Week 29

A-Level Chemistry

Homework bundle for this week

本周作业合集

exercises.lol

Contents 目录

17. Carbonyl compounds

Starter Quiz · 课前小测

A-Level Chemistry Name: _____ Score: _____

1. 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
2. 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
3. Oxidising a secondary alcohol gives:
   - ☐ a ketone
   - ☐ an aldehyde
   - ☐ a carboxylic acid
   - ☐ an alkene
4. A silver mirror with Tollens' reagent indicates:
   - ☐ an aldehyde
   - ☐ a ketone
   - ☐ an alcohol
   - ☐ an alkene
5. Reducing a carbonyl compound (with $NaBH_4$) gives:
   - ☐ an alcohol
   - ☐ an alkene
   - ☐ a carboxylic acid
   - ☐ a halogenoalkane
6. 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 C=O bond forming

   ☐ a carbocation forming

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

    ☐ CH_3CO– group

    ☐ C=C bond

    ☐ –COOH group

    ☐ C–X bond

A-Level Chemistry

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

   Both have the carbonyl C=O; in an aldehyde it is terminal (–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 → primary, ketone → 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 C=O; the O^- then takes an H^+.

10. **CH_3CO– group**

    The iodoform (CHI_3) test is positive for compounds containing the CH_3CO– group (and $CH_3CH(OH)$–).

A-LEVEL CHEMISTRY • EXERCISE SHEET

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.

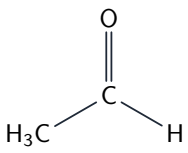
You must be able to:

- 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

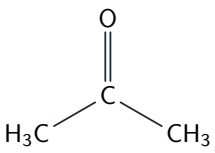
■ Carbonyl compounds

aldehyde



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

ketone

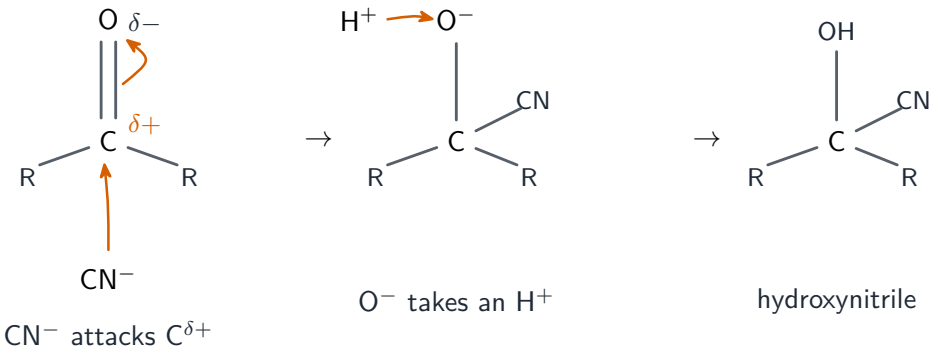


C=O carbon in the middle, between two carbons

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

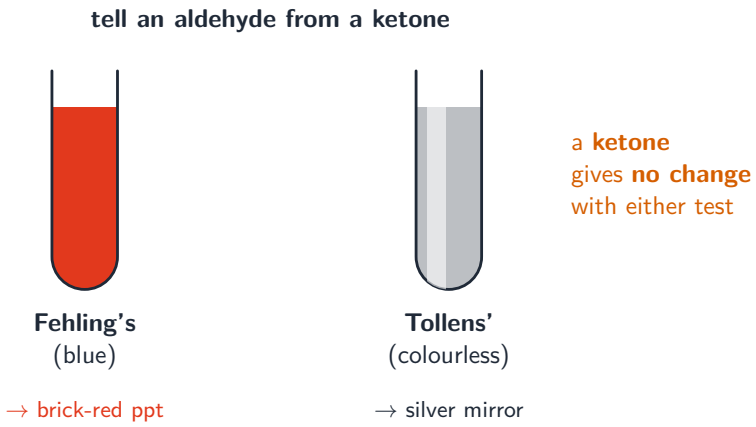
Made by oxidising alcohols: primary (distil) → **aldehyde**; secondary → **ketone**. Reduced back by $NaBH_4$/$LiAlH_4$. With HCN (KCN catalyst) → a **hydroxynitrile** (+1 carbon).

