

Carbonyl Compounds

A-Level Chemistry ■ Topic 17

A-Level Chemistry



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

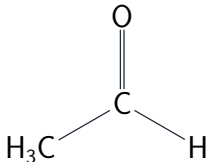
Aldehydes vs ketones

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

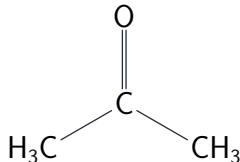
- an **aldehyde** 醛 ($-\text{CHO}$) – $\text{C}=\text{O}$ on the end
- a **ketone** 酮 – $\text{C}=\text{O}$ in the middle

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.

aldehyde



ketone



$\text{C}=\text{O}$ carbon on the end $\text{C}=\text{O}$ carbon in the middle,

Reactions

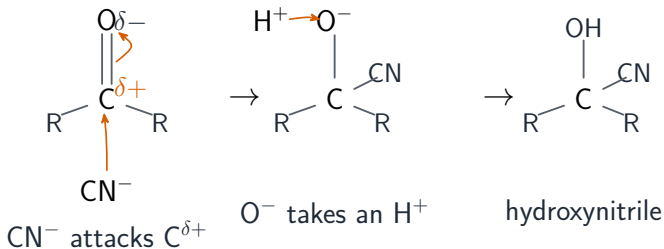
- **reduction** 还原 with NaBH_4 or LiAlH_4 turns a carbonyl compound back into an alcohol (an aldehyde gives a primary alcohol; a ketone gives a secondary alcohol).
- reaction with **hydrogen cyanide** 氰化氢 (HCN), with KCN as catalyst and heat, adds H and CN across the $\text{C}=\text{O}$ to make a **hydroxynitrile**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

Nucleophilic addition

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

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

Reduction 还原 ($NaBH_4$) gives back an alcohol.



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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 $\delta+$ 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 $C=O$.
- **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** ($\rightarrow$ hydroxynitrile); show the curly arrows.
- The **iodoform (tri-iodomethane)** test is positive for CH_3CO- groups.

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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 $\text{C}=\text{O}$ 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 $\text{C}=\text{O}$ 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

- 1 Where is the $\text{C}=\text{O}$ in a ketone?
- 2 What attacks the carbonyl carbon in the HCN mechanism?
- 3 What reagent confirms any carbonyl?
- 4 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