

Week 26

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

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17. Carbonyl compounds

Starter Quiz · 课前小测

A-Level Chemistry

Name: _____ Score: _____

- The difference between an aldehyde and a ketone is that:
 - ☐ the C=O is on the end of the chain in an aldehyde, and in the middle in a ketone
 - ☐ an aldehyde has no C=O group
 - ☐ a ketone has an -OH group
 - ☐ they have different molecular formulas always
- An orange precipitate with 2,4-DNPH shows the compound is:
 - ☐ an aldehyde or a ketone (a carbonyl compound)
 - ☐ an alcohol
 - ☐ an alkane
 - ☐ a carboxylic acid only
- Oxidising a secondary alcohol gives:
 - ☐ a ketone
 - ☐ an aldehyde
 - ☐ a carboxylic acid
 - ☐ an alkene
- A silver mirror with Tollens' reagent indicates:
 - ☐ an aldehyde
 - ☐ a ketone
 - ☐ an alcohol
 - ☐ an alkene
- Reducing a carbonyl compound (with NaBH₄) gives:
 - ☐ an alcohol
 - ☐ an alkene
 - ☐ a carboxylic acid
 - ☐ a halogenoalkane
- Aldehydes have the carbonyl group at the end of the carbon chain.
 - ☐ True ☐ False

7. Tollens' reagent gives a silver _____ with an aldehyde but not a ketone.

8. Fehling's solution turns from blue to a brick-red precipitate with:

- ☐ an aldehyde
- ☐ a ketone
- ☐ a tertiary alcohol
- ☐ an alkane

9. In the nucleophilic addition of HCN, the first step is:

- ☐ CN^- attacking the slightly positive carbonyl carbon
- ☐ the oxygen taking a proton
- ☐ the $\text{C}=\text{O}$ bond forming
- ☐ a carbocation forming

10. A pale-yellow precipitate of CHI_3 in the iodoform test shows the compound has the:

- ☐ $\text{CH}_3\text{CO}-$ group
- ☐ $\text{C}=\text{C}$ bond
- ☐ $-\text{COOH}$ group
- ☐ $\text{C}-\text{X}$ bond

17. Carbonyl compounds

Answers · 答案

A-Level Chemistry

1. **the $\text{C}=\text{O}$ is on the end of the chain in an aldehyde, and in the middle in a ketone**

Both have the carbonyl $\text{C}=\text{O}$; in an aldehyde it is terminal ($-\text{CHO}$), in a ketone it is between two carbons.

2. **an aldehyde or a ketone (a carbonyl compound)**

2,4-DNPH gives an orange precipitate with any carbonyl (aldehyde or ketone).

3. **a ketone**

Secondary alcohols oxidise to ketones; primary alcohols (with distillation) give aldehydes.

4. **an aldehyde**

Aldehydes are oxidised and reduce Tollens' to silver (a mirror); ketones give no change.

5. **an alcohol**

Reduction turns a carbonyl back into an alcohol (aldehyde $\rightarrow$ primary, ketone $\rightarrow$ secondary).

6. **True**

Ketones have it in the middle.

7. **mirror**

Aldehydes are oxidised; ketones are not.

8. **an aldehyde**

An aldehyde reduces Fehling's to a brick-red precipitate; a ketone does not react.

9. **CN^- attacking the slightly positive carbonyl carbon**

The cyanide nucleophile attacks the $\delta+$ carbon, breaking the $\text{C}=\text{O}$; the O^- then takes an H^+ .

10. **$\text{CH}_3\text{CO}-$ group**

The iodoform (CHI_3) test is positive for compounds containing the $\text{CH}_3\text{CO}-$ group (and $\text{CH}_3\text{CH}(\text{OH})-$).

17.1 Aldehydes and ketones

Name: _____ Class: _____ Date: _____

Total: 13 marks

KEY WORDS nucleophilic addition 亲核加成 • tollens' reagent 托伦试剂 • carbonyl 羰基
• aldehyde 醛 • ketone 酮

Objective

Build the skills to answer exam questions on **aldehydes and ketones** 醛和酮 — making them, **nucleophilic addition** 亲核加成 of HCN, and the tests that tell an aldehyde from a ketone.

