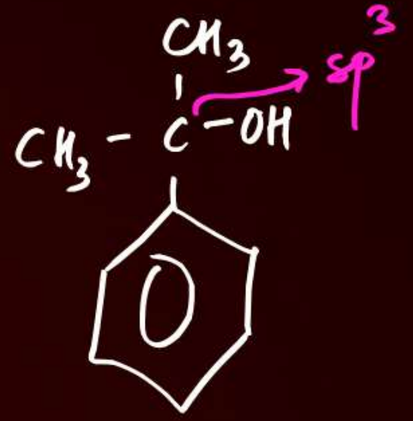
(3°)

(c) Benzylic alcohols :

(1°)



(2°)



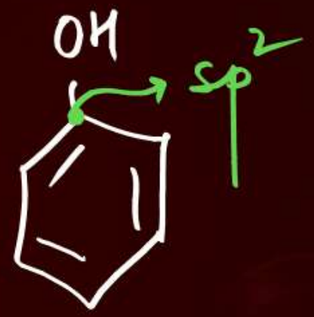
(3°)

(3) On the basis of C_{sp^2}-OH :

Vinyl alcohol

$CH_2 = \underset{\displaystyle OH}{\overset{\displaystyle \overset{\displaystyle sp^2}{\downarrow}}{CH}}$

Phenol



Ethers

$R-O-R'$ (where $R, R' \neq H$)

Simple / Symmetrical Ether

CH_3-O-CH_3

$C_2H_5-O-C_2H_5$

Mixed / Unsymmetrical Ether

$CH_3-O-C_2H_5$

Nomenclature

1. Alcohols : [2° Suffix : -ol]

Common Name : Alkyl alcohol

IUPAC Name : Alkanol

(i) $\overset{1}{C}H_3-OH$

Methanol (Methyl alcohol)

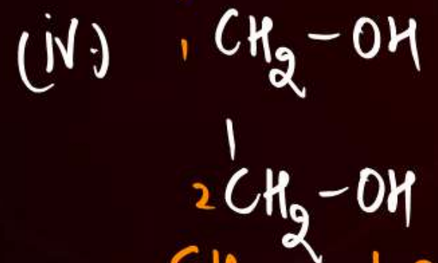
(ii) $\overset{3}{C}H_3-\overset{2}{C}H_2-\overset{1}{C}H_2OH$

Propanol (n-Propyl alcohol)

(iii) $\overset{1}{C}H_3-\overset{2}{C}H(\overset{3}{C}H_3)-OH$

Propan-2-ol (Isopropyl alcohol)

(iv)

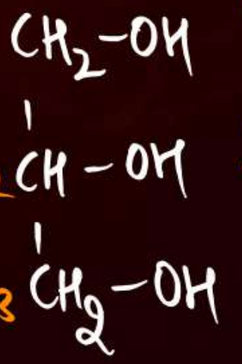


Ethane-1,2-diol

(v)

Cyclopentanol

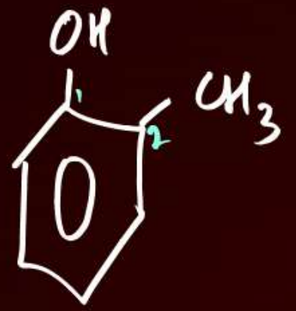
(vi)



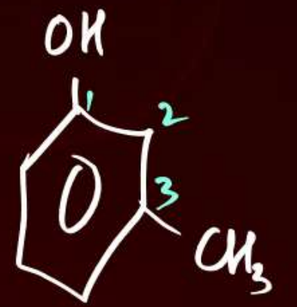
: Propane-1,2,3-triol

2. Phenols :

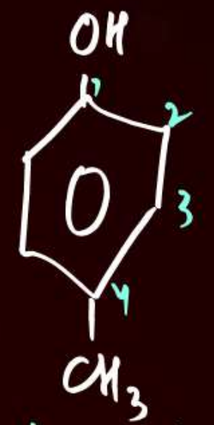
Phenol
(Carbolic acid)



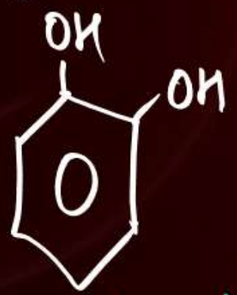
2-Methylphenol
(o-Cresol)



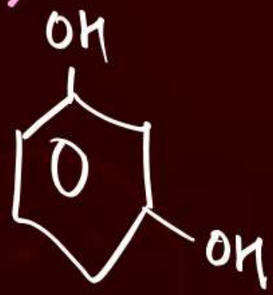
3-Methylphenol
(m-Cresol)



4-Methylphenol
(p-Cresol)



Benzene-1,2-diol
(Catechol)



Benzene-1,3-diol
(Resorcinol)

Benzene-1,4-diol
(Quinol)

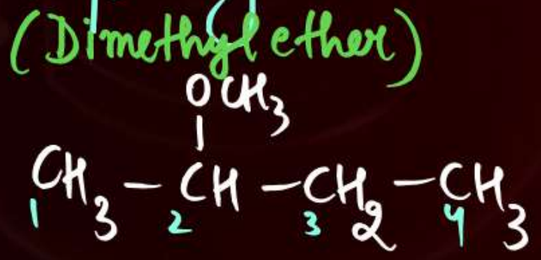
3. Ethers :

Common Name : Alkyl ether

IUPAC Name : Alkoxyalkane

$CH_3 - O - CH_3$

Methoxymethane
(Dimethyl ether)

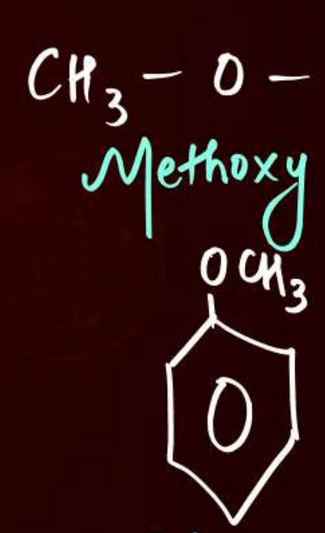


2- Methoxybutane

$C_2H_5 - O - C_2H_5$

Ethoxyethane
(Diethyl ether)

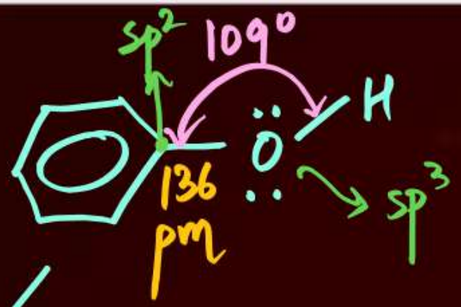
1-Methoxycyclobutane



Methoxybenzene
(Anisole)

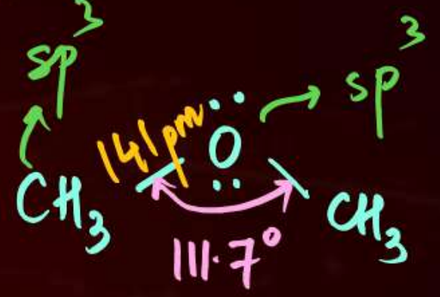
Methoxy ethane
(Ethyl methyl ether)

