

# Carbonyl Compounds

## Question Paper 1

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	Carbonyl Compounds
<b>Sub-Topic</b>	
<b>Paper Type</b>	Theory
<b>Booklet</b>	Question Paper 1

**Time Allowed:** 70 minutes

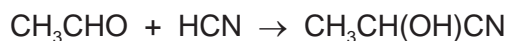
**Score:** /58

**Percentage:** /100

**Grade Boundaries:**

A*	A	B	C	D	E	U
>85%	77.5%	70%	62.5%	57.5%	45%	<45%

- 1 Ethanal reacts with hydrogen cyanide, in the presence of a small amount of NaCN, as shown.



- (a) Use bond energies from the *Data Booklet* to calculate the enthalpy change for this reaction. Include a sign with your answer.

enthalpy change = ..... kJ mol<sup>-1</sup> [3]

- (b) The product of this reaction shows stereoisomerism as it contains a chiral centre. This reaction produces an equimolar mixture of two optical isomers.

- (i) Explain the meanings of the terms *stereoisomerism* and *chiral centre*.

stereoisomerism .....

.....

.....

chiral centre .....

.....

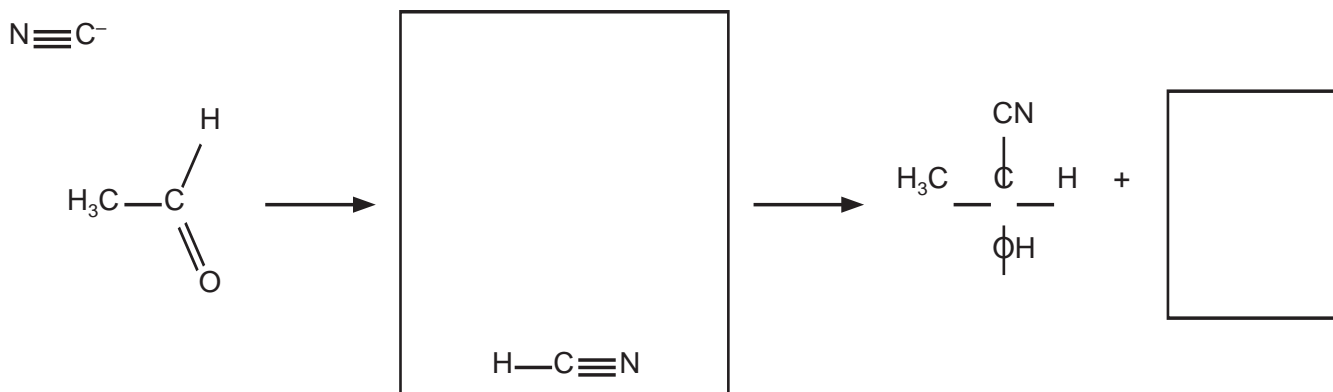
[2]

- (ii) Suggest why the two optical isomers are produced in equal amounts by this reaction.

.....

..... [1]

- (c) (i) Complete the diagram to show the mechanism of this reaction. Include all necessary charges, partial charges, lone pairs and curly arrows and show the structure of the intermediate.



[5]

- (ii) With reference to your mechanism in (i), explain the role of the NaCN in this reaction.

.....

..... [1]

