

Carbonyl Compounds

A-Level Chemistry ▪ Topic 17

A-Level Chemistry



Carbonyl Compounds

What we will cover

- 1 Aldehydes vs ketones
- 2 Nucleophilic addition
- 3 Tests for carbonyls
- 4 Silver mirror & iodoform



propanone, a ketone

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Structure and mechanism

Carbonyl Compounds

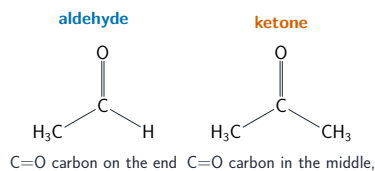
Structure and mechanism

Aldehydes vs ketones

Both have the **carbonyl** 羰基 ($\text{C}=\text{O}$) group:

- an **aldehyde** 醛 ($-\text{CHO}$) – $\text{C}=\text{O}$ on the end
- a **ketone** 酮 – $\text{C}=\text{O}$ in the middle

Both are made by the **oxidation** 氧化 of an alcohol with acidified $\text{K}_2\text{Cr}_2\text{O}_7$: a **primary** alcohol with **distillation** 蒸馏 gives the aldehyde, a **secondary** alcohol gives the ketone.



Carbonyl Compounds

Structure and mechanism

Reactions

- **reduction** 还原 with NaBH_4 or LiAlH_4 turns a carbonyl compound back into an alcohol (an aldehyde gives a primary alcohol; a ketone gives a secondary alcohol).
- reaction with **hydrogen cyanide** 氰化氢 (HCN), with KCN as catalyst and heat, adds H and CN across the $\text{C}=\text{O}$ to make a **hydroxynitrile** 羟基腈.

Carbonyl Compounds

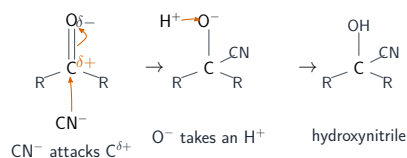
Structure and mechanism

Nucleophilic addition

HCN adds across the $\text{C}=\text{O}$ by **nucleophilic addition** 亲核加成:

- CN^- attacks the δ^+ carbon
- $\text{C}=\text{O}$ breaks to O^-
- O^- takes an H^+ → a **hydroxynitrile** 羟基腈

Reduction 还原 (NaBH_4) gives back an alcohol.



2 Tests

Tests for carbonyls

tell an aldehyde from a ketone



Fehling's
(blue)
→ brick-red ppt



Tollens'
(colourless)
→ silver mirror

a **ketone**
gives **no change**
with either test

2,4-DNPH 2,4-二硝基苯肼 gives an orange precipitate → any carbonyl.

To tell them apart (aldehydes oxidise, ketones don't):
Fehling's 斐林试剂 → brick-red; **Tollens'** 托伦试剂 → silver mirror – only with an aldehyde.

Detecting any carbonyl

Add **2,4-DNPH** reagent (2,4-dinitrophenylhydrazine).

An orange precipitate confirms that the compound is an aldehyde or a ketone.

Silver mirror and iodoform



A positive **Tollens'** 托伦试剂 test coats the tube with a shiny silver mirror – the aldehyde reduces Ag^+ to silver. The **iodoform test** 碘仿试验 (alkaline I_2) detects the $\text{CH}_3\text{CO}-$ group, giving yellow CHI_3 .

Nucleophilic addition, and telling aldehyde from ketone

step 1	the nucleophile attacks the δ^+ carbon of the $\text{C}=\text{O}$
step 2	this breaks the $\text{C}=\text{O}$ double bond, leaving a negative oxygen (O^-)
step 3	the O^- takes a proton, giving the alcohol group
the difference	aldehydes are easily oxidised to carboxylic acids; ketones are not
Tollens'	the silver mirror test – aldehyde positive, ketone negative
Fehling's reagent 斐林试剂	blue solution to a brick-red precipitate – aldehyde positive, ketone negative

An aldehyde's carbonyl carbon carries a hydrogen, which is what can be **oxidised** 氧化. A ketone's does not – so both tests are really testing for that hydrogen.

Exam tips

- **2,4-DNPH** gives an orange precipitate with **any** carbonyl – it tests for $\text{C}=\text{O}$.
- **Tollens' (silver mirror)** and **Fehling's (brick-red)** are positive for **aldehydes only** – this is how you tell aldehydes from ketones.
- Nucleophilic addition of HCN adds **one carbon** (→ hydroxynitrile); show the curly arrows.
- The **iodoform (tri-iodomethane)** test is positive for $\text{CH}_3\text{CO}-$ groups.

3 Recap

Worked example – aldehyde or ketone?

Propanal and propanone are in unlabelled tubes. Give one test that tells them apart.

- Both give an orange precipitate with 2,4-DNPH – that only proves a C=O is present.
- So 2,4-DNPH **cannot** separate them. Use an **oxidising** 氧化的 test instead.
- Add Tollens' reagent and warm: propanal (aldehyde) reduces Ag^+ to a **silver mirror**.
- Propanone gives **no change** – a ketone has no H on the carbonyl carbon to lose.

2,4-DNPH proves C=O present. Tollens' or Fehling's then splits aldehyde (positive) from ketone (negative).

Topic 17 – key takeaways

1 Carbonyl

aldehyde ($-\text{CHO}$) vs ketone (middle)

2 Mechanism

nucleophilic addition of HCN

3 Detect

2,4-DNPH gives an orange precipitate

4 Distinguish

Fehling's & Tollens' react with aldehydes

Check yourself

- Where is the C=O in a ketone?
- What attacks the carbonyl carbon in the HCN mechanism?
- What reagent confirms any carbonyl?
- What does Tollens' give with an aldehyde?



Answers 1. in the middle of the chain 2. the cyanide ion CN^- 3. 2,4-DNPH 4. a silver mirror