Structure of Functional Group



→ Due to l·p – l·p & l·p – b·p repulsion; bond angle is slightly less than Td angle

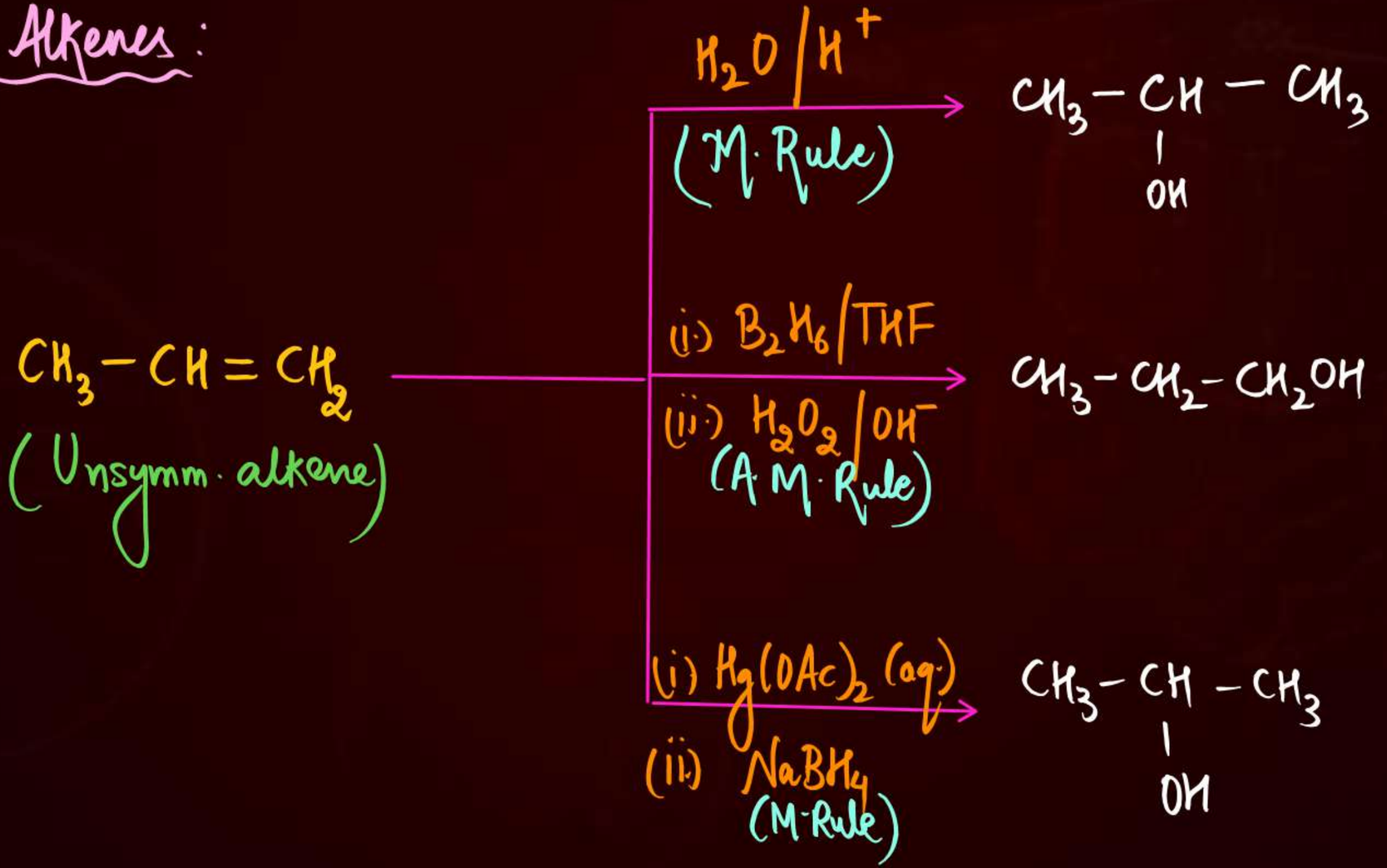
→ ★ In phenol; due to resonance, C – O bond acquires partial double bond character & ∴ bond length ↓ses.



★ In ethers; bond angle is always more than Td angle bcz of repulsion b/w two bulky alkyl groups.

MOP of Alcohols

1. From Alkenes :



↳ Rearrangement is possible

{ Acid-catalysed hydration of alkene }

{ Hydroboration – oxidn } → No Rearrangement

{ Oxymercuration – Demercuryn } → No Rearrangement

(2) $R-X + aq.\ KOH \longrightarrow R-OH + KX$

(3) $>C=O \xrightarrow[LiAlH_4 \text{ or } NaBH_4]{H_2/Pd \text{ or}} >CH-OH$ {Red^n of aldehydes & ketones}

e.g. $CH_3-\overset{O}{\overset{\|}{C}}-H \xrightarrow{LiAlH_4} CH_3-CH_2-OH$

Ethanal → Ethanol (1°)

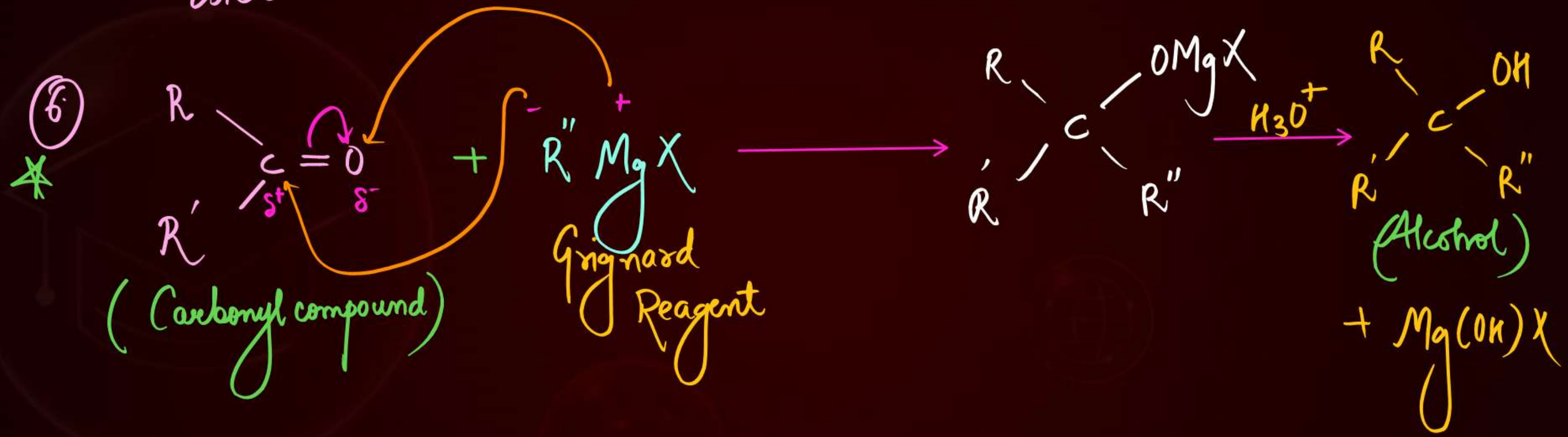
$CH_3-\overset{O}{\overset{\|}{C}}-CH_3 \xrightarrow{NaBH_4} CH_3-\underset{OH}{\underset{|}{CH}}-CH_3$