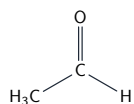
You must be able to:

- describe how aldehydes and ketones are made and reduced
- describe the nucleophilic addition mechanism of HCN
- use 2,4-DNPH, Fehling's and Tollens' tests, and the iodoform test

1 Worked examples

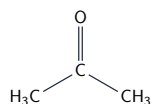
■ Carbonyl compounds

aldehyde



C=O carbon on the end
(also carries an H): -CHO

ketone

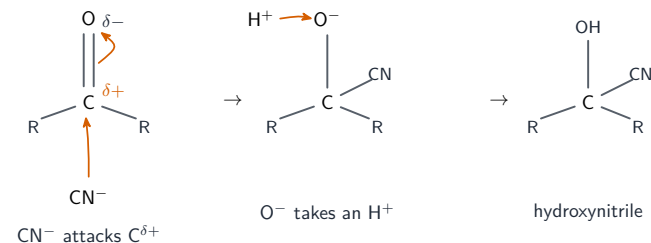


C=O carbon in the middle,
between two carbons

Both have the C=O carbonyl group: aldehyde = on the end (-CHO); ketone = in the middle

Made by oxidising alcohols: primary (distil) → **aldehyde**; secondary → **ketone**.
Reduced back by NaBH₄/LiAlH₄. With HCN (KCN catalyst) → a **hydroxynitrile** (+1 carbon).

■ Nucleophilic addition of HCN



CN^- attacks the $\delta+$ carbon; the $\text{C}=\text{O}$ breaks to O^- ; O^- takes an H^+ to give the hydroxynitrile

■ Tests

tell an aldehyde from a ketone



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

2,4-DNPH (orange ppt) detects any carbonyl. Aldehyde: Fehling's → brick-red, Tollens' → silver mirror. Ketone: no change

The **iodoform test** (alkaline I₂) gives a yellow CHI₃ precipitate for a CH₃CO- group.

2 Practice

2.1 State the difference in structure between an aldehyde and a ketone. [2]

2.2 Name the reagent used to detect the presence of any carbonyl compound. [1]

3 Exam-style questions

3.1 Which reagent gives a silver mirror with an aldehyde but no change with a ketone?[1]

- **A** 2,4-DNPH
- **B** Tollens' reagent
- **C** bromine water
- **D** NaBH₄

3.2 The reaction of HCN with a ketone is classified as: [1]

- **A** electrophilic addition
- **B** nucleophilic addition
- **C** free-radical substitution
- **D** elimination

3.3 (a) Describe the mechanism of the nucleophilic addition of HCN to ethanal. [3]

(b) State the reagent and condition to reduce propanone to an alcohol, and name the alcohol formed. [2]

3.4 Describe how you would use chemical tests to distinguish between propanal (an aldehyde) and propanone (a ketone). [3]

Solutions

2.1 in an aldehyde the C=O is on the end of the chain (carries an H, -CHO); in a ketone the C=O is in the middle, between two carbons.

2.2 2,4-dinitrophenylhydrazine (2,4-DNPH).

3.1 B. Tollens' reagent gives a silver mirror with an aldehyde only.

3.2 B. Addition of HCN to a carbonyl is nucleophilic addition.

3.3 (a) the CN⁻ nucleophile attacks the $\delta+$ carbonyl carbon (curly arrow from the lone pair); the C=O π bond breaks, the electrons going to the oxygen to give O⁻; the O⁻ takes an H⁺ (from HCN) to form the hydroxynitrile.

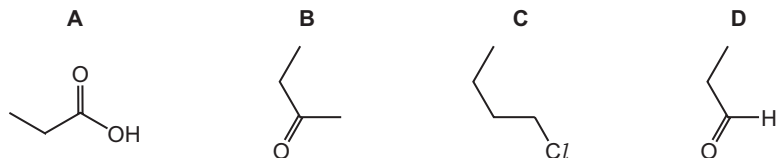
(b) NaBH₄ (or LiAlH₄); propan-2-ol (a secondary alcohol).

