

33.1 Carboxylic acids

Name: _____ Class: _____ Date: _____

Total: 10 marks

Objective

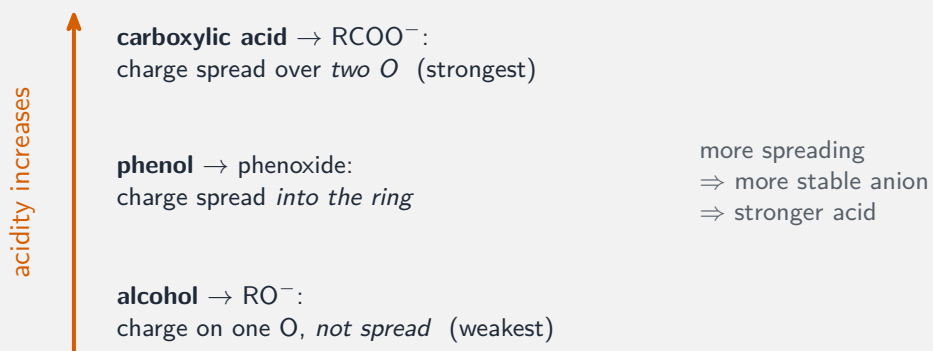
Build the skills to answer exam questions on **carboxylic acids** 羧酸—making them, the special acids that oxidise further, and the trends in **acidity** 酸性.

You must be able to:

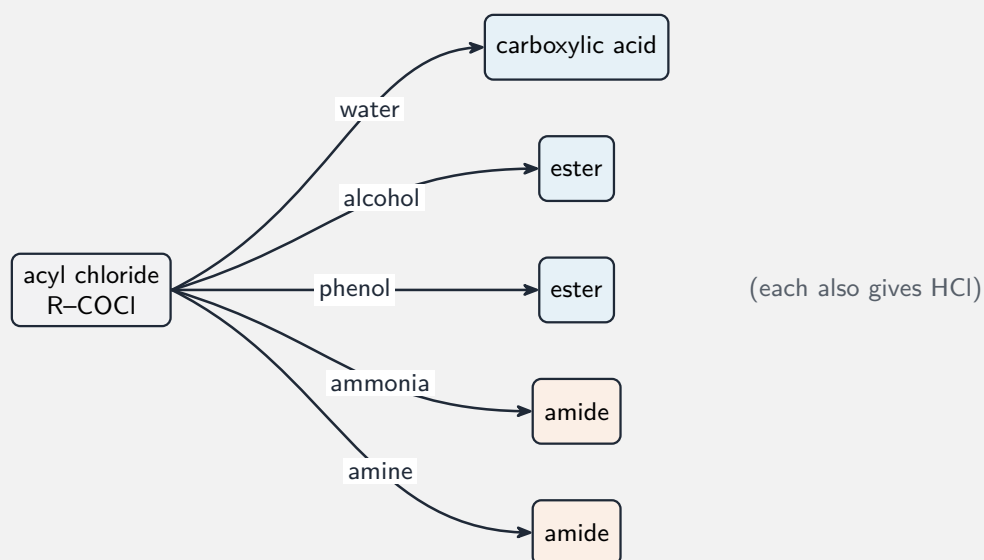
- make benzoic acid by side-chain oxidation; make an acyl chloride from an acid
- recall which carboxylic acids can be oxidised further
- explain the acidity order alcohol < phenol < carboxylic acid
- explain how chlorine substituents affect acid strength

1 Worked examples

■ Acidity trends



The more the negative charge on the conjugate base is spread out, the more stable the ion and the stronger the acid



Carboxylic acids and their acyl chloride reactions

- **acidity:** alcohol < phenol < **carboxylic acid** —the carboxylate spreads its charge over **two** oxygens.
- **electron-withdrawing** Cl atoms (inductive effect) pull electron density away, spread the charge more → **stronger** acid; more Cl (and closer to $-\text{COOH}$) = stronger.
- **make benzoic acid:** methylbenzene + hot alkaline KMnO_4 , then acid (whole side-chain → $-\text{COOH}$).

2 Practice

2.1 Give the reagents to oxidise methylbenzene to benzoic acid. [2]

2.2 State which is the stronger acid: ethanoic acid or chloroethanoic acid. [1]

3 Exam-style questions

3.1 A carboxylic acid is more acidic than phenol because its conjugate base spreads the negative charge over: [1]

- **A** one oxygen atom
- **B** two oxygen atoms
- **C** the benzene ring only

- **D** no atoms
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3.2 Which is the **strongest** acid?

[1]

- **A** ethanoic acid, CH_3COOH
 - **B** chloroethanoic acid, CH_2ClCOOH
 - **C** dichloroethanoic acid, CHCl_2COOH
 - **D** trichloroethanoic acid, CCl_3COOH
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3.3 Explain, in terms of the conjugate base, why a carboxylic acid is more acidic than an alcohol.

[2]

3.4 Trichloroethanoic acid is a much stronger acid than ethanoic acid. Explain why, in terms of the inductive effect.

[3]

4 Go further

You are now ready for the real exam questions on this subtopic. Open the **33.1 Carboxylic acids** past-paper sheet in the Library, or try these in **Practice mode**:

- 9701/41 N25 —Q7 (carboxylic acids)
- 9701/44 N25 —Q6 (carboxylic acids)

Solutions

2.1 hot alkaline KMnO_4 (potassium manganate(VII)); then dilute acid (acidify).

2.2 chloroethanoic acid.

3.1 B. The carboxylate ion spreads its negative charge over two oxygen atoms.

3.2 D. Three electron-withdrawing chlorine atoms spread the charge most, giving the strongest acid.

3.3 when a carboxylic acid loses H^+ , the charge is delocalised over two oxygen atoms, making a very stable carboxylate ion; an alkoxide (RO^-) cannot spread its charge, so it is less stable and the alcohol is far less acidic.

3.4 chlorine is electron-withdrawing and pulls electron density away through the inductive effect; this helps spread out the negative charge on the conjugate base, stabilising the ion; three Cl atoms in CCl_3COOH do this much more than the CH_3 in ethanoic acid, so it is a far stronger acid.