Propanone → Propan-2-ol (2°)

(4) $R-COOH \xrightarrow[H_2O]{LiAlH_4} R-CH_2OH$ [Red^n]

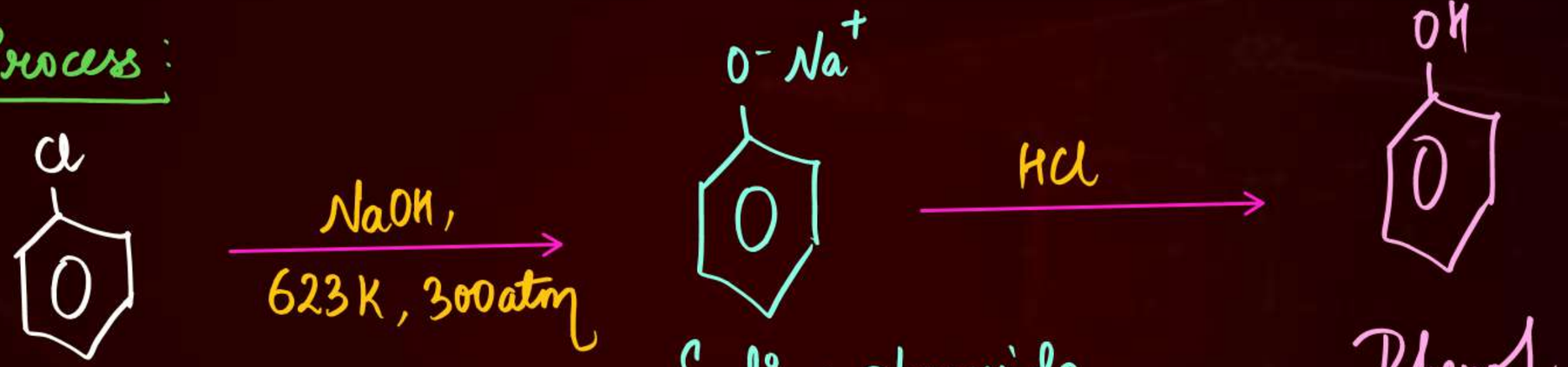
Carboxylic acid → (1° alcohol)

(5) $R-\overset{O}{\overset{\|}{C}}-OR'$ (Ester) $\xrightarrow[LiAlH_4]{H_2 \,/\, Pd \text{ or }}$ $RCH_2OH + R'OH$

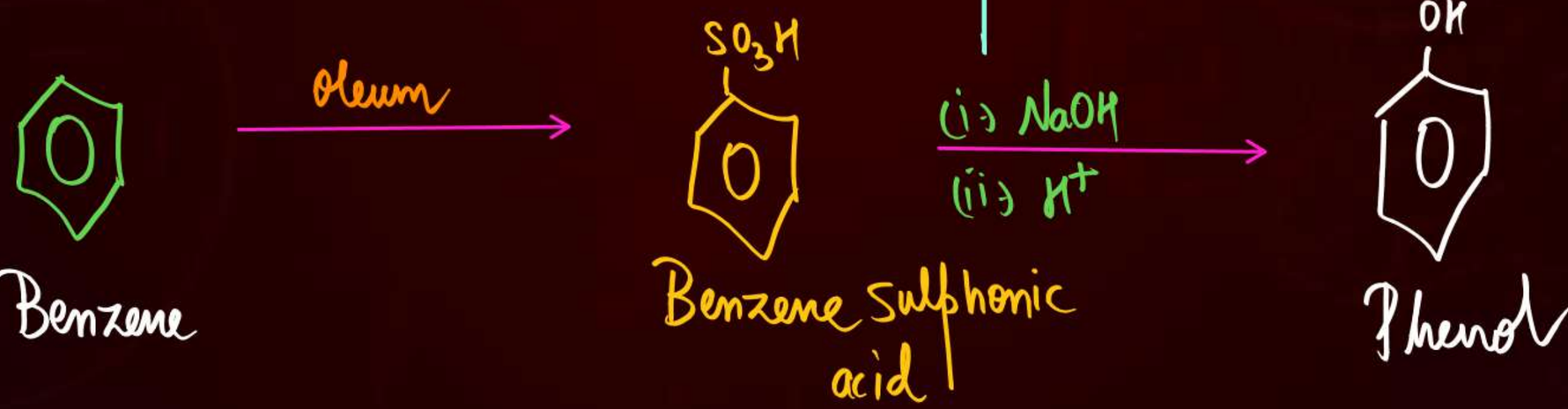
(6) 

MOP of Phenols

1. Dow's Process :



2.



(3)

Aniline

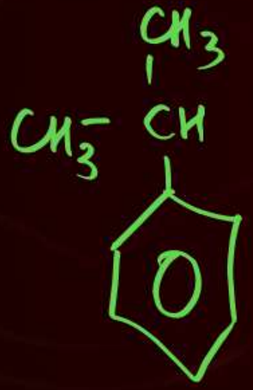
$NaNO_2 + HCl$ (0-5°C)

Benzene diazonium chloride

Warm H_2O

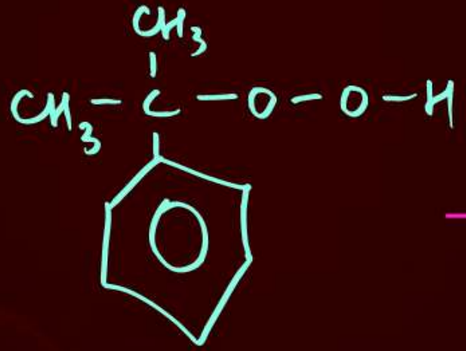
Phenol

(4) Imp.



Cumene

O_2



Cumene hydroperoxide

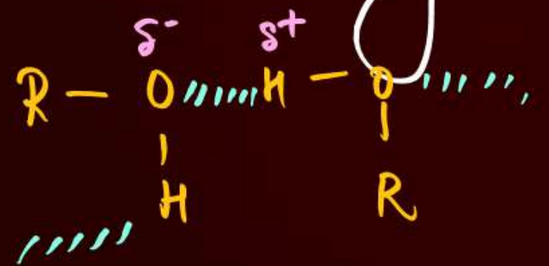
H_2O / H^+

Phenol + CH_3COCH_3

Acetone or Propanone

Physical Properties

⇒ Alcohols : have higher B.Pt. than other class of compounds (except carboxylic acids) of similar mol. mass due to presence of intermol. H-bonding.

