▶ Video explanation (YouTube Short)

Preparing Carboxylic Acids: Four Routes

Carboxylic acids are made by oxidation, by hydrolysis, or by adding CO_2 to a Grignard reagent (NCERT 8.7).

1. Oxidation of primary alcohols and aldehydes

$RCH_2OH \rightarrow (RCHO) \rightarrow RCOOH$ with $KMnO_4$ (neutral, acidic or alkaline) or $K_2Cr_2O_7$ / CrO_3 in acid. The number of carbons does not change. Example: $CH_3CH_2OH \rightarrow CH_3CHO \rightarrow CH_3COOH$.

2. Oxidation of alkylbenzenes

Vigorous oxidation with chromic acid or acidic/alkaline $KMnO_4$ turns the whole side chain into –COOH, whatever its length: toluene, ethylbenzene and propylbenzene all give benzoic acid, C_6H_5COOH (alkaline $KMnO_4$, then H_3O^+). The carbon attached to the ring must carry at least one H (a tert-butyl group is not oxidised).

3. Hydrolysis

Nitriles: $R–C\equiv N \rightarrow (H^+ \text{ or } OH^-, H_2O) \rightarrow R–CONH_2$ (amide) $\rightarrow RCOOH$. Esters, acid chlorides and anhydrides also give acids on hydrolysis.

4. Grignard reagent + CO_2 (dry ice)

Step	Reaction
Make the Grignard reagent	$CH_3Br + Mg$ (dry ether) $\rightarrow CH_3MgBr$
Add to CO_2	$CH_3MgBr + CO_2 \rightarrow CH_3COO^-\,{}^+MgBr$
Hydrolyse	$CH_3COO^-\,{}^+MgBr + H_3O^+ \rightarrow CH_3COOH$

Mechanism. The C–Mg bond is polar (C δ^-, Mg δ^+). Its electron pair attacks the carbon of CO_2 (a new C–C bond) while a C=O π pair moves onto oxygen. The acid has **one carbon more** than the alkyl halide.

Solved example

Q. How would you convert bromobenzene into benzoic acid?
A. $C_6H_5Br + Mg$ (dry ether) $\rightarrow C_6H_5MgBr$; $+ CO_2 \rightarrow C_6H_5COO^-\,{}^+MgBr$; $+ H_3O^+ \rightarrow C_6H_5COOH$.

Key takeaways

- Oxidation: 1° alcohol or aldehyde → acid, same carbon count.
- Alkylbenzene → benzoic acid, any chain length (benzylic H needed).
- Hydrolysis: nitrile → amide → acid; esters and acid chlorides too.
- RMgX + CO_2, then H_3O^+: acid with one carbon more.

Practice questions

1. (MCQ) Toluene with alkaline $KMnO_4$, then H_3O^+, gives: (a) benzaldehyde (b) benzoic acid (c) phenol (d) benzyl alcohol
2. (MCQ) CH_3MgBr + CO_2, then H_3O^+, gives: (a) methanoic acid (b) ethanoic acid (c) propanoic acid (d) ethanol
3. (MCQ) Partial hydrolysis of a nitrile gives: (a) an amine (b) an amide (c) an ester (d) an aldehyde
4. (Very short) Which compound gives benzoic acid on oxidation: tert-butylbenzene or propylbenzene?
5. (Very short) Name an oxidising agent that converts ethanol to ethanoic acid.
6. (Short) Why does the Grignard route give an acid with one carbon more than the alkyl halide?
7. (Short) Show with curved arrows how CH_3MgBr adds to CO_2.
8. (Application) Starting from ethyl bromide, prepare propanoic acid.

Answer key

1. (b) benzoic acid.
2. (b) ethanoic acid.
3. (b) an amide.
4. Propylbenzene (tert-butylbenzene has no benzylic H).
5. $KMnO_4$ or $K_2Cr_2O_7$ in acid.
6. The carbon of CO_2 becomes the COOH carbon, joined to the alkyl group by a new C–C bond.
7. One arrow from the C–Mg bond to the carbon of CO_2; one from a C=O π bond of CO_2 to its oxygen (giving $CH_3COO^-\ ^+MgBr$).
8. CH_3CH_2Br + Mg (dry ether) → CH_3CH_2MgBr; + CO_2 → $CH_3CH_2COO^-\ ^+MgBr$; + H_3O^+ → CH_3CH_2COOH.

▶ Watch the video explanation