▶ Video explanation (YouTube Short)

Why Carboxylic Acids Are Acidic

Carboxylic acids react with metals, alkalis and even the weak base $NaHCO_3$ (NCERT 8.9.1).

1. The test: brisk effervescence with $NaHCO_3$

$CH_3COOH + NaHCO_3 \rightarrow CH_3COONa + H_2O + CO_2\uparrow$. Alcohols and phenol do not liberate CO_2 from $NaHCO_3$, so this is a test for –COOH.

2. Ionisation and the rule

$RCOOH + H_2O \rightleftharpoons RCOO^- + H_3O^+$. The more stable the carboxylate ion, the further the equilibrium lies to the right and the stronger the acid (lower pKa).

3. Resonance in the carboxylate ion

An O^- lone pair moves in to form C=O while the old C=O π pair moves onto the other oxygen. The two resonance structures are **equivalent**: the negative charge is shared equally by two electronegative oxygens, and both C–O bonds have the same length. This makes the carboxylate ion stable.

4. Acid vs phenol vs alcohol

Anion	Where the charge goes	pKa of the acid
carboxylate $RCOO^-$	two equal O atoms (equivalent structures)	≈ 4–5 (acetic 4.76)
phenoxide $C_6H_5O^-$	O and less electronegative ring carbons (non-equivalent)	≈ 10
alkoxide $CH_3CH_2O^-$	one O only (no resonance)	≈ 16

5. Effect of substituents

Electron-withdrawing groups (–Cl, $–NO_2$, –CN, –F) pull electron density through the σ bonds (–I effect), spread the negative charge further and increase acidity; electron-donating alkyl groups decrease it.

Acid	pKa
CH_3COOH	4.76
$ClCH_2COOH$	2.86
$Cl_2CHCOOH$	≈ 1.3
Cl_3CCOOH	≈ 0.7

Solved example

Q. Arrange in increasing acidity: CH_3COOH, Cl_3CCOOH, $ClCH_2COOH$, C_2H_5OH.
A. $C_2H_5OH < CH_3COOH < ClCH_2COOH < Cl_3CCOOH$.

Key takeaways

- Stable conjugate base = strong acid.
- Carboxylate: charge shared by two equal oxygens.
- RCOOH > phenol > alcohol in acidity.
- Electron-withdrawing groups raise acidity (lower pKa).

Practice questions

1. (MCQ) Which liberates CO_2 from $NaHCO_3$? (a) ethanol (b) phenol (c) acetic acid (d) acetone
2. (MCQ) The strongest acid is: (a) CH_3COOH (b) $ClCH_2COOH$ (c) $Cl_2CHCOOH$ (d) Cl_3CCOOH
3. (MCQ) In the acetate ion the two C–O bonds are: (a) one double, one single (b) equal (c) both double (d) both single and unequal
4. (Very short) What does a lower pKa mean?
5. (Very short) Name the effect by which Cl increases the acidity of acetic acid.
6. (Short) Why is acetic acid more acidic than phenol?
7. (Short) Why is ethanol much less acidic than acetic acid?
8. (Application) Draw the resonance structures of the acetate ion with curved arrows.

Answer key

1. (c) acetic acid.
2. (d) Cl_3CCOOH.
3. (b) equal.
4. A stronger acid.
5. The –I (inductive) effect.
6. In acetate the charge is shared equally by two oxygens (equivalent structures); in phenoxide it moves onto less electronegative ring carbons.
7. Ethoxide has no resonance: the charge stays on one oxygen, so the ion is less stable.
8. $CH_3–C(=O)–O^- \longleftrightarrow CH_3–C(–O^-)=O$: one arrow from an O^- lone pair to the C–O bond, one from the C=O π bond to the other O.

▶ Watch the video explanation