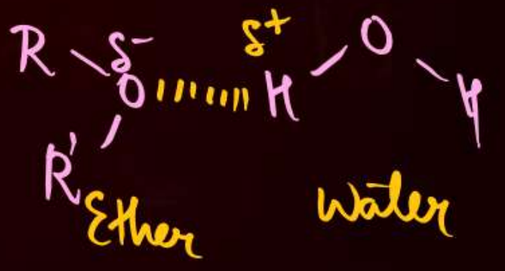


B.Pt. ∝ Mol. mass

B.Pt ∝ $\frac{1}{\text{Branching}}$

⇒ Alcohols, phenols & ethers : soluble in water

↳ show intermol. H-bonding with water.



Alcohols :

CH_3-OH

C_2H_5-OH

C_3H_7-OH

C_4H_9-OH

⋮

no. of C atoms ↑

Hydrophobic part ↑

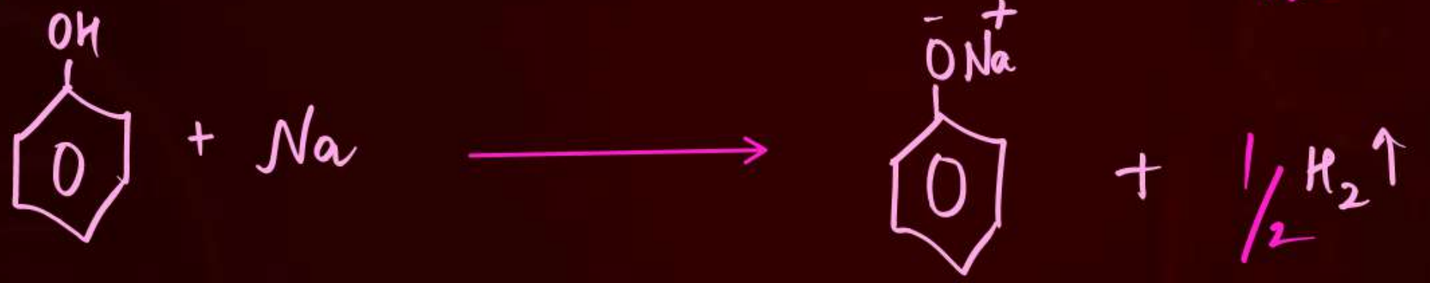
Solubility in water ↓se

Chemical Properties of Alcohols

- Reaction involving cleavage of O - H bond:

1. Acidity of alcohols & phenols

$$C_2H_5OH + Na \longrightarrow C_2H_5O^-Na^+ + \frac{1}{2}H_2\uparrow$$



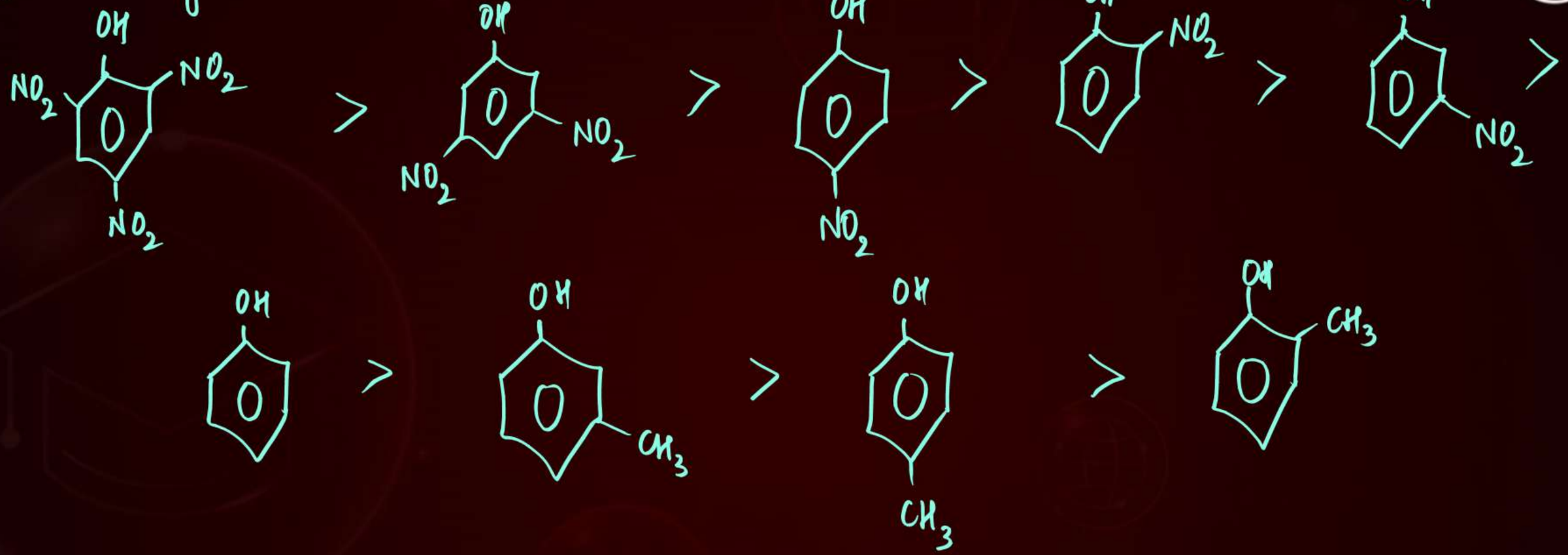
Acidic strength $\propto \frac{-I \text{ effect}}{+I \text{ effect}}$

$$\frac{1}{pKa} \propto \text{Acidic strength} \propto Ka$$

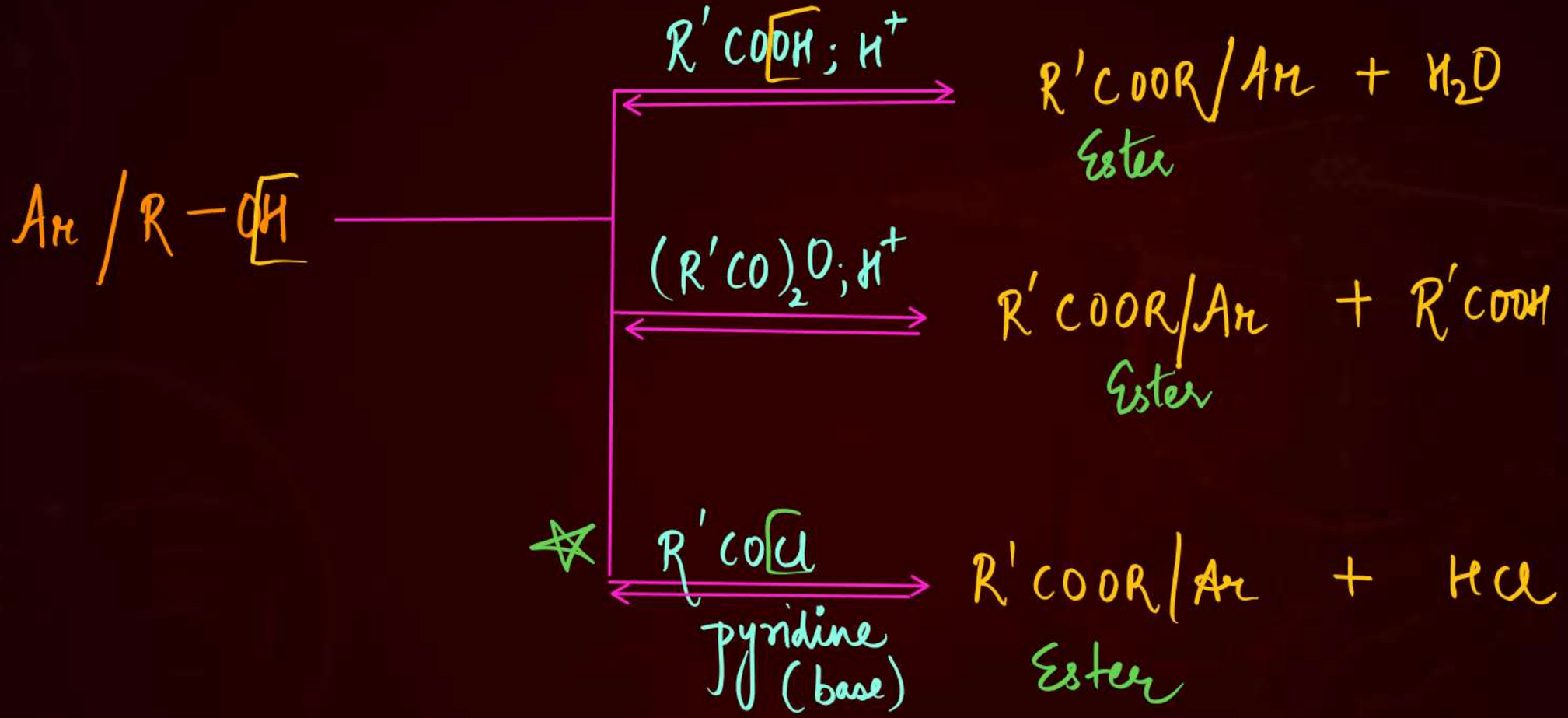
Acidic strength :