■ Nucleophilic addition of HCN



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

■ Tests



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

The **iodoform test** (alkaline I_2) gives a yellow CHI_3 precipitate for a CH_3CO- 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** $NaBH_4$

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) $NaBH_4$ (or $LiAlH_4$); propan-2-ol (a secondary alcohol).

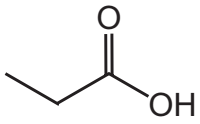
3.4 add Tollens' reagent (or Fehling's) and warm; propanal (aldehyde) gives a silver mirror (or brick-red precipitate); propanone (ketone) gives no change.

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

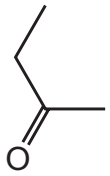
Molecules of compound R each contain four carbon atoms.

What is compound Q?

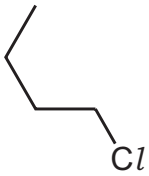
A



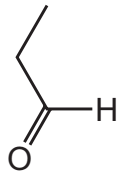
B



C



D



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)?

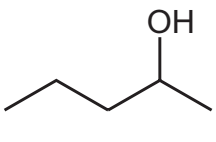
A 1 **B** 2 **C** 3 **D** 4

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

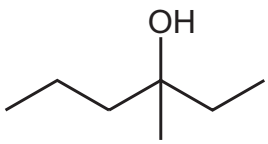
CH_3CH_2Li reacts with pentan-2-one. The mechanism is nucleophilic addition. The first step produces an anion which is then protonated to form the final product.

Which organic product is formed?

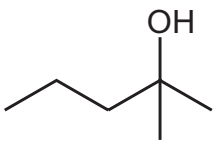
A



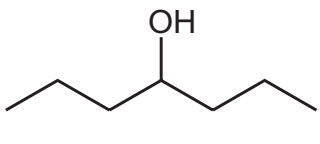
B



C



D

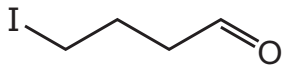


34 Three tests were performed on an unknown organic compound.

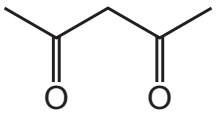
test reagent	test result
2,4-DNPH reagent	orange ppt
Tollens' reagent	no change
alkaline I_2(aq)	yellow ppt

What is the organic compound tested?

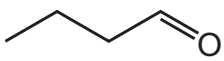
A



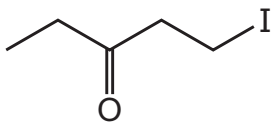
B



C



D



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.

P $CH_3(CH_2)_3CHO$ **Q** $CH_3CH_2CH(CH_3)CHO$ **R** $(CH_3)_2CHCH_2CHO$

S $(CH_3)_3CCHO$ **T** $CH_3CH_2CH_2COCH_3$ **U** $CH_3CH_2COCH_2CH_3$

V $(CH_3)_2CHCOCH_3$

(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]

P $CH_3(CH_2)_3CHO$ **Q** $CH_3CH_2CH(CH_3)CHO$ **R** $(CH_3)_2CHCH_2CHO$

S $(CH_3)_3CCHO$ **T** $CH_3CH_2CH_2COCH_3$ **U** $CH_3CH_2COCH_2CH_3$

V $(CH_3)_2CHCOCH_3$

(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.