3.4 add Tollens' reagent (or Fehling's) and warm; propanal (aldehyde) gives a silver mirror (or brick-red precipitate); propanone (ketone) gives no change.

36 Compound Q reacts when heated with HCN in the presence of a catalyst to produce compound R.

Molecules of compound R each contain four carbon atoms.

What is compound Q?



38 Seven aldehydes and ketones

- contain only **one** oxygen atom per molecule
- have four or fewer carbon atoms in their structures.

Alkaline $I_2(aq)$ is added to each of these carbonyl compounds separately.

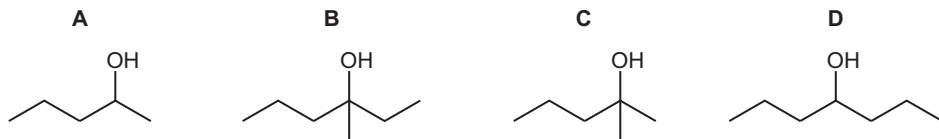
How many of these carbonyl compounds produce a yellow precipitate with alkaline $I_2(aq)$?

A 1 **B** 2 **C** 3 **D** 4

34 An organometallic lithium compound, RLi, contains the nucleophile R^- .

CH_3CH_2Li reacts with pentan-2-one. The mechanism is nucleophilic addition. The first step produces an anion which is then protonated to form the final product.

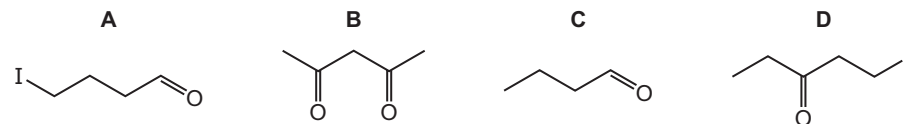
Which organic product is formed?



34 Three tests were performed on an unknown organic compound.

test reagent	test result
2,4-DNPH reagent	orange ppt
Tollens' reagent	no change
alkaline $I_2(aq)$	yellow ppt

What is the organic compound tested?

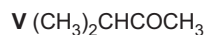
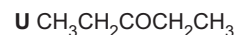
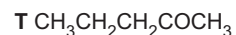
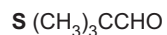
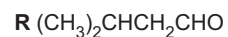
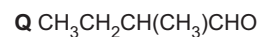
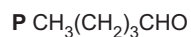


35 Butanone, $CH_3CH_2COCH_3$, and HCN mixed with a little KCN react together in a nucleophilic addition reaction.

Which description of the mechanism of this nucleophilic addition reaction is correct?

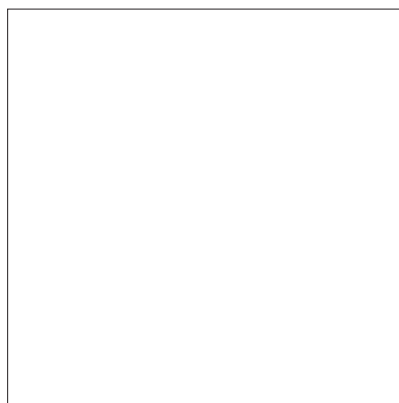
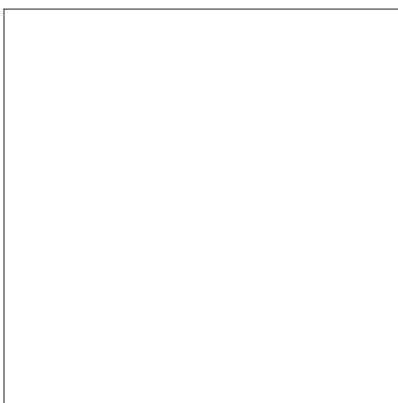
- A** The π bond pair of $C=O$ accepts H^+ from HCN and then CN^- acts as a nucleophile.
B A π bond pair from CN^- attacks the δ^+ C and HCN then donates H^+ to O.
C The lone pair on O accepts H^+ from HCN and then CN^- acts as a nucleophile.
D A lone pair from CN^- attacks the δ^+ C and then O^- accepts H^+ from HCN.