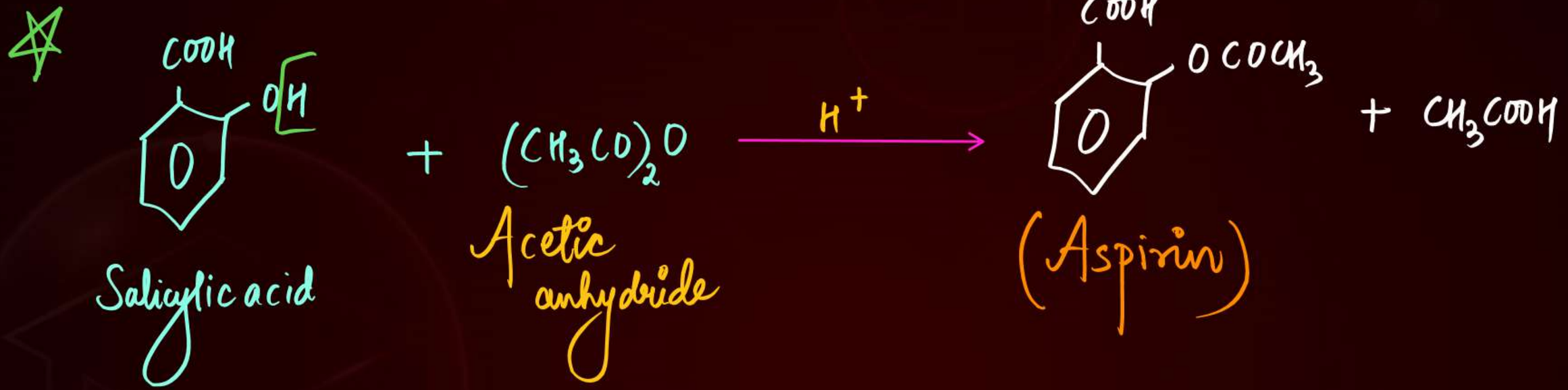
(1.) Phenols > CH_3OH > Water > Other alcohols

Acidic Strength:



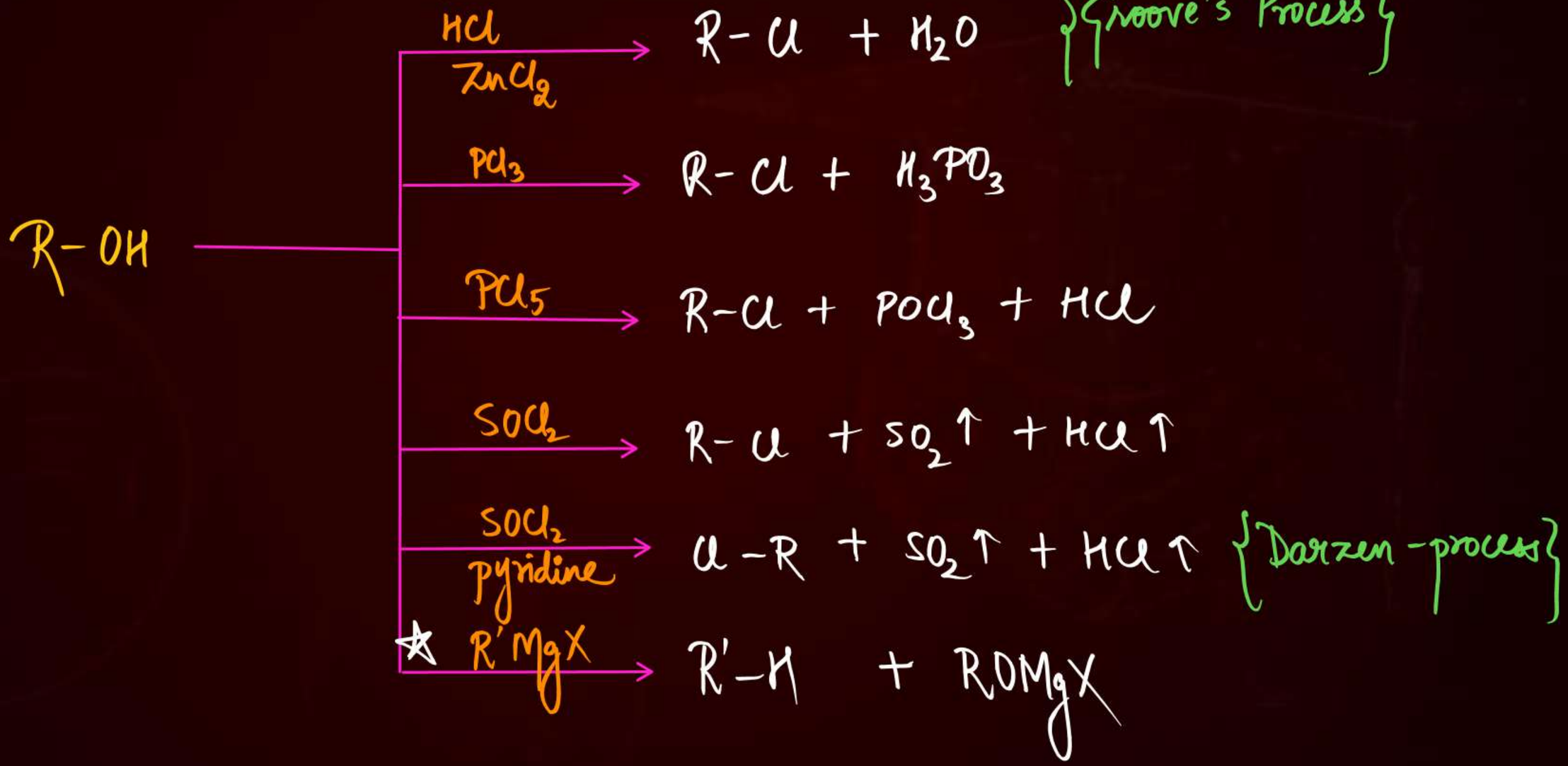
2. Esterification




COOH
OH
O
Salicylic acid
+
$(CH_3CO)_2O$
Acetic anhydride
H^+
COOH
$OCOCH_3$
O
(Aspirin)
+
CH_3COOH

