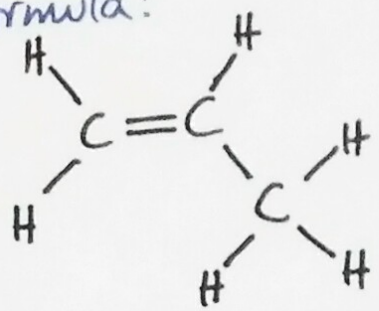
Organic Chemistry

Representation

① Empirical Formula: ratio; CH_2
② Molecular Formula: numbers; C_3H_6
③ Structural Formula: $CH_3HC=CH_2$
④ Displayed formula:



⑤ Skeletal Formula:

Stereoisomerism

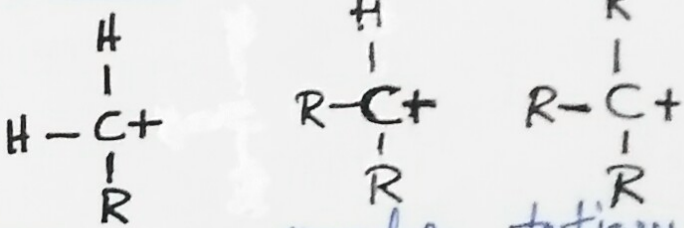
① Cis-trans isomerism.
- C=C: no free rotation
- C must be attached to two different groups.

② Optical isomerism.
- chiral centre must be attached to 4 different groups
- Optical isomer with its mirror image.

Structural isomerism

① Position isomerism: change in position of functional group
② Functional isomerism: same molecular formula but different functional groups.
(acid + ester; alcohol + ether; aldehyde + ketone)
③ Chain isomerism: difference in skeleton or the way the carbons are placed.

Electrophile: accepts a pair of electrons.



Primary secondary tertiary

Nucleophile: donator of a pair of electrons.

Oxidation: Alcohol + Cr_2O_7/H^+
$1^\circ \rightarrow$ Aldehyde $\rightarrow$ Carboxylic acid.
$2^\circ \rightarrow$ Ketone

Free radical substitution: alkane + X_2
Electrophilic addition: alkene C=C
Nucleophilic substitution: Halogenoalkane + $OH^-/CN^-/NH_3$
Nucleophilic addition: aldehyde/ketone + HCN $\rightarrow$ nitrile.
Oxidation: MnO_4^- / H^+ (hot) + Alkene $1^\circ \rightarrow CO_2$
$2^\circ \rightarrow$ Aldehyde $\rightarrow$ Carboxylic acid
$3^\circ \rightarrow$ Ketone.
Cold $\rightarrow$ diol

Alkane

* Substitution (Free Radical)

$$Cl_2 \xrightarrow{\text{UV light}} 2Cl\cdot$$

$$CH_4 + Cl\cdot \longrightarrow \cdot CH_3 + HCl$$
$$\cdot CH_3 + Cl_2 \longrightarrow CH_3Cl + Cl\cdot$$

$$\cdot CH_3 + Cl\cdot \rightarrow CH_3Cl$$
$$\cdot CH_3 + \cdot CH_3 \rightarrow C_2H_6$$
$$\cdot Cl + \cdot Cl \rightarrow Cl_2$$

* Alkene C=C

Addition of $H_{2(g)}$ Catalyst: Nickel; 140°C

$$CH_2=CH_2 + H_2 \rightarrow CH_3CH_3$$

Addition of $H_2O_{(g)}$ H_3PO_4; 330°C; 6MPa

$$CH_2=CH_2 + H_2O \rightarrow CH_3CH_2OH$$

Addition of $HX_{(aq)}$ room temp.

$$CH_2=CH_2 + HBr \rightarrow CH_3CH_2Br$$

Addition of $X_{2(aq)}$ rtp.

