

An Introduction to Organic Chemistry

Question Paper 1

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	An Introduction to Organic Chemistry
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 1

Time Allowed: 82 minutes

Score: /68

Percentage: /100

Grade Boundaries:

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

1 The two compounds **V** and **W** are isomers with the molecular formula C_4H_8O , and show the following properties and reactions.

- Both compounds react with sodium metal, and both decolourise bromine water.
- Compound **V** forms a yellow precipitate with alkaline aqueous iodine, whereas compound **W** does not.
- When reacted with cold $KMnO_4(aq)$, both **V** and **W** produce the same neutral compound **X**, $C_4H_{10}O_3$.
- Both **V** and **W** exist as pairs of stereoisomers.

(a) Suggest which functional groups are responsible for the reactions with

(i) sodium,

.....

(ii) bromine water,

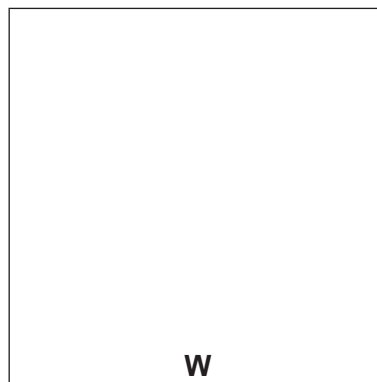
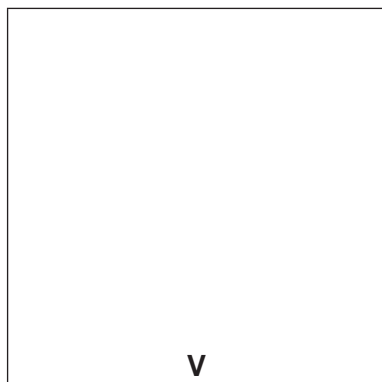
.....

(iii) alkaline aqueous iodine.

.....

[3]

(b) Suggest structures for **V** and **W**.

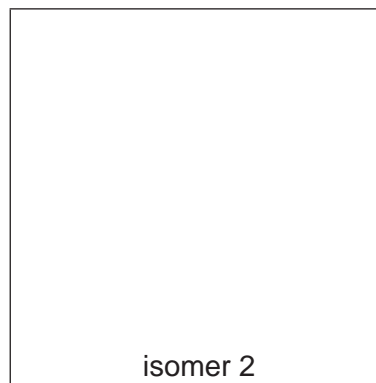
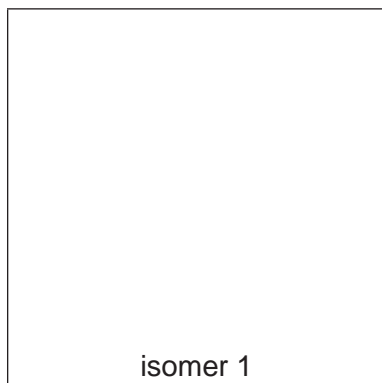


[2]

- (c) State the type of stereoisomerism shown by compound **V** and draw the structures of the stereoisomers.

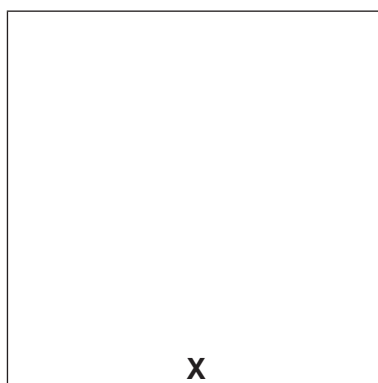
type of stereoisomerism

structures of stereoisomers



[2]

- (d) Suggest the structure of the neutral compound **X**.



[1]

[Total: 8]

- 2 Although now remembered for his music, the Russian composer Alexander Borodin was a chemist. He is credited with the discovery of the *aldol reaction*, a product of which is compound **J**. **J** shows the following properties:

- its molecular formula is $C_4H_8O_2$,
- it is neutral,
- it reacts with sodium metal,
- it reacts with Fehling's solution,
- it does not react with aqueous bromine.

- (a) Suggest which functional groups are responsible for the reactions with

- (i) sodium,

.....

- (ii) Fehling's solution.

