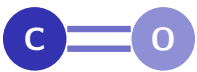
Carbonyl Compounds

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

1 Structure and mechanism

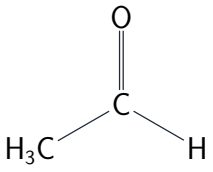
Aldehydes vs ketones

Both have the **carbonyl** 羰基 (C=O) group:

- an **aldehyde** 醛 (−CHO) – C=O on the end
- a **ketone** 酮 – C=O in the middle

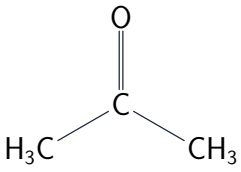
Both are made by the **oxidation** 氧化 of an alcohol with acidified $K_2Cr_2O_7$: a primary alcohol with **distillation** 蒸馏 gives the aldehyde, a secondary alcohol gives the ketone.

aldehyde



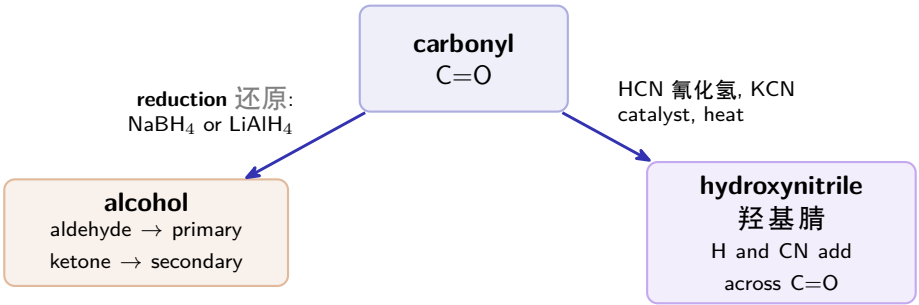
C=O carbon on the end

ketone



C=O carbon in the middle,

Reactions

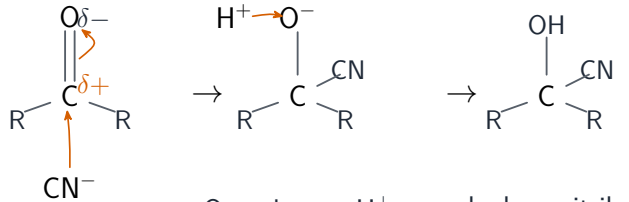

carbonyl
C=O
reduction 还原:
$NaBH_4$ or $LiAlH_4$
alcohol
aldehyde → primary
ketone → secondary
HCN 氰化氢, KCN
catalyst, heat
hydroxynitrile
羟基腈
H and CN add
across C=O

Nucleophilic addition

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

- CN^- attacks the $\delta+$ 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.



CN^- attacks $C^{\delta+}$ O^- takes an H^+ hydroxynitrile

2 Tests

Tests for carbonyls

tell an aldehyde from a ketone

Fehling's
(blue)
→ brick-red ppt

Tollens'
(colourless)
→ silver mirror

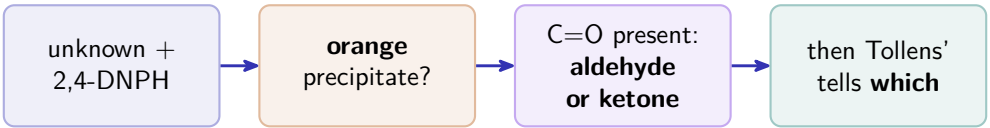
a **ketone**
gives **no change**
with either test

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):



2,4-DNPH detects **any** carbonyl; it cannot tell an aldehyde from 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 CH_3CO- group, giving yellow CHI_3.

Nucleophilic addition, and telling aldehyde from ketone

step 1	the nucleophile attacks the $\delta+$ carbon of the C=O
step 2	this breaks the C=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.

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 ($-CHO$) vs ketone (middle)

2 Mechanism

nucleophilic addition of HCN

3 Detect

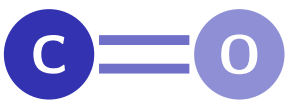
2,4-DNPH gives an orange precipitate

4 Distinguish

Fehling's & Tollens' react with aldehydes

Check yourself

1. Where is the C=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