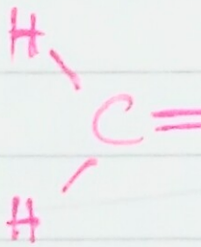
$$CH_2=CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$$

Oxidation

Cold MnO_4^{2+}/H^+ Purple → colourless

$$CH_2=CH_2 + H_2O + [O] \rightarrow CH_2(OH)CH_2OH$$

Hot MnO_4^{2+}/H^+

1°  $\rightarrow CO_2$

2° $=CRH \rightarrow R\text{-}COOH$ acid *

3° $=CR_1R_2 \rightarrow R_1R_2C=O$ ketone

Halogenoalkanes

Nucleophilic substitution (under reflux)

OH^- → alcohol $-OH$
CN^- → nitrile $-C\equiv N$
NH_3 → amine $-NH_2$

Alcohols

alcohol + hydrogen halide → halogenoalkane + water

$C_2H_5OH + Na \rightarrow C_2H_5O^-Na^+ + H_2$
sodium ethoxide

* Esterification Conc. H_2SO_4 ; under reflux

ethanol + ethanoic acid ⇌ ethyl ethanoate + water

* Hydrolysis of Esters.

ester + water $\overset{H^+}{\rightleftharpoons}$ carboxylic acid + alcohol.

ester + alkali → salt of acid + alcohol

$H_3C-COO-CH_3 + NaOH \rightarrow H_3COO^-Na^+ + CH_3OH$

* Dehydration Catalyst: Al_2O_3 or conc. H_2SO_4

alcohol$_{(g)}$ $\xrightarrow{\text{hot catalyst}}$ alkene + water

* Oxidation $Cr_2O_7^{2-}/H^+_{(aq)}$ (orange → green)

1° $CH_3CH_2OH + [O] \rightarrow H_3C-\overset{\overset{O}{\|}}{C}-OH + H_2O$

2° $CH_3CH(OH)CH_3 + [O] \rightarrow H_3C-\overset{\overset{O}{\|}}{C}-CH_3 + H_2O$

3° $CH_3\underset{\underset{CH_3}{|}}{C}(OH)CH_3 + [O] \rightarrow$ no reaction

Carboxylic acids

nitrile + HCl + H_2O $\xrightarrow{\text{(under reflux)}}$ carboxylic acid + NH_4Cl

acid + alkali → salt + water

acid + metal → salt + hydrogen.

acid + carbonate → salt + water + CO_2

*Reduction: $LiAlH_4$ or $NaBH_4$

acid + [H] → ethanol + water.

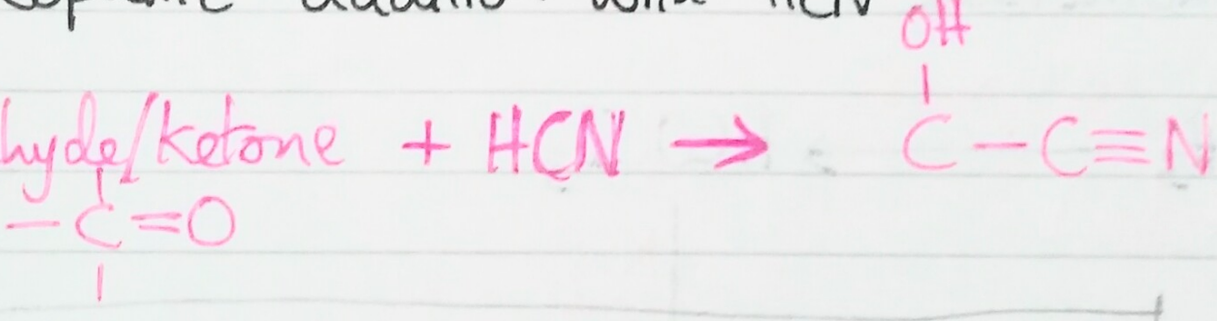
Aldehyde & Ketone

* Preparation: (Oxidation of alcohols) $Cr_2O_7^{2-}/H^+$

1° alcohol + [O] → aldehyde + water
2° alcohol + [O] → ketone + water

* Reduction to alcohols $NaBH_4$ or $LiAlH_4$ (in dry ether)

* Nucleophilic addition with HCN



$-CN + H^+ + H_2O \rightarrow -COOH + NH_4^+$
$-CN + 4[H] \rightarrow -CH_2NH_2$

* Testing with 2,4-DNPH

aldehyde/ketone: deep orange colour.
(condensation reaction)

* Testing with Tollens' reagent
  * Aldehyde + silver nitrate in ammonia → deposit of Ag atoms
  * No reaction with ketone

* Testing with Fehling's solution
  * Aldehyde + Cu^{2+} ions → opaque red/orange colour
  * Ketone → no reaction

