FREE NOTES · NCERT + JEE/NEET LEVEL

Aldehydes, Ketones & Carboxylic Acids

Carbonyl group, banana, nucleophilic addition, oxidation aur reduction, aldol aur Cannizzaro, tests, carboxylic acids: banana, acidity aur reactions, saare named reactions ek table me.

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01 Carbonyl group & naming

C=O ka carbon **sp²**, trigonal planar (120°). Bond polar hai: C δ+ (nucleophile yahan attack karta), O δ− (electrophile yahan).

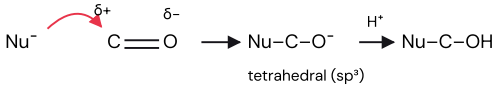
Formula	Common	IUPAC
HCHO	Formaldehyde	Methanal
CH_3CHO	Acetaldehyde	Ethanal
CH_3COCH_3	Acetone (dimethyl ketone)	Propanone
C_6H_5CHO	Benzaldehyde	Benzenecarbaldehyde
$C_6H_5COCH_3$	Acetophenone	1-Phenylethanone
HCOOH / CH_3COOH	Formic / acetic acid	Methanoic / ethanoic acid

Boiling points: alkane < ether < aldehyde/ketone (dipole) < alcohol < carboxylic acid (H-bond se dimer).

02 Aldehydes & ketones banana

Tareeka	Kya milta
1° alcohol ka oxidation (PCC) / 2° alcohol (CrO_3, $K_2Cr_2O_7$)	Aldehyde / ketone
Dehydrogenation (Cu, 573 K)	Aldehyde / ketone
Alkenes ka ozonolysis (O_3, phir Zn/H_2O)	Aldehydes/ketones
Alkynes ka hydration ($HgSO_4$, H_2SO_4)	Ethyne → ethanal; baaki → ketones
Rosenmund: RCOCl + H_2, Pd/$BaSO_4$	Aldehyde
Stephen: RCN + $SnCl_2$/HCl, phir H_3O^+	Aldehyde
RCN + DIBAL-H, phir H_2O	Aldehyde (esters se bhi)
Etard: toluene + CrO_2Cl_2	Benzaldehyde
Toluene + CrO_3/$(CH_3CO)_2O$, phir H_3O^+	Benzaldehyde
Gatterman-Koch: benzene + CO + HCl, $AlCl_3$/CuCl	Benzaldehyde
2RMgX/R_2Cd + R′COCl	Ketone
RCN + R′MgX, phir H_3O^+	Ketone
Friedel-Crafts acylation: ArH + RCOCl/$AlCl_3$	Aryl ketone

03 Nucleophilic addition



planar sp² carbonyl carbon is attacked from above or below

C=O pe nucleophilic addition

Aldehydes ketones se zyada reactive: (1) kam bheed (steric), (2) ketone ke do alkyl groups C ka δ+ ghata dete (electronic). Aromatic carbonyls kam reactive (resonance).

Reagent	Product
HCN (base catalysed)	Cyanohydrin
$NaHSO_3$	Bisulphite adduct (crystalline; alag/shuddh karne me)
RMgX, phir H_3O^+	Alcohols
R′OH / dry HCl	Hemiacetal → acetal; ketone + ethylene glycol → ketal
NH_3 derivatives ($H_2N–Z$)	C=N–Z (addition-elimination, pH ~3.5)

$H_2N–Z$	Product
NH_2OH	Oxime
NH_2NH_2	Hydrazone
$C_6H_5NHNH_2$	Phenylhydrazone
2,4-DNP	2,4-Dinitrophenylhydrazone (orange/peela ppt: C=O ka test)
$NH_2NHCONH_2$	Semicarbazone

04 Reduction, oxidation & tests

- $NaBH_4$/$LiAlH_4$ ya H_2/Ni ⇒ alcohols.
- **Clemmensen:** Zn-Hg/conc. HCl ⇒ C=O → CH_2.
- **Wolff-Kishner:** NH_2NH_2, phir KOH/ethylene glycol, garam ⇒ CH_2.

Test	Aldehyde	Ketone
Tollens' (ammoniacal $AgNO_3$)	Silver mirror	Kuch nahi
Fehling's (Cu^{2+} tartrate)	Laal-bhoora Cu_2O ppt (sirf aliphatic; benzaldehyde nahi)	Kuch nahi
Iodoform (NaOI)	CH_3CO- group (ethanal, methyl ketones) aur $CH_3CH(OH)-$ se peela CHI_3	

Ketones sirf strong oxidants se oxidise hote, C–C bond tootta (Popoff's rule: C=O chhote alkyl group ke saath rehta).

05 α-hydrogen wale reactions

α-H **acidic** hota kyunki carbanion (enolate) C=O ke saath resonance se stable.

ALDOL CONDENSATION

α-H wale aldehydes/ketones + dilute NaOH ⇒ β-hydroxy aldehyde (aldol) ya β-hydroxy ketone (ketol), jo garam karne pe paani chhod ke ⇒ α,β-unsaturated carbonyl. $2CH_3CHO$ → $CH_3CH(OH)CH_2CHO$ → $CH_3CH{=}CHCHO$ (but-2-enal). Do alag carbonyls ⇒ **cross aldol** (4 products).

CANNIZZARO REACTION

Bina α-H wale aldehydes (HCHO, C_6H_5CHO) + conc. NaOH ⇒ disproportionation: ek molecule oxidise hoke acid salt, doosra reduce hoke alcohol. $2HCHO$ → CH_3OH + HCOONa.

Ring reactions: –CHO aur –COOH deactivating, **meta directing** (benzaldehyde → m-nitrobenzaldehyde).