- **Reaction involving cleavage of C - O bond in alcohols:**

(a) Reaction with HX, PCl_3, PCl_5 & $SOCl_2$



(b) Dehydration

$$\overset{\beta}{CH_3}-\overset{\alpha}{CH_2}-OH \xrightarrow[443K]{\text{Conc. } H_2SO_4} CH_2=CH_2 + H_2O$$

Ethene

$$CH_3-\overset{\beta}{CH_2}-\underset{\underset{OH}{|}}{\overset{\alpha}{CH}}-\overset{\beta}{CH_3} \xrightarrow[\Delta]{H^+} \underset{\text{But-1-ene}}{CH_3-CH_2-CH=CH_2} + \underset{\text{But-2-ene (Major)}}{CH_3-CH=CH-CH_3}$$

☆ Relative ease of dehydration of alcohols : $3^\circ > 2^\circ > 1^\circ$

(c) Oxidation

$$R-CH_2OH \xrightarrow{[O]} R-CHO \xrightarrow{[O]} R-COOH$$

1° alcohol → Aldehyde → Carboxylic acid

[O] strong O.A.

1° alcohol $\xrightarrow[\text{mild O.A.}]{[O]}$ Aldehyde

↳ PCC | PDC | Collins Reagent

Strong O.A. : HNO_3 ; $KMnO_4/H^+$; (i) $KMnO_4/OH^-$ (ii) H^+ ; $K_2Cr_2O_7/H^+$

$$R-\underset{\underset{OH}{|}}{CH}-R' \xrightarrow[\text{mild O.A. or strong O.A.}]{[O]} R-\overset{\overset{O}{||}}{C}-R'$$

(2° alcohols) → (Ketone) → tough to oxidise further

→ undergo oxd^n in drastic conditions

3° alcohols → don't undergo oxd^n

$\Rightarrow$ $R-CH_2OH$ (1°) $\xrightarrow[573\,K]{Cu}$ $R-CHO$ (Aldehyde)

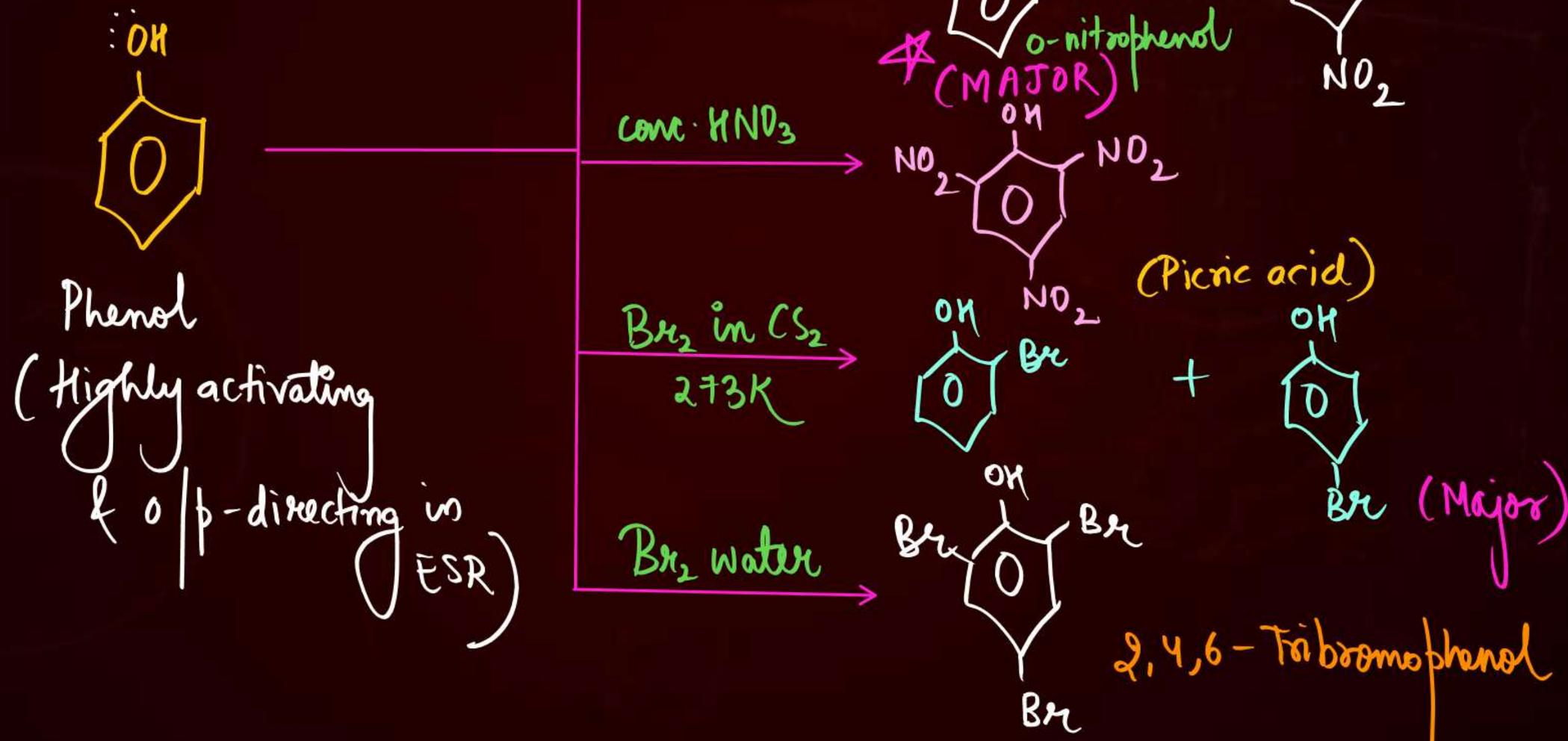
$\Rightarrow$ $R-\underset{\underset{OH}{|}}{CH}-R'$ (2°) $\xrightarrow[573\,K]{Cu}$ $R-\underset{\underset{O}{||}}{C}-R'$ (Ketone)

$\Rightarrow$ ★ $(CH_3)_3C-OH$ (3°) $\xrightarrow[573\,K]{Cu}$ $CH_3-\underset{\underset{CH_3}{|}}{C}=CH_2$ (2-Methylpropene) $+ H_2O$

Dehydrogenation (removal of H_2)