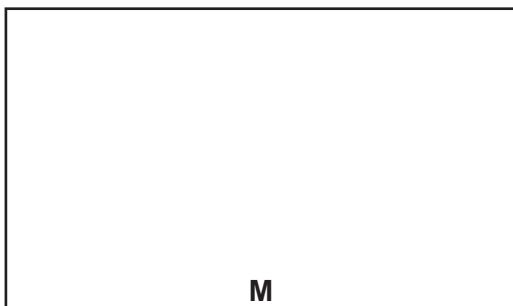
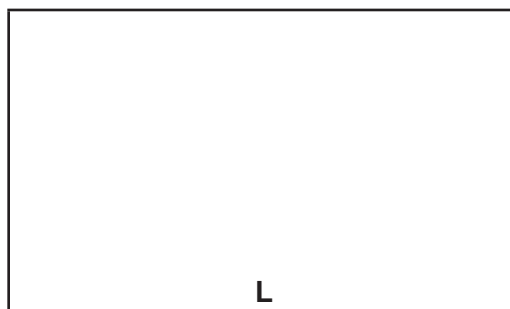
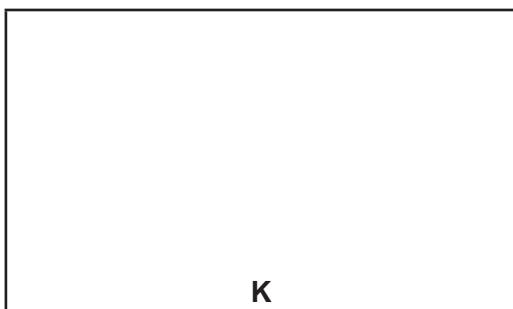
.....

[2]

- (b) The result of the bromine test shows a functional group is absent from compound **J**. Suggest the identity of this functional group.

..... [1]

- (c) In the boxes below, draw three possible **straight-chain** structures for **J** that fit the above results, and that are structural isomers of each other.



[3]

(d) Compound **J** reacts with alkaline aqueous iodine to give a pale yellow precipitate.

(i) Which functional group does this reaction show that **J** contains?

.....

(ii) Which of your three structures **K**, **L** or **M** contains this group and is therefore **J**?

.....

[2]

(e) Compound **J** exists as stereoisomers.

(i) Name the type of stereoisomerism shown by **J**.

.....

(ii) Draw two structures of **J** to illustrate this stereoisomerism.



[2]

[Total: 10]

- 3 Organic chemistry is the chemistry of carbon compounds. The types of organic reactions that you have studied are listed below.

addition	elimination	hydrolysis
oxidation	reduction	substitution

Addition and substitution reactions are further described as follows.

electrophilic	nucleophilic	free radical
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Complete the table below.

Fill in the central column by using **only** the types of reaction given in the lists above.

Use **both** lists when appropriate.

In the right hand column give the formula(e) of the reagent(s) you would use to carry out the reaction given.

organic reaction	type of reaction	reagent(s)
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{Br} \rightarrow$ $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{NH}_2$		
$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH} \rightarrow$ $\text{BrCH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$		
$\text{CH}_3\text{COCH}_3 \rightarrow$ $\text{CH}_3\text{C}(\text{OH})(\text{CN})\text{CH}_3$		
$\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3 \rightarrow$ $\text{CH}_3\text{CH}=\text{CHCH}_3$		

[Total: 11]

4 Compound **X** has the molecular formula $C_4H_8O_2$.

(a) Treatment of **X** with sodium metal produces a colourless flammable gas.
What does this result tell you about the functional groups that could be present in **X**?

.....
.....

(ii) There is no reaction when **X** is treated with sodium hydrogencarbonate, $NaHCO_3$.
What does this result tell you about the functional groups that could be present in **X**?

.....
.....

(iii) When **X** is shaken with aqueous bromine the orange colour disappears.
What does this result tell you about the functional groups that could be present in **X**?

.....
.....

[3]

(b) The molecule of **X** has the following features.

- The carbon chain is unbranched and the molecule is not cyclic.
- No oxygen atom is attached to any carbon atom which is involved in π bonding.
- No carbon atom has more than one oxygen atom joined to it.

There are five possible isomers of **X** which fit these data. Four of these isomers exist as two pairs of stereoisomers.

(i) Draw displayed formulae of **each** of these two pairs.

pair 1		
pair 2		

(ii) These four isomers of **X** show two types of stereoisomerism.

State which type of isomerism each pair shows.

