

Carbonyl Compounds

Question Paper 2

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Carbonyl Compounds
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 2

Time Allowed: 77 minutes

Score: /64

Percentage: /100

Grade Boundaries:

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

1 Many organic compounds, including alcohols, carbonyl compounds, carboxylic acids and esters, contain oxygen.

(a) The table below lists some oxygen-containing organic compounds and some common laboratory reagents.

(i) Complete the table as fully as you can.

If you think no reaction occurs, write 'no reaction' in the box for the structural formula(e).

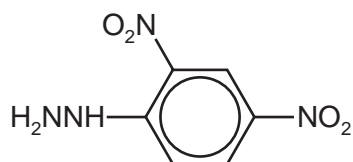
reaction	organic compound	reagent	structural formula(e) of organic product(s)
A	$(\text{CH}_3)_3\text{COH}$	$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ heat under reflux	
B	$\text{CH}_3\text{CH}_2\text{CHO}$	Fehling's reagent warm	
C	$\text{HCO}_2\text{CH}(\text{CH}_3)_2$	$\text{NaOH}(\text{aq})$ warm	
D	$\text{CH}_2=\text{CHCHO}$	NaBH_4	
E	$(\text{CH}_3)_3\text{COH}$	NaBH_4	
F	$\text{CH}_3\text{CH}_2\text{COCH}_3$	$\text{MnO}_4^-/\text{H}^+$ heat under reflux	

- (ii) During some of the reactions in (i) a colour change occurs. Complete the table below for any such reactions, stating the letter of the reaction and what the colour change is.

reaction	colour at the beginning of the reaction	colour at the end of the reaction

[10]

- (b) Some oxygen-containing compounds react with 2,4-dinitrophenylhydrazine.



2,4-dinitrophenylhydrazine

- (i) Draw the structural formula of the organic compound formed when $\text{HOCH}_2\text{CH}_2\text{CHO}$ reacts with 2,4-dinitrophenylhydrazine reagent.

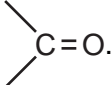
- (ii) Suggest the colour of the organic product.

.....

[2]

[Total: 12]

2 Ketones are widely used as solvents and as intermediates in the chemical industry.

Ketones contain the reactive keto group,  C=O.

(a) Propanone, CH₃COCH₃, undergoes a reaction with hydrogen cyanide, HCN.

(i) What type of reaction is this?

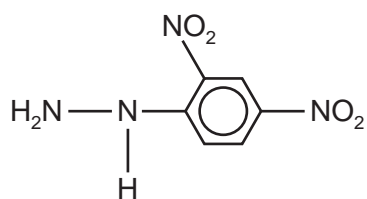
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(ii) What reagents are used?

.....

(iii) Draw a diagram to show the dipole present in the propanone molecule.

(b) Propanone reacts with 2,4-dinitrophenylhydrazine reagent.

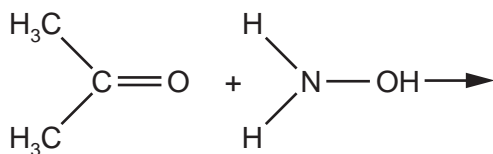


2,4-dinitrophenylhydrazine

(i) Construct a balanced equation for the reaction between propanone and 2,4-dinitrophenylhydrazine.

(ii) A similar type of reaction occurs between propanone and hydroxylamine, NH_2OH .

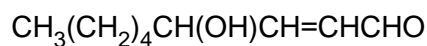
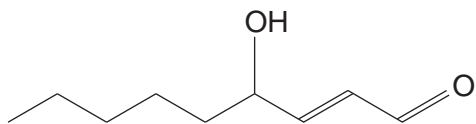
Draw the displayed formula of the organic product of this reaction.



[3]

[Total: 6]

- 3 The compound *trans*-4-hydroxy-2-nonenal (HNE) is thought to lead to infections of the lung when cigarettes are smoked.



***trans*-4-hydroxy-2-nonenal**

- (a) What is the empirical formula of *trans*-4-hydroxy-2-nonenal?

.....

[1]

- (b) (i) HNE contains an alkene group. Name as fully as you can **two** other functional groups which are present in the HNE molecule.

.....

.....

- (ii) How would you confirm the presence of the alkene group in HNE?
State the reagent used and the observation you would make.

reagent

observation

[5]

HNE is a reactive compound.

(c) Give the structural formulae of all of the carbon-containing compounds formed in each case when HNE is reacted separately with the following reagents.