7 **P, Q, R, S, T, U,** and **V** are the seven structural isomers with molecular formula $C_5H_{10}O$ that have a carbonyl group.



(a) Only one of these seven compounds has stereoisomers.

Draw three-dimensional diagrams of the **two** stereoisomers of this compound.



[2]

(b) **P, Q, R, S, T, U,** and **V** are treated separately with alkaline $I_2(aq)$ and the product mixture is acidified.

(i) Identify the **two** compounds that give a positive result with alkaline $I_2(aq)$.

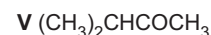
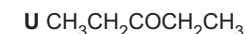
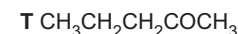
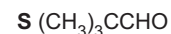
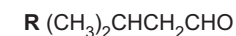
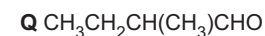
..... and [1]

(ii) Describe the observations when **one** of the compounds you have identified in (b)(i) is treated with alkaline $I_2(aq)$ and give the structural formulae of the **two** carbon-containing products of this reaction.

observations

two carbon-containing products

and [2]



(c) The proton (1H) NMR spectra of **P, Q, R, S, T, U,** and **V** are compared.

(i) Identify the only compound that gives a spectrum with two singlets and no other peaks.

..... [1]

Fig. 7.1 shows the spectrum obtained from one of the compounds.

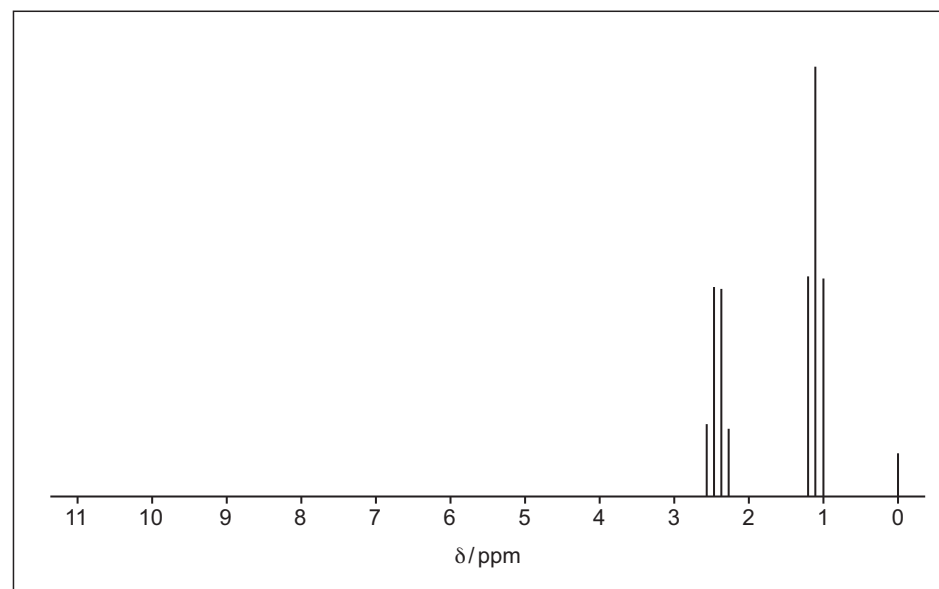


Fig. 7.1

(ii) Identify the compound that gives this spectrum.

..... [1]

(iii) Name the splitting pattern of the peak at $\delta = 1.1$ in Fig. 7.1.

Give the reason for this splitting.

name

reason [1]

(iv) Identify the substance that gives the small peak at $\delta = 0$ in Fig. 7.1.

..... [1]

(d) The carbon-13 NMR spectra of **R**, **S**, **T** and **U** are compared.

Complete Table 7.1 to state the number of peaks in the spectrum of each compound.

Table 7.1

compound	number of peaks
R $(\text{CH}_3)_2\text{CHCH}_2\text{CHO}$	
S $(\text{CH}_3)_3\text{CCHO}$	
T $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCH}_3$	
U $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$	

[2]

[Total: 11]