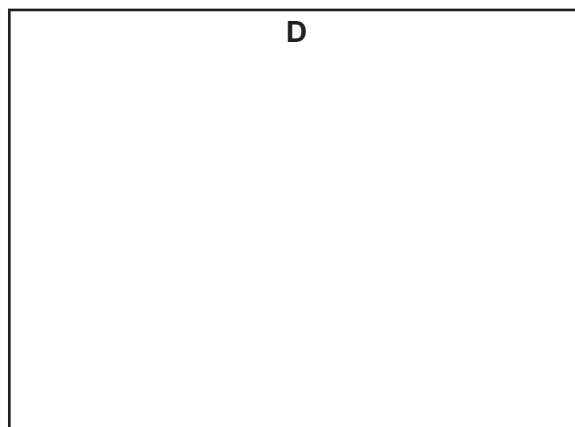
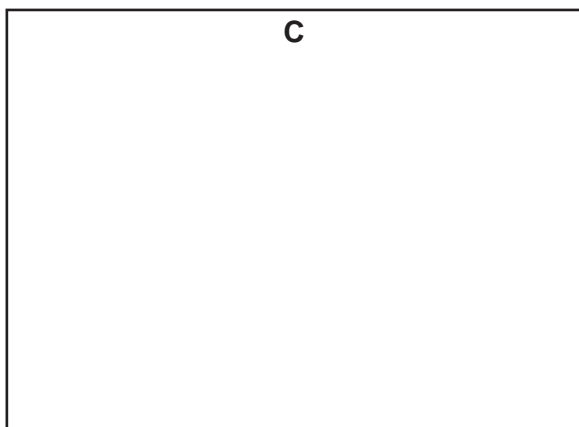
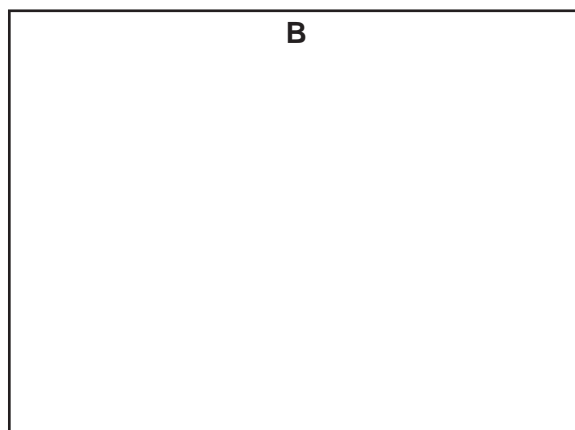
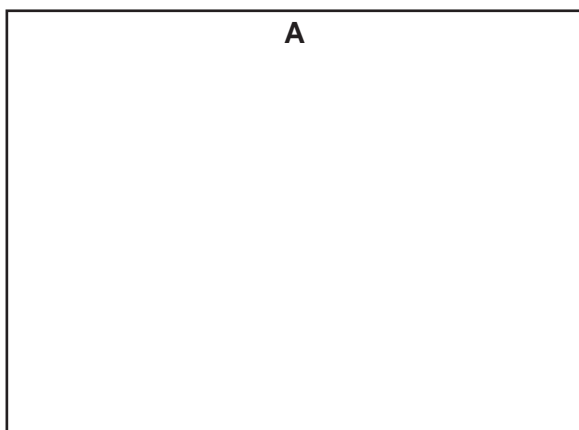
[Total: 12]

- 2 There are seven structural isomers with the molecular formula  $C_5H_{10}O$  that are carbonyl compounds. Four of these are aldehydes.

These four aldehydes, **A**, **B**, **C** and **D**, have the following properties.

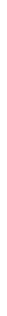
- Aldehyde **A** has a straight chain while **B**, **C** and **D** are branched.
- Aldehyde **B** is the only one of the four isomers with a chiral centre and it exists as a pair of optical isomers.
- Aldehyde **C** has two methyl groups in its structure but **D** has three.

(a) Give the structure of each of the four isomers.



[4]

(ii) Draw the three-dimensional structures of the two optical isomers of **B**.



[2]

- (b) (i) Describe a chemical test that would allow you to distinguish between any of the four isomers **A** to **D** and any of the other three structural isomers of  $C_5H_{10}O$ , that are carbonyl compounds.

In your answer you should describe any necessary reagents and conditions as well as explaining what you would **see** in each case.

.....  
.....  
.....  
.....  
..... [3]

- (ii) Describe a test that would give the same result with all seven carbonyl isomers of  $C_5H_{10}O$ .