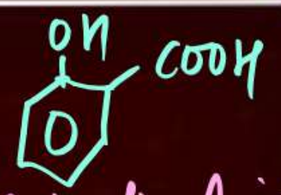
{Dehydration}

Chemical Properties of Phenols



Chemical Properties of Phenols

(i) NaOH
(ii) CO_2, H^+



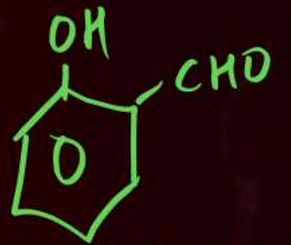
Salicylic Acid

★ {Kolbe's Rxn}

$CHCl_3$, NaOH

★ Riemer - Tiemann Rxn

H_2O/H^+



Salicylaldehyde

Zn dust
[Redⁿ]

→ Benzene

$Na_2Cr_2O_7 + H_2SO_4$
or
H_2CrO_4

Benzoquinone

Some Commercially Important Alcohols

① Methanol (Wood spirit)

$$CO + 2H_2 \xrightarrow[573-673K,\ 200-300 atm]{ZnO-Cr_2O_3} CH_3OH$$

Methanol

→ highly poisonous.

② Ethanol : C_2H_5OH

$$C_{12}H_{22}O_{11} + H_2O \xrightarrow{Invertase} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

Sucrose

$$C_6H_{12}O_6 \xrightarrow{Zymase} 2C_2H_5OH + 2CO_2\uparrow$$

Ethanol

→ Absolute alcohol

→ Rectified spirit

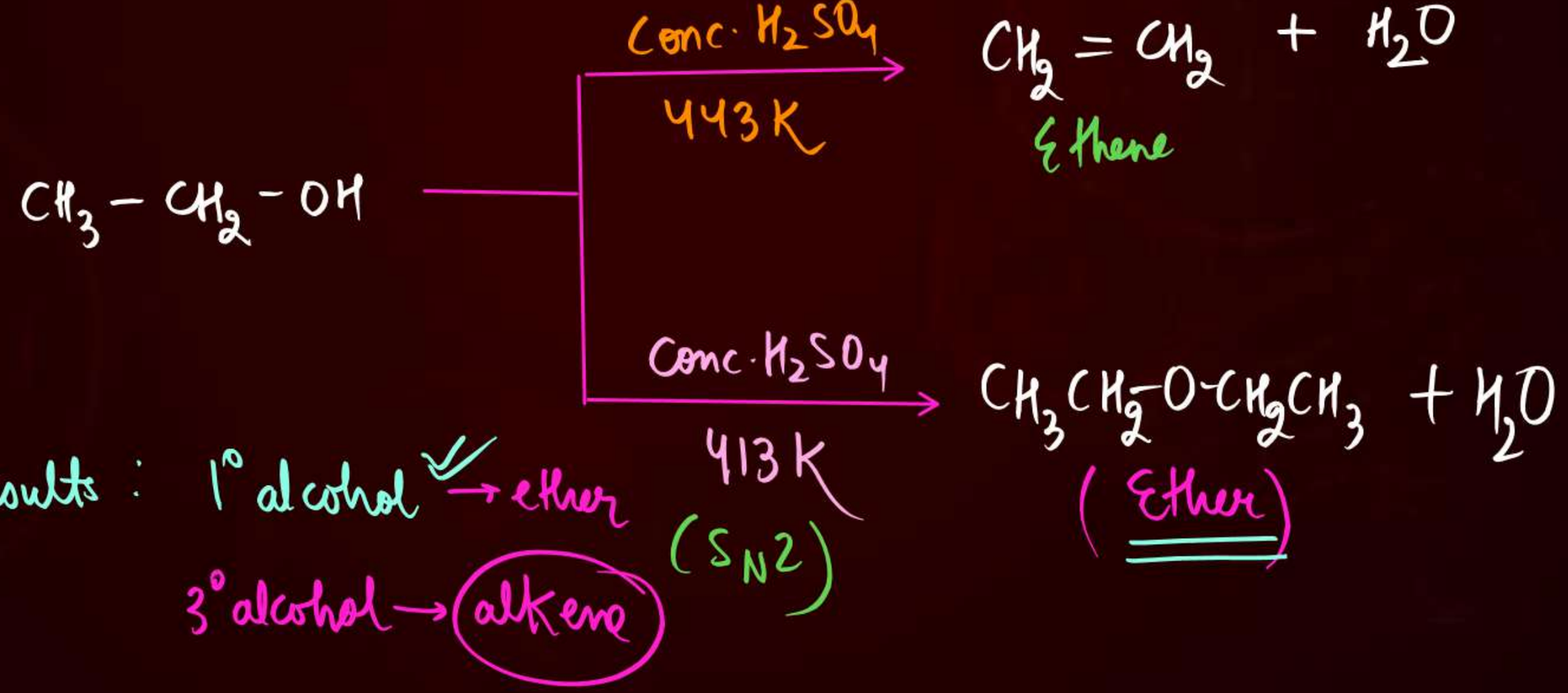
→ Power Alcohol

→ Denatured alcohol : Ethanol + Methanol

Ethers

Preparation

1. By dehydration of alcohols



2. Williamson synthesis

$$\overset{\delta+}{R}-\overset{\delta-}{X} + R'\bar{O}Na^{+} \xrightarrow{S_N2} R'-O-R + NaX$$

Alkyl halide — Sodium alkoxide — Ether

↳ better results are obtained when alkyl halide → 1°

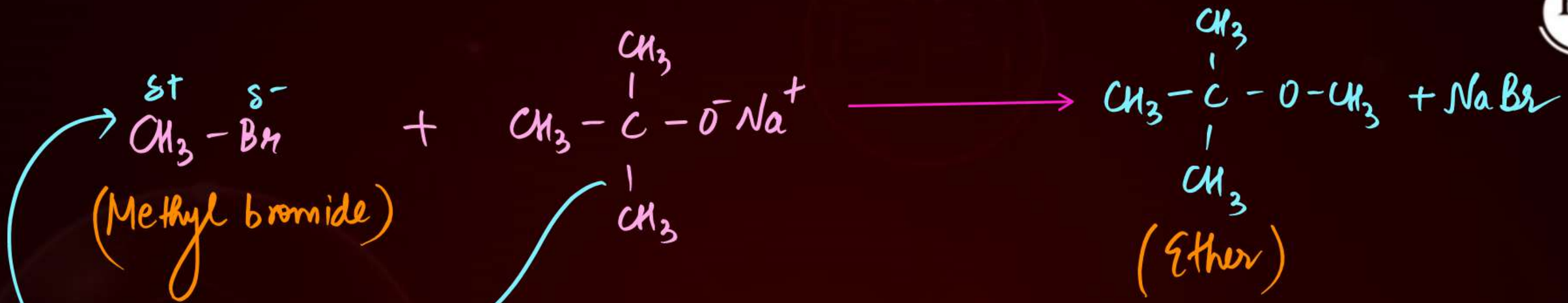
3° alkyl halide → elimⁿ

★ Q.