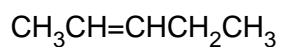
pair 1

pair 2

[6]

[Total: 9]

5 The structural formulae of six different compounds, **P** – **U**, are given below.



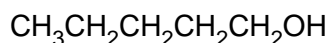
P



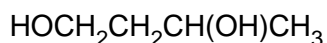
Q



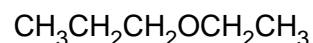
R



S



T



U

(a) (i) What is the empirical formula of compound **T**?

.....

(ii) Draw the skeletal formula of compound **S**.

[2]

(b) (i) Compounds **S** and **U** are isomers.

What type of isomerism do they show?

.....

(ii) Two of the six formulae **P** – **U** can **each** be drawn in two forms which are known as stereoisomers.

Which two compounds have formulae that can be drawn in two forms?

What type of stereoisomerism does each show?

Identify each compound by its letter.

compound	type of stereoisomerism

[3]

(c) Compound **S** can be converted into compound **R**.

(i) What type of reaction is this?

.....

(ii) What reagent would you use for this reaction?

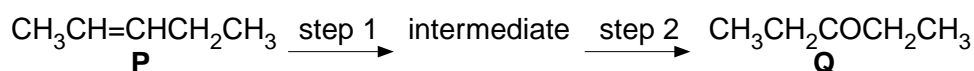
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(iii) Write the structural formula of the compound formed when **T** undergoes the same reaction using an excess of the reagent you have used in (c)(ii).

.....

[3]

(d) Compound **P** may be converted into compound **Q** in a two-step reaction.



(i) What is the structural formula of the intermediate compound formed in this sequence?

(ii) Outline how step 1 may be carried out to give this intermediate compound.

.....
.....
.....

(iii) What reagent would be used for step 2?

.....

[4]

[Total: 12]

- 6 Compound **C** has the molecular formula $C_7H_{14}O$. Treating **C** with hot concentrated acidified $KMnO_4(aq)$ produces two compounds, **D**, C_4H_8O , and **E**, $C_3H_4O_3$. The results of four tests carried out on these three compounds are shown in the following table.

test reagent	result of test with		
	compound C	compound D	compound E
$Br_2(aq)$	decolourises	no reaction	no reaction
$Na(s)$	fizzes	no reaction	fizzes
$I_2(aq) + OH^-(aq)$	no reaction	yellow precipitate	yellow precipitate
2,4-dinitrophenylhydrazine	no reaction	orange precipitate	orange precipitate

- (a) State the functional groups which the above four reagents test for.

(i) $Br_2(aq)$

.....

(ii) $Na(s)$

.....

(iii) $I_2(aq) + OH^-(aq)$

.....

(iv) 2,4-dinitrophenylhydrazine

.....

[4]

- (b) Based upon the results of the above tests, suggest structures for compounds **D** and **E**.

D, C_4H_8O

E, $C_3H_4O_3$

[2]

(c) Compound **C** exists as two stereoisomers.

Draw the structural formula of **each** of the two isomers, and state the type of stereoisomerism involved.

type of stereoisomerism

[3]

[Total: 9]

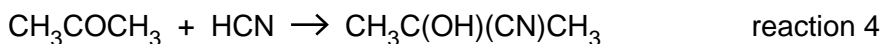
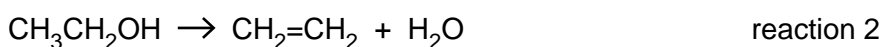
- 7 Organic reactions involve substances which may be
atoms, molecules, ions or free radicals.

We also apply the terms

electrophilic, nucleophilic, addition, elimination and substitution

to organic reactions.

Consider the following reactions.



- (a) Using the terms mentioned above, state as clearly as you can the nature of each of the following reactions.

reaction 1

reaction 2 [2]

- (b) By considering the four reactions above, suggest a formula for **each** of the following substances.

In **each** case, state which reaction you are considering.

- (i) **one** substance that is an addition product

reaction..... addition product

- (ii) **one** substance that is a leaving group

reaction..... leaving group

- (iii) **one** substance that behaves as an electrophile

reaction..... electrophile

(c) What is meant by the term *nucleophile*?

.....
..... [1]

(d) Reactions 3 and 4 involve nucleophiles.

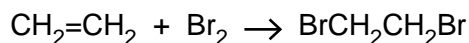
For **each** reaction, give the formula of the nucleophile.

reaction 3

reaction 4

[2]

(e) One characteristic reaction of ethene is its ability to decolourise bromine.



In this reaction, ethene behaves as a nucleophile.

Suggest an explanation for how ethene can behave in this way.

.....
..... [1]

[Total: 9]