Carbonyl compounds

A-Level Chemistry

Aldehydes and ketones

Aldehydes and ketones are **carbonyl compounds** 羰基化合物—they contain the C=O **carbonyl** 羰基 group.

- in an **aldehyde** 醛 the carbonyl carbon is on the end of the chain (it also carries an H), written –CHO.
- in a **ketone** 酮 the carbonyl carbon is in the middle, between two other carbons.

Propanone (acetone), the simplest ketone, is the solvent in nail-polish remover

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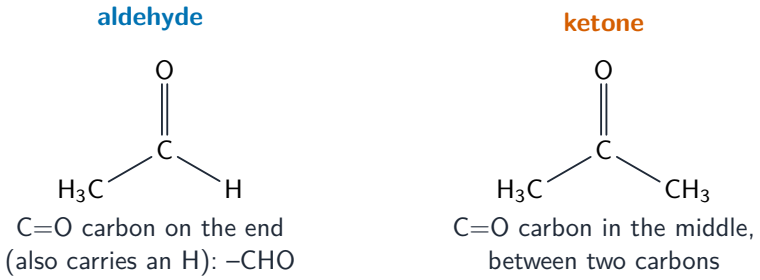


Both have the C=O carbonyl group: in an aldehyde it is on the end of the chain (–CHO), in a ketone it is in the middle

Making aldehydes and ketones

Both are made by the **oxidation** 氧化 of an **alcohol** 醇 with acidified $K_2Cr_2O_7$ or $KMnO_4$:

- a **primary** alcohol, with **distillation** 蒸馏, gives an aldehyde.

- a **secondary** alcohol gives a ketone.

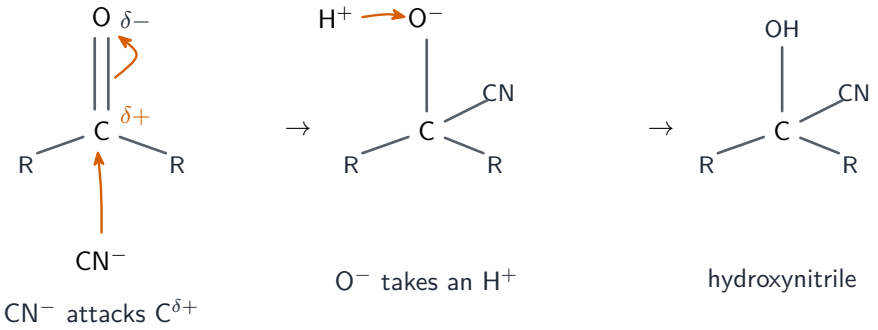
Reactions

- **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 C=O to make a **hydroxynitrile** 羟基腈. This adds one carbon to the chain.

The mechanism: nucleophilic addition

The reaction with HCN is a **nucleophilic addition** 亲核加成. The carbonyl carbon is slightly positive (oxygen pulls the electrons away). So:

1. the CN^- ion (a nucleophile) attacks the slightly positive carbon.
2. this breaks the C=O double bond, leaving a negative oxygen (O^-).
3. the O^- takes an H^+ (from HCN) to finish the hydroxynitrile.



Nucleophilic addition of HCN: CN^- attacks the $\delta+$ carbonyl carbon, the C=O breaks to O^-, then O^- takes an H^+

Tests for carbonyl compounds

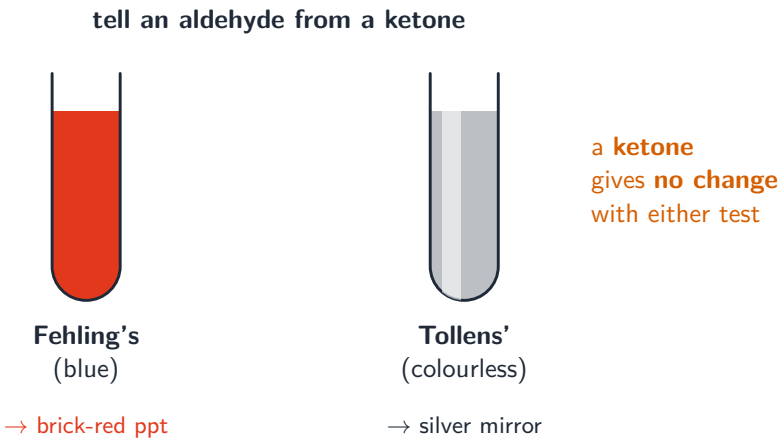
Detecting any carbonyl

Add **2,4-DNPH** reagent (2,4-dinitrophenylhydrazine). An orange precipitate confirms that the compound is an aldehyde or a ketone.

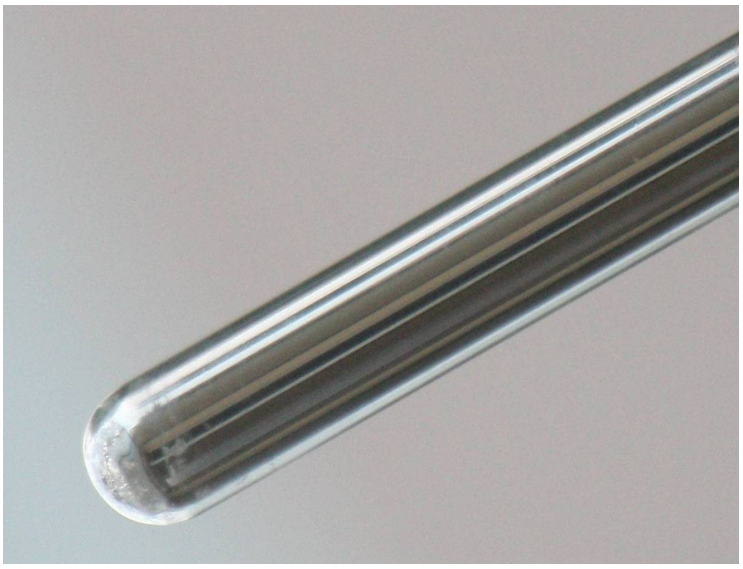
Telling an aldehyde from a ketone

Aldehydes are easily oxidised to carboxylic acids, but ketones are not. Two tests use this difference:

Test	Aldehyde	Ketone
Fehling's reagent 斐林试剂 (blue solution)	turns to a brick-red precipitate	no change
Tollens' reagent 托伦试剂 (colourless)	gives a silver mirror	no change



Telling an aldehyde from a ketone: an aldehyde gives a brick-red precipitate with Fehling's and a silver mirror with Tollens'; a ketone gives no change



A positive Tollens' test: an aldehyde coats the tube with a shiny silver mirror

The iodoform test

If the compound has the CH_3CO- group, warming it with alkaline aqueous iodine gives a pale yellow precipitate of **tri-iodomethane** 三碘甲烷 (CHI_3) and the ion RCO_2^-.