Alcohols

Question Paper 3

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Hydroxy Compounds
Sub-Topic	Alcohols
Paper Type	Theory
Booklet	Question Paper 3

Time Allowed: **87 minutes**

Score: **/72**

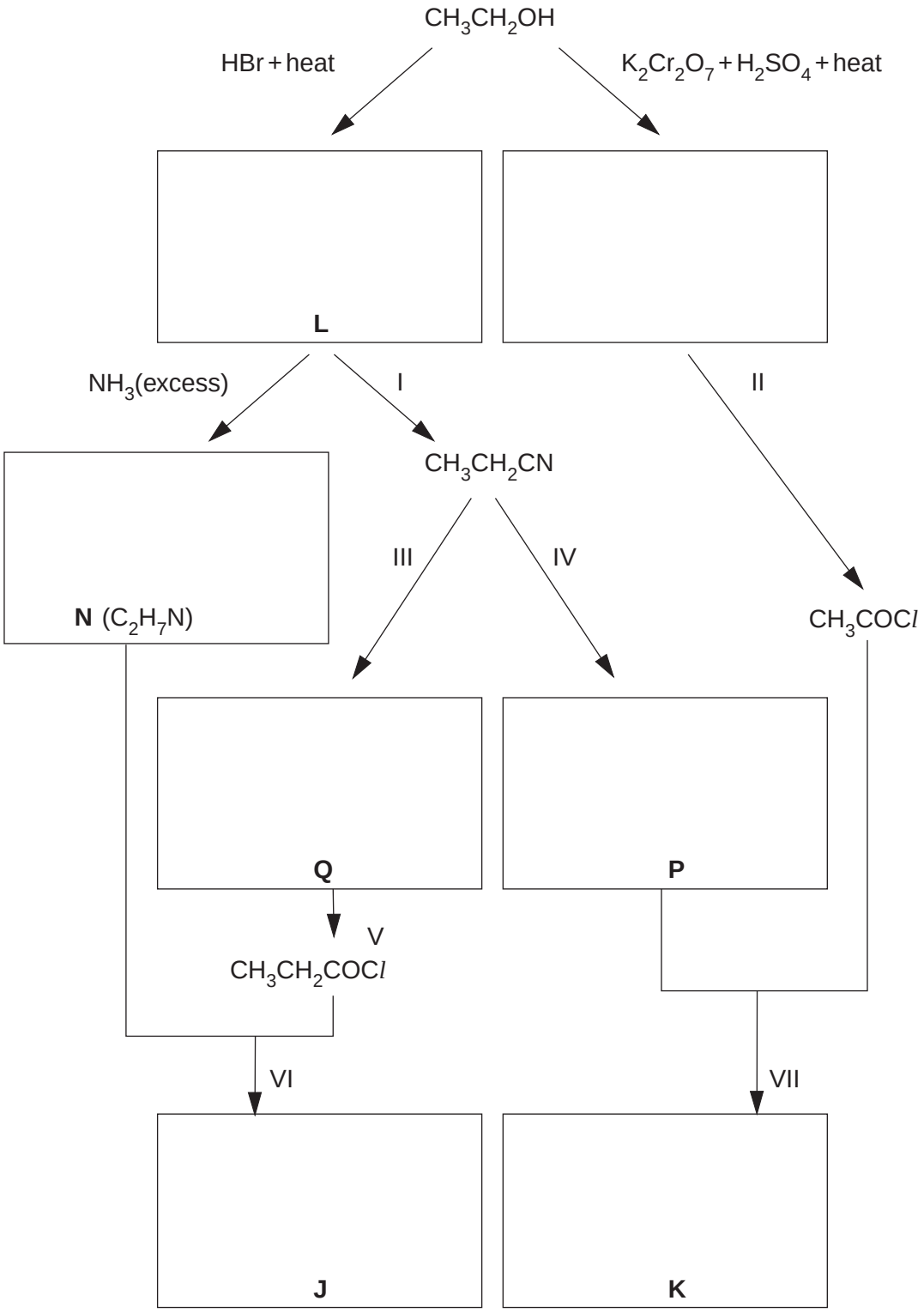
Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E	U
>85%	777.5%	70%	62.5%	57.5%	45%	<45%

1 Compounds **J** and **K** are isomers with the molecular formula $C_5H_{11}NO$, and they contain the same functional group.