(i) hot concentrated manganate(VII) ions in acid solution

(ii) hot phosphorus trichloride, PCl_3

(iii) sodium tetrahydridoborate(III), $NaBH_4$

[4]

[Total: 10]

- 4 Astronomers using modern telescopes of various types have found many molecules in the dust clouds in space. Many of these molecules are those of organic compounds and astronomers constantly look for evidence that amino acids such as aminoethanoic acid, $\text{H}_2\text{NCH}_2\text{CO}_2\text{H}$, are present.

One molecule that has been found in the dust clouds is hydroxyethanal, HOCH_2CHO .

(a) Hydroxyethanal contains two functional groups.

- (i) Name, **as fully as you can**, each of the functional groups present in hydroxyethanal.

1

2

- (ii) For **each** functional group, identify a reagent that will react with this group and **not** react with the other functional group present.

In each case, describe what would be observed when this reaction is carried out.

functional group 1 reagent

observation.....

functional group 2 reagent

observation.....

[7]

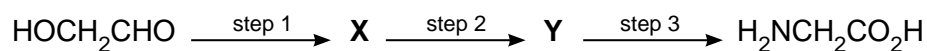
- (b) Give the **skeletal** formulae of the organic compounds formed when hydroxyethanal is reacted separately with the following.

(i) NaBH_4

(ii) $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ under reflux conditions

[2]

In a school or college laboratory, it is possible to convert a sample of hydroxyethanal into aminoethanoic acid in a three-step process.



By considering the possible reactions of the functional groups present in hydroxyethanal, you are to deduce a possible route for this conversion.

- (c) (i) In the boxes below, draw the structural formulae of your suggested intermediates **X** and **Y**.

X	Y
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- (ii) State the reagents for **each** of the three steps you have chosen.

step 1.....

step 2.....

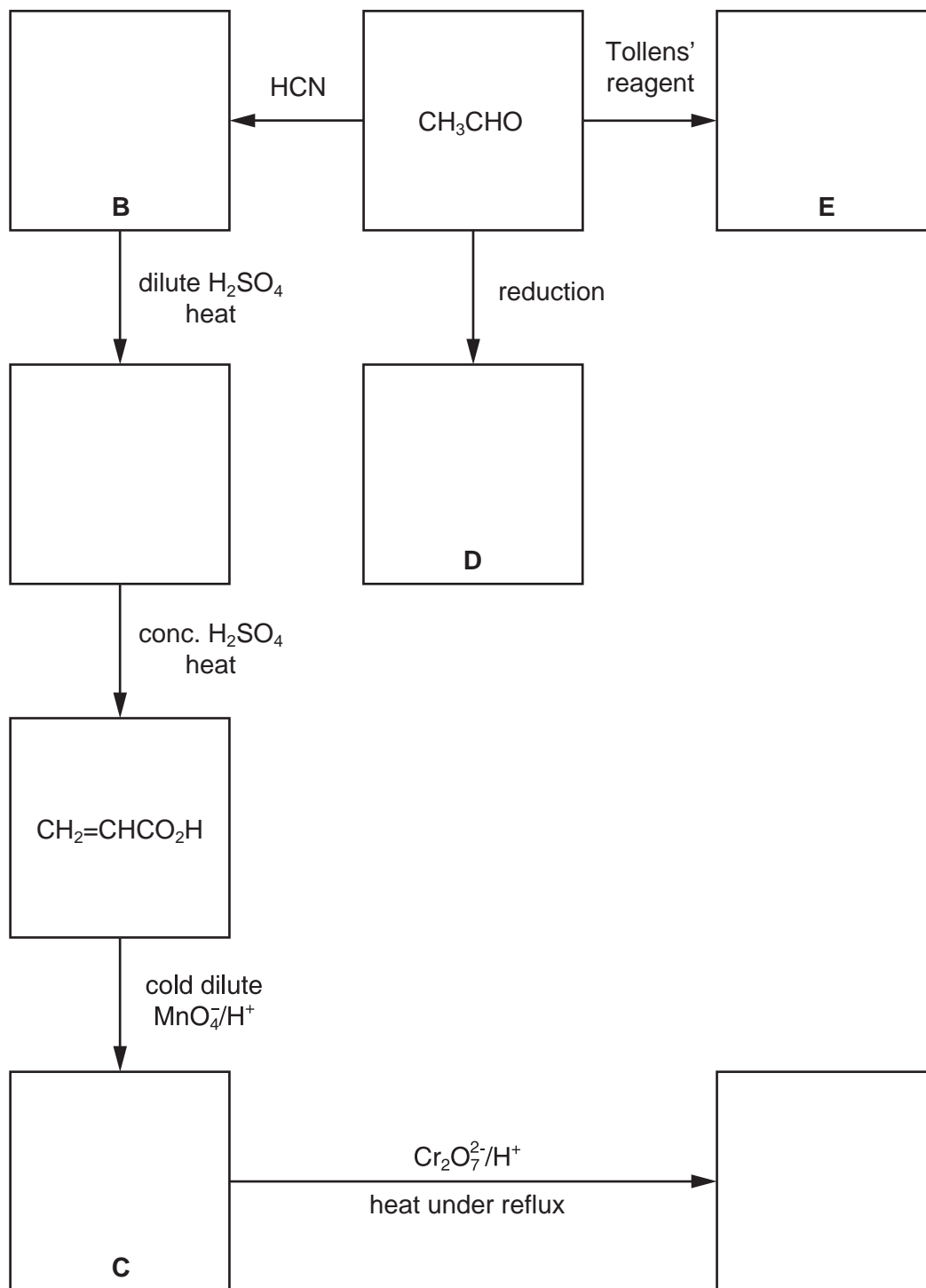
step 3.....