$$CH_3-\underset{\alpha}{\overset{\beta CH_3}{C}}(CH_3)-Br + CH_3\bar{O}Na^{+} \longrightarrow CH_3-\overset{CH_2}{\overset{\|}{C}}-CH_3 + CH_3OH + NaBr$$

(3° alkyl halide)

2-Methylpropene (Alkene)


δ+ δ−
CH3 − Br
(Methyl bromide)
+
CH3
CH3 − C − O⁻ Na⁺
CH3
CH3
CH3 − C − O − CH3
CH3
+ NaBr
(Ether)

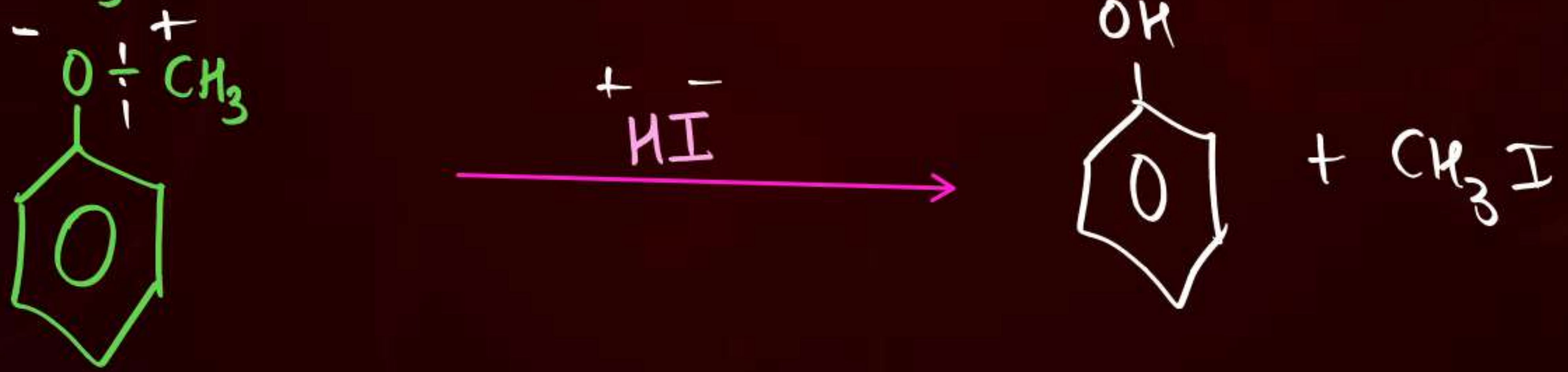
Chemical Properties

1. Cleavage of C–O bond in ethers

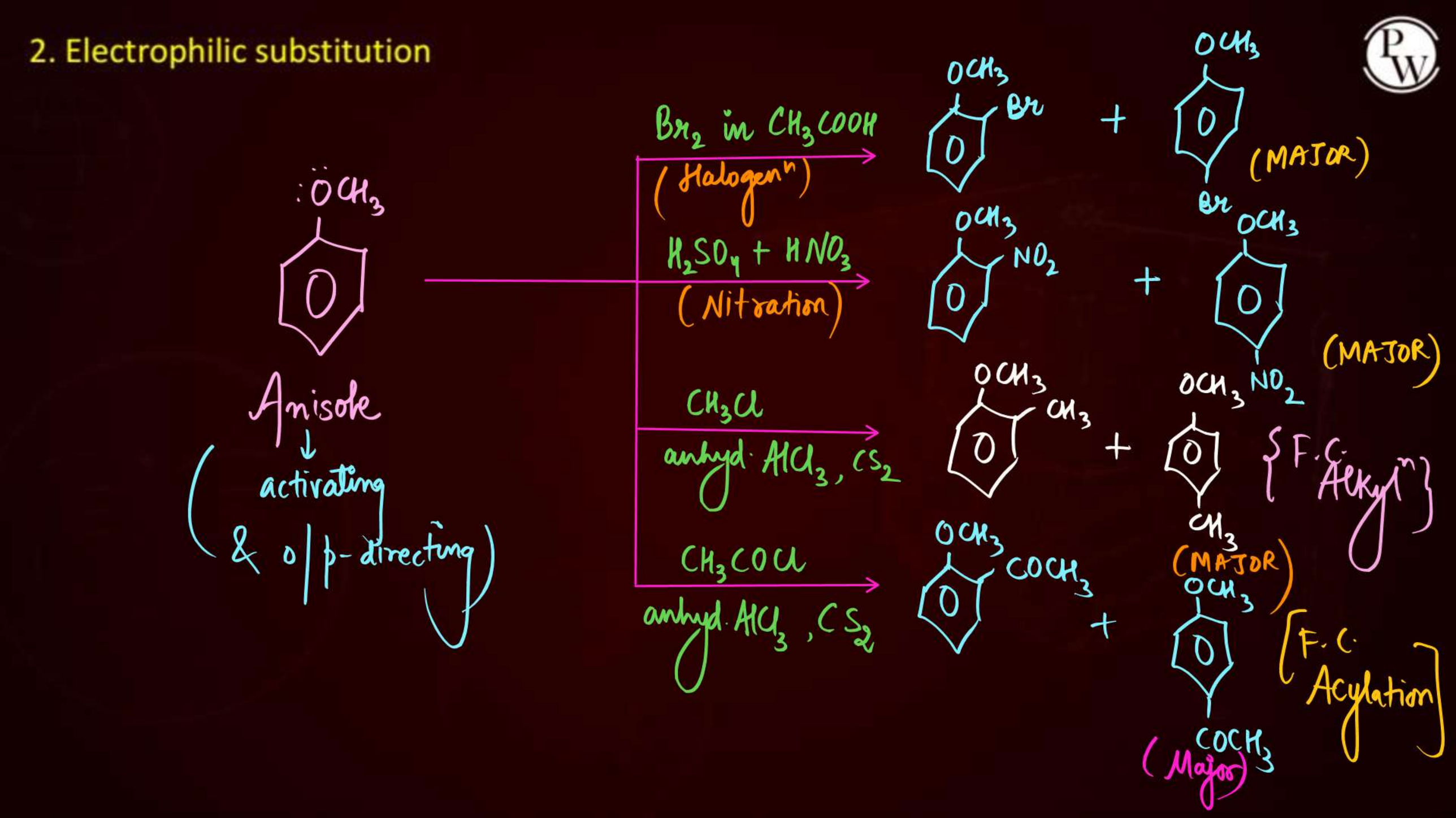
(i) $\overset{+}{C}H_3 \,\vdots\, \overset{-}{O}-CH_2-CH_3 \xrightarrow[(S_N2)]{\overset{+}{H}\overset{-}{I}} CH_3I + CH_3CH_2OH \xrightarrow{HI\,(excess)} C_2H_5I + H_2O$

(ii) $CH_3-\underset{CH_3}{\overset{CH_3}{|}}{\overset{+}{C}} \,\vdots\, \overset{-}{O}-CH_3 \xrightarrow[(S_N1)]{\overset{+}{H}\overset{-}{I}} CH_3-\underset{CH_3}{\overset{CH_3}{|}}{C}-I + CH_3OH$

(iii)



2. Electrophilic substitution



THANK YOU