They may both be obtained from ethanol by the following routes.



(a) Draw the structural formulae of the lettered compounds **J** to **Q** in the boxes above. [7]

(b) Suggest reagents and conditions for the following.

reaction I

.....

reaction II

.....

reaction IV

.....[3]

(c) What *type of reaction* is occurring in

reaction IV,

.....

reaction VI?

.....[2]

(d) **(i)** Name the functional group that is common to compounds **J** and **K**.

.....

(ii) Name the functional group that is common to compounds **N** and **P**.

.....[2]

[Total: 14]

2 Commercial paint and varnish removers contain a mixture of dichloromethane, CH_2Cl_2, and methanol, CH_3OH.

(a) What would be observed when the following reactions are carried out?
In each case, give the name or formula of the reaction product which is responsible for the observation you have made.

(i) CH_2Cl_2 is reacted with NaOH(aq) and $AgNO_3$(aq) and the mixture left to stand.

observation .....

product responsible .....

(ii) CH_3OH is mixed with PCl_5.

observation .....

product responsible .....

(iii) CH_3OH is reacted with sodium.

observation .....

product responsible .....

[6]

(b) When CH_2Cl_2 is heated under reflux with an excess of NaOH(aq), a compound **W** is formed.

W has the following composition by mass: C, 40.0%; H, 6.7%; O, 53.3%.

Use this information and the *Data Booklet* to show that the empirical formula of **W** is CH_2O.

[2]

(c) Compounds with the empirical formula CH_2O can have the molecular formula $C_2H_4O_2$.

Two possible structural formulae for compounds with molecular formula $C_2H_4O_2$ are HCO_2CH_3 and $H_2C{=}C(OH)_2$.

In the boxes below, draw displayed formulae for **three further** structural isomers with the molecular formula $C_2H_4O_2$.

Do **not** attempt to draw any structures containing rings or O–O bonds.

X	**Y**	**Z**

[3]

(d) Identify which of your compounds, **X**, **Y**, or **Z**, will react with the following reagents.

In **each** case, state what you would observe.

(i) solid $NaHCO_3$

compound .....

observation .....

(ii) Tollens' reagent

compound .....

observation .....

[4]

(e) **One** of the three compounds, **X**, **Y**, or **Z**, shows stereoisomerism.

Draw displayed, labelled structures of the stereoisomers of this compound.

[2]

[Total: 17]

3 Many organic reactions are substitution reactions in which the number of carbon atoms in the organic compound is unchanged.

(a) What is meant by the term *substitution reaction*?

.....

.....[1]

(b) One example of a substitution reaction is the formation of an alcohol from a halogenoalkane.

(i) Write a balanced equation for the formation of ethanol from bromoethane.

.....

(ii) State the conditions for this reaction.

.....[2]

(c) In a few organic reactions, the product contains **one** more carbon atom than the starting material.

(i) Write the equation for a reaction in which the organic compound bromoethane, which contains **two** carbon atoms, is converted into an organic compound which contains **three** carbon atoms.

.....

(ii) State the conditions for this reaction.

.....[2]

(d) Ethanol may be converted into propanoic acid in a three-stage process which uses ethanol as the only organic compound.

$$C_2H_5OH \xrightarrow{\text{step I}} \mathbf{K} \xrightarrow{\text{step II}} \mathbf{L} \xrightarrow{\text{step III}} C_2H_5CO_2H$$

(i) Give the structural formulae of the intermediate compounds **K** and **L**.

K .....

L .....

(ii) State the reagent(s) used and give the essential condition(s) for step I and for step III.

step I

reagent(s) .....

condition(s) .....

step III

reagent(s) .....

condition(s).....