[5]

[Total: 14]

5 (a) Complete the following reaction scheme which starts with ethanal.

In **each empty** box, write the **structural formula** of the organic compound that would be formed.



[6]

(b) Write the structural formula for the organic compound formed when, under suitable conditions,

(i) compound **C** reacts with compound **D**,

(ii) compound **C** reacts with compound **E**.

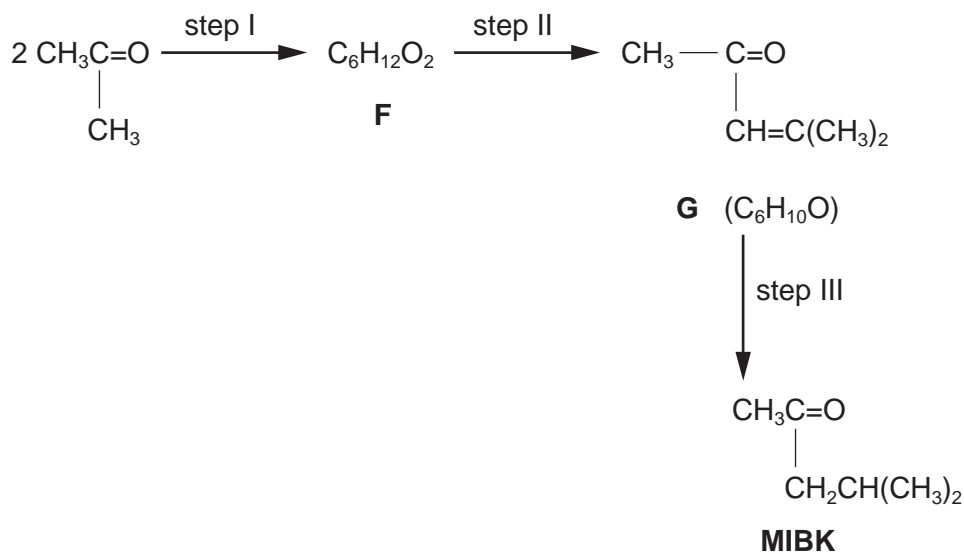
[2]

(c) Compound **B** is chiral. Draw displayed formulae of the two optical isomers of compound **B**, indicating with an asterisk (*) the chiral carbon atom.

[3]

[Total: 11]

- 6 Propanone, CH_3COCH_3 , an important industrial solvent, can be converted into another industrially important solvent, MIBK, by the following sequence.



- (a) When **F** is formed in step I no other compound is produced. Suggest a structural formula for **F**, which contains one -OH group.

[1]

- (b) Compound **G** has two functional groups.

Name **one** functional group present in **G** and show how you would identify it. Put your answers in the table.

functional group in G	reagent used in test	what would be seen

[3]

- (c) **G** is formed from **F** in step II. Use your answers to (a) and (b) to suggest

(i) what type of reaction occurs in step II,

(ii) a reagent for step II.

[2]

- (d) The production of MIBK from **G** in step III involves the hydrogenation of the $>C=C<$ group and is carried out catalytically. A mixture of compounds is formed because the $>C=O$ group is also reduced.

What reagent(s) and solvent are normally used in a laboratory to reduce a $>C=O$ group without reducing a $>C=C<$ group present in the same molecule?

reagent(s)

solvent [2]

G has a number of structural isomers.

- (e) Draw the displayed formulae of a pair of structural isomers of **G** which contain the CH_3CO- group and which exhibit *cis-trans* isomerism.

Label each structure *cis* or *trans* and give your reasoning.

[3]

[Total: 11]