06 Carboxylic acids banana

- 1° alcohols / aldehydes ka oxidation ($KMnO_4$, $K_2Cr_2O_7$).
- Alkylbenzene + $KMnO_4$ (benzylic H wali koi bhi chain) ⇒ benzoic acid.
- Nitriles (RCN + H_3O^+) aur amides ka hydrolysis.
- Grignard + CO_2 (dry ice), phir H_3O^+ ⇒ RCOOH (ek C zyada).
- Acyl halides, anhydrides, esters ka hydrolysis.

07 Carboxylic acids ki acidity

RCOOH alcohols aur phenols se zyada acidic kyunki **carboxylate ion** ke do barabar resonance structures (charge do O pe). $NaHCO_3$ se CO_2 nikalta (test).

- Electron-withdrawing groups acidity badhate: CF_3COOH > CCl_3COOH > $CHCl_2COOH$ > $ClCH_2COOH$ > CH_3COOH.
- EWG jitna paas, asar utna zyada: 2-chlorobutanoic > 3-chloro > 4-chloro.
- Halo acids me F > Cl > Br > I (electronegativity).
- HCOOH > C_6H_5COOH > CH_3COOH. Electron-releasing groups acidity ghatate.
- Nitro-benzoic acids > benzoic acid.

08 Carboxylic acids ke reactions

Reagent	Product
Metals, NaOH, $NaHCO_3$	Salts (+ H_2 ya CO_2)
P_2O_5 / garam	Anhydride
R'OH / H^+	Ester (esterification)
PCl_5, PCl_3, $SOCl_2$	Acyl chloride
NH_3, phir garam	Amide
$LiAlH_4$ (ya B_2H_6)	1° alcohol ($NaBH_4$ –COOH ko reduce nahi karta)
Soda lime (NaOH + CaO), garam	Alkane, ek C kam (decarboxylation)
RCOONa ka Kolbe electrolysis	R–R
HVZ: X_2 / red P	α-halo acid (α-H chahiye)

09 Saare named reactions ek jagah

Naam	Kya karta
Rosenmund	RCOCl → RCHO (H_2, Pd/$BaSO_4$)
Stephen	RCN → RCHO ($SnCl_2$/HCl)
Etard	Toluene → benzaldehyde (CrO_2Cl_2)
Gatterman-Koch	Benzene → benzaldehyde (CO, HCl)
Clemmensen / Wolff-Kishner	C=O → CH_2 (acid / base)
Aldol	α-H carbonyl + dil. base → β-hydroxy carbonyl
Cannizzaro	Bina α-H aldehyde + conc. base → alcohol + acid salt
HVZ	RCH_2COOH → RCHXCOOH
Decarboxylation	RCOONa + soda lime → RH

10 JEE Extra + Tricks

JEE LEVEL

- Nucleophilic addition ki reactivity: HCHO > CH_3CHO > ketones (steric + electronic). Aromatic aldehydes aliphatic se kam.
- Aldol: α-H chahiye (patla NaOH). Cannizzaro: α-H nahi (conc. NaOH, HCHO, PhCHO) ⇒ alcohol + acid salt. Crossed Cannizzaro: HCHO oxidise.
- Tests: aldehydes ke liye Tollens (silver mirror) aur Fehling (laal Cu_2O) (aromatic aldehydes Fehling nahi dete); CH_3CO- aur $CH_3CH(OH)-$ ke liye iodoform.
- Acids ki acidity: electron-withdrawing groups badhate: CF_3COOH > CCl_3COOH > $ClCH_2COOH$ > HCOOH > CH_3COOH.
- HVZ: acids ka α-halogenation (X_2/red P). Clemmensen (Zn-Hg/HCl) aur Wolff–Kishner (NH_2NH_2/KOH) C=O ko CH_2.
- Rosenmund (acid chloride → aldehyde, Pd/$BaSO_4$), Stephen (nitrile → aldehyde), Etard (toluene → benzaldehyde).

11 Solved questions, mistakes & practice

Q1. Ethanal aur propanone me fark kaise karein?

Tollens': ethanal silver mirror deta, propanone nahi. (Iodoform dono dete.)

Q2. Benzaldehyde + conc. NaOH ka product?

Cannizzaro: benzyl alcohol + sodium benzoate.

Q3. Chloroacetic acid acetic acid se strong kyun?

Cl (–I) electrons kheenchta aur carboxylate ion ko stable karta.

- CH_3CHO pe Cannizzaro lagana (isme α-H hai, ye aldol deta).
- Kehna ki benzaldehyde Fehling's test deta.
- Sochna ki $NaBH_4$ –COOH ko reduce karta.
- –CHO ko ortho/para directing kehna.

1. Kisi bhi C=O ke test ka reagent?
2. HCN se kaun zyada reactive: HCHO ya CH_3COCH_3?
3. CH_3MgBr + CO_2 phir H_3O^+ ka product?
4. CH_3COONa + soda lime ka product?

ANSWERS

1) 2,4-DNP · 2) HCHO · 3) CH_3COOH · 4) CH_4

12 Quick revision: exam se 5 minute pehle

CARBONYL

- Reactivity: aldehyde > ketone.
- Nucleophilic addition.
- 2,4-DNP: C=O ka test.

TESTS

- Tollens': aldehydes (mirror).
- Fehling's: aliphatic aldehydes.
- Iodoform: $CH_3CO–$.

A-H

- α-H + dil. base ⇒ aldol.
- Bina α-H + conc. base ⇒ Cannizzaro.
- HVZ ⇒ α-halo acid.

ACIDS

- $NaHCO_3$ ⇒ CO_2 (test).
- EWG ↑ acidity; F > Cl.
- Soda lime ⇒ ek C kam.

Koi doubt? padhaiadda.netlify.app pe AI Doubt Solver se poocho, ya is chapter ka mock test do.