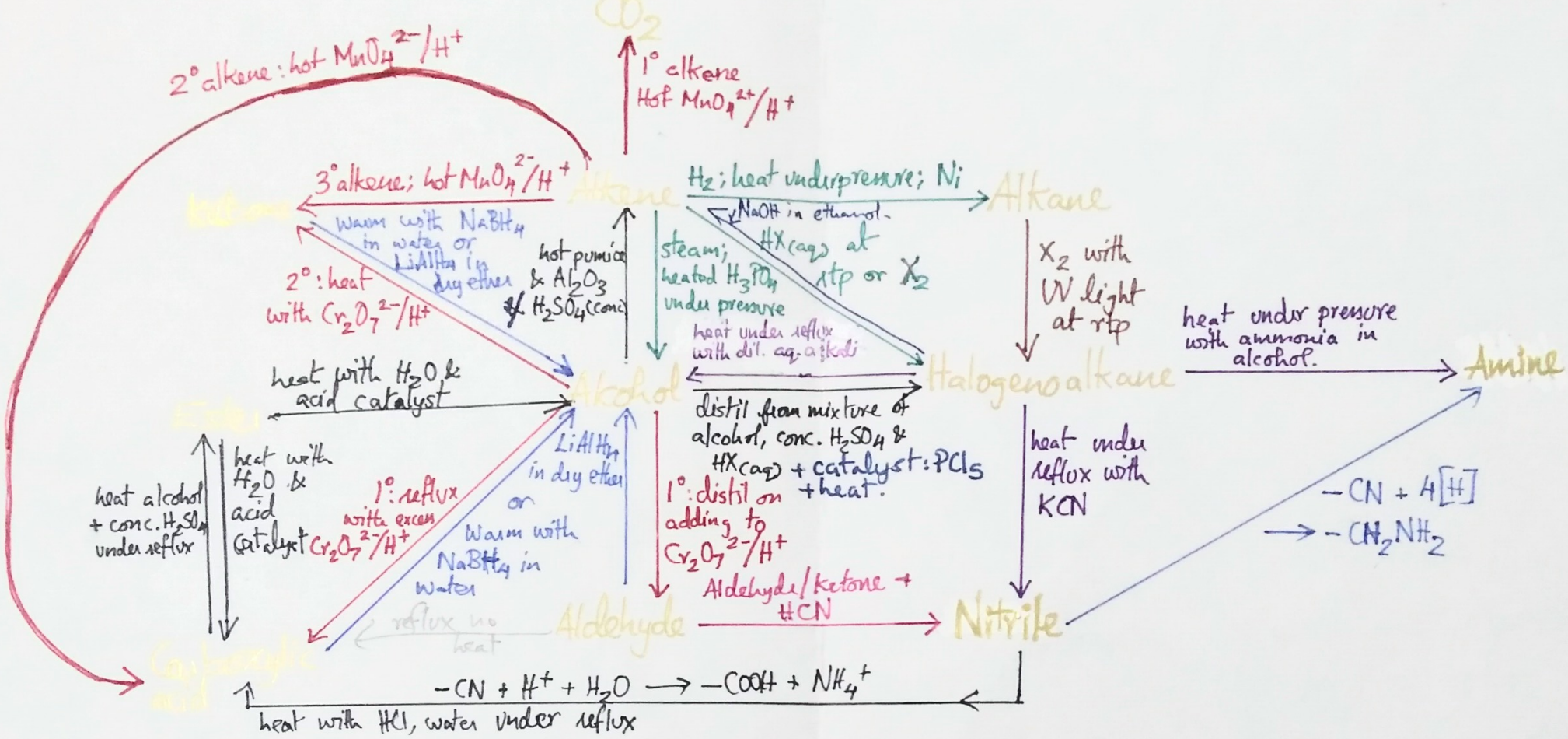
* Tri-iodomethane

$$RCOCH_3 \xrightarrow{I_2;\ NaOH} RCOCI_3$$

(methyl ketone)

$RCOCI_3$ —(NaOH (aq))→ $RCOO^-Na^+ + CHI_3$

tri-iodomethane (yellow precipitate)



— Free radical substitution
— Electrophilic addition
— Nucleophilic substitution
— Nucleophilic addition.

— Oxidation
— Reduction