.....  
.....  
..... [2]

[Total: 11]

3 A, B, C, D, E and F are all structural isomers with the molecular formula  $C_4H_8O$ .

(a) A, B and C all give an orange precipitate when treated with 2,4-DNPH but only A and B give a brick-red precipitate when warmed with Fehling's solution.

(i) Draw the **skeletal** formulae of A, B and C.

A	B	C

[3]

(ii) Name the type of structural isomerism shown by A and B.

..... [1]

(iii) State what you would **see** when a sample of A is warmed with Tollens' reagent.

..... [1]

(b) **D**, **E** and **F** all decolourise bromine and effervesce slowly with sodium metal.

**E** shows geometrical isomerism. Only **D** has a branched chain.

None of these isomers contains an oxygen atom bonded to a carbon atom involved in  $\pi$  bonding.

None of these isomers contains a chiral centre.

(i) Give the structures of **D**, **E** and **F**. Show the two stereoisomers of **E** and label the stereoisomerism shown.

<p><b>D</b></p>	
<p><b>E</b></p> <p>.....</p>	<p><b>E</b></p> <p>.....</p>
<p><b>F</b></p>	

[5]

(ii) Identify the gas produced during the reaction of each of these isomers with sodium metal.

..... [1]

(c) Another compound, **G**,  $C_3H_6O$ , contains the same functional group as **A**.

Give equations for the reactions of **G** with each of acidified potassium dichromate(VI) and sodium tetrahydridoborate,  $NaBH_4$ , using [O] or [H] as appropriate.

(i) reaction with acidified potassium dichromate(VI)



(ii) reaction with  $NaBH_4$



[Total: 13]

4 **P**, **Q** and **R** are structural isomers with the molecular formula  $C_4H_8$ .

All three compounds readily decolourise bromine in the dark.

**P** and **Q** do not exhibit stereoisomerism but **R** exists as a pair of geometrical (cis-trans) isomers.

All three compounds react with hot concentrated, acidified potassium manganate(VII) to produce a variety of products as shown in the table.

compound	products
<b>P</b>	$CO_2$ and <b>S</b> ( $C_3H_6O$ )
<b>Q</b>	$CO_2$ and $CH_3CH_2CO_2H$
<b>R</b>	$CH_3CO_2H$ only

**S** reacts with 2,4-dinitrophenylhydrazine reagent, 2,4-DNPH, to form an orange crystalline product but does not react with Fehling's reagent.

(a) Give the structural formulae of **P**, **Q**, **R** and **S**.

**P** ..... **Q** .....

**R** ..... **S** .....

[4]

(b) (i) Explain what is meant by the term *stereoisomerism*.

.....  
 .....  
 ..... [2]



(ii) Draw the **displayed** formulae of the geometrical isomers of **R** and name them both.

name ..... name ..... [2]

(c) State a reagent that could be used for the reduction of **S** and **name** the organic product of this reduction.

reagent ..... product ..... [2]

[Total: 10]

5 Crotonaldehyde,  $\text{CH}_3\text{CH}=\text{CHCHO}$ , occurs in soybean oils.

- (a) In the boxes below, write the **structural formula** of the organic compound formed when crotonaldehyde is reacted separately with each reagent under suitable conditions. If you think no reaction occurs, write 'NO REACTION' in the box.

reaction	reagent	product
A	$\text{Br}_2$ in an inert organic solvent	
B	$\text{PCl}_3$	
C	$\text{H}_2$ and Ni catalyst	
D	$\text{NaBH}_4$	
E	$\text{K}_2\text{Cr}_2\text{O}_7/\text{H}^+$	

[5]

- (b) Crotonaldehyde exists in more than one stereoisomeric form. Draw the **displayed formulae** of the **stereoisomers** of crotonaldehyde. Label **each** isomer.

[3]

(c) Draw the **skeletal formula** of crotonaldehyde.

[1]

(d) The product of reaction E in the table opposite will react with a solution containing acidified manganate(VII) ions.

Draw the **structural formulae** of the organic products when the reagent is

(i) cold, dilute;

(ii) hot, concentrated.

[3]

[Total: 12]