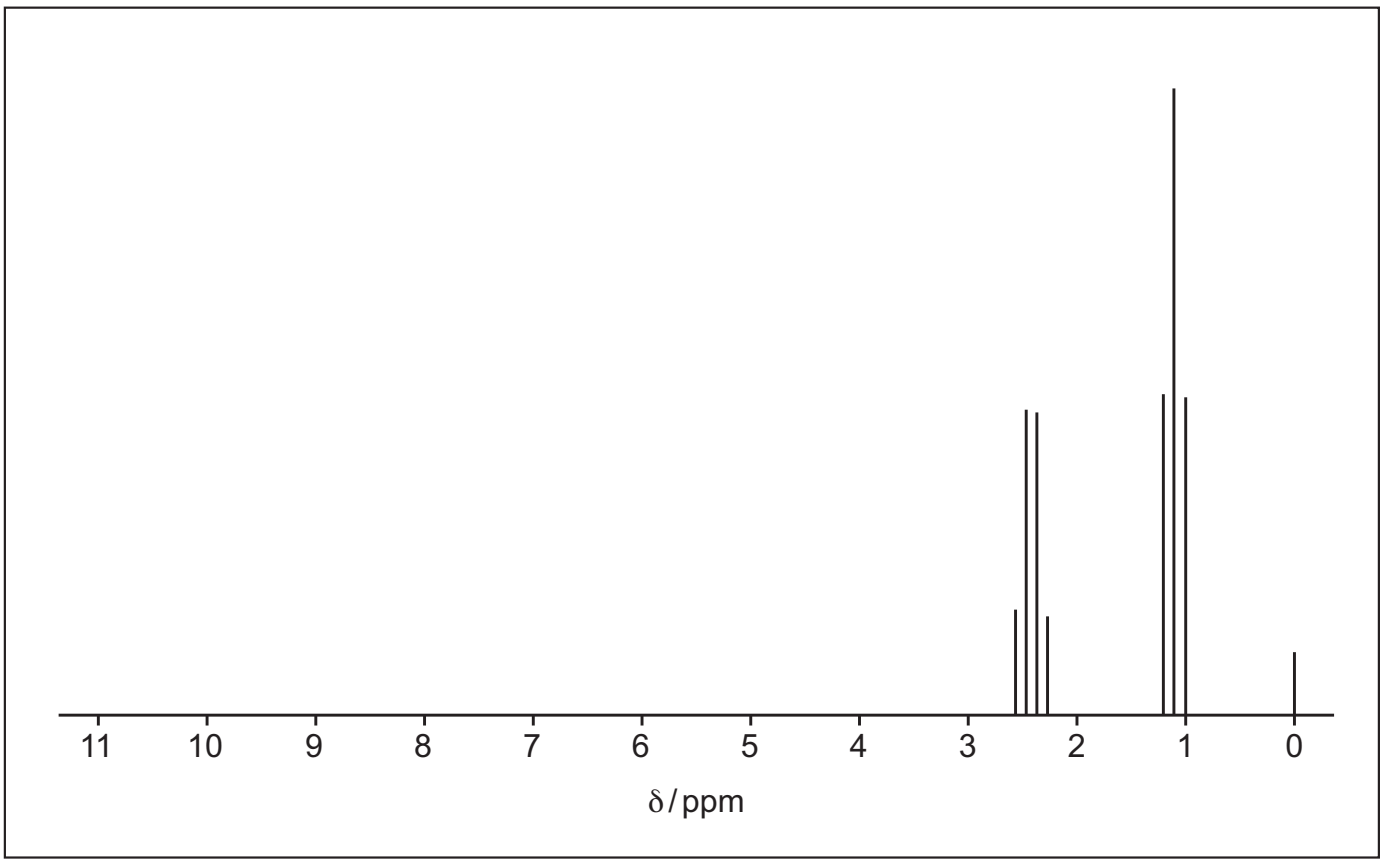


Fig. 7.1

(ii) Identify the compound that gives this spectrum.

..... [1]

(iii) Name the splitting pattern of the peak at δ = 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 δ = 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	$(CH_3)_2CHCH_2CHO$	
S	$(CH_3)_3CCHO$	
T	$CH_3CH_2CH_2COCH_3$	
U	$CH_3CH_2COCH_2CH_3$	

[2]

[Total: 11]