[6]

[Total: 11]

4 Octadecane, $C_{18}H_{38}$, is a long chain hydrocarbon which is present in crude oil. Such long chain hydrocarbons are 'cracked' to produce alkanes and alkenes which have smaller molecules.

(a) Give **two** different conditions under which long chain molecules may be cracked.

.....

.....

..... [2]

(b) Octadecane, $C_{18}H_{38}$, can be cracked to form hexane and an alkene.

Write a balanced equation for this reaction.

..... [1]

Alkenes are important industrially because the C=C bond makes them very reactive.

(c) Ethene reacts with bromine to give 1,2-dibromoethane.

(i) What type of reaction is this?

.....

(ii) Outline the mechanism of this reaction, giving the structure of the intermediate.

Show clearly any relevant dipoles, charges and lone pairs of electrons.

[4]

The unsaturated hydrocarbon **Z** is obtained by cracking hexane and is important in the chemical industry.

The standard enthalpy change of combustion of **Z** is –2059 kJ mol^{-1}.

(d) Define the term *standard enthalpy change of combustion*.

.....

..... [2]

When 0.47 g of **Z** were completely burnt in air, the heat produced raised the temperature of 200 g of water by 27.5 °C.

(e) **(i)** Calculate the amount of heat released in this experiment.

(ii) Use the data above and your answer to **(i)** to calculate the relative molecular mass of **Z**.

[4]

(f) Deduce the molecular formula of **Z**.

[1]

(g) The unsaturated hydrocarbon **Z** can be polymerised.

Draw the structure of the polymer of **Z** showing **two** repeat units.

[1]

[Total: 15]

5 Lactic acid, 2-hydroxypropanoic acid, $CH_3CH(OH)CO_2H$, occurs in sour milk.

Glycollic acid, 2-hydroxyethanoic acid, $HOCH_2CO_2H$, occurs in sugar cane.

(a) Lactic acid may be synthesised from propene by the following sequence.

$$CH_3CH{=}CH_2 \xrightarrow{\text{step I}} CH_3CH(OH)CH_2OH \xrightarrow{\text{step II}} CH_3CH(OH)CO_2H$$

(i) What reagent(s) and condition(s) are used for step I?

reagent(s) .....

condition(s) .....

(ii) What type of reaction is step II?

.....

[3]

(b) Glycollic acid may be synthesised from ethanoic acid by the following sequence.

$$CH_3CO_2H \xrightarrow{\text{step III}} ClCH_2CO_2H \xrightarrow{\text{step IV}} HOCH_2CO_2H$$

(i) Suggest the reagent(s) and condition(s) that are used for step III.

reagent(s) .....

condition(s) .....

(ii) What reagents and conditions are used in step IV?

reagent(s) .....

condition(s) .....

[4]

(c) Lactic acid and glycollic acid react differently when heated under reflux with acidified dichromate(VI) ions.

Draw the structural formula of the organic product in **each** case.

product from lactic acid product from glycollic acid

[2]

(d) Lactic acid is chiral. Draw displayed formulae of the two optical isomers of lactic acid clearly showing their three-dimensional structures. Indicate with an asterisk (*) the chiral carbon atom in each.

[2]

Glycollic acid and lactic acid each give the reactions of an alcohol group and of a carboxylic acid group. Each compound will react with the other to give an ester.

(e) When one molecule of glycollic acid reacts with one molecule of lactic acid, it is possible to form two different esters.

Draw the structure of **each** of these esters.

[2]

Glycollic acid and lactic acid are reacted together to make the material for 'soluble stitches' (also known as 'soluble sutures') which are used in surgery.

In this material, many molecules of each acid have been reacted to form a long chain 'polyester' molecule which contains many ester groups.

This polyester is used in surgery to sew up wounds inside the body.

Over a period of time, the polyester undergoes a chemical reaction and breaks up to re-form the two individual hydroxy-acids.

(f) **(i)** This reaction occurs where the pH of the body is about pH5 to pH6. Suggest what type of chemical reaction causes the polyester material to break up.

.....

(ii) Suggest why the products of this reaction are soluble in water.

.....

.....

[2]

[Total: 15]