

# Alcohols

## Question Paper 2

<b>Level</b>	International A Level
<b>Subject</b>	Chemistry
<b>Exam Board</b>	CIE
<b>Topic</b>	Hydroxy Compounds
<b>Sub-Topic</b>	Alcohols
<b>Paper Type</b>	Theory
<b>Booklet</b>	Question Paper 2

**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 molecular formula  $C_4H_9OH$  represents four different alcohols, **W**, **X**, **Y** and **Z**.

W	X	Y	Z
$CH_3CH_2CH_2CH_2OH$	$CH_3CH_2CH(OH)CH_3$	$(CH_3)_2CHCH_2OH$	$(CH_3)_3COH$

- (a) Draw the **skeletal formula** of **Z**.

[1]

- (b) Acidified potassium dichromate(VI) is used as an oxidising agent in organic chemistry.

Give the **structural formula** of the organic product formed when **each** of the four alcohols above is heated under reflux with acidified potassium dichromate(VI).  
If you believe that no reaction occurs, write 'no reaction' in the box.

<b>W</b>	
<b>X</b>	
<b>Y</b>	
<b>Z</b>	

[4]

- (c) One of the alcohols, **W**, **X**, **Y** or **Z**, can be dehydrated to give more than one organic product.

Identify this alcohol and give the structural formulae of **two** of the products.

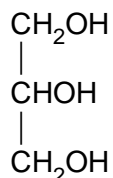
alcohol	
product 1	
product 2	

[2]

[Total: 7]

- 2 Although there are many different types of food eaten around the world, animal fats and/or vegetable oils are commonly used in cooking.

Animal fats and vegetable oils are usually glyceryl esters, that is esters of glycerol, propane-1,2,3-triol.



Many animal fats contain esters of stearic acid,  $\text{CH}_3(\text{CH}_2)_{16}\text{CO}_2\text{H}$ .

Vegetable oils often contain esters of oleic acid,  $\text{CH}_3(\text{CH}_2)_7\text{CH}=\text{CH}(\text{CH}_2)_7\text{CO}_2\text{H}$ .

- (a) Draw the structural formula of the glyceryl ester formed when one molecule of glycerol is completely esterified with stearic acid.

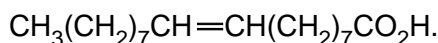
[1]

- (b) What reagent(s) would you use, in a school or college laboratory, to obtain a small sample of oleic acid,  $\text{C}_{17}\text{H}_{33}\text{CO}_2\text{H}$ , from the glyceryl ester present in a vegetable oil?

.....

[1]

Oleic acid is the *cis* isomer and elaidic acid the *trans* isomer of



- (c) By using this formula, draw the structural formula of elaidic acid, clearly showing the stereochemistry.

[1]

Oleic and elaidic acids are examples of mono-unsaturated acids. Many vegetable oils contain esters of polyunsaturated fatty acids. Such oils are often hydrogenated to form esters containing saturated or mono-unsaturated fatty acids.

(d) (i) Suggest the meaning of the term *polyunsaturated fatty acid*.

.....  
.....

(ii) What reagent and condition(s) are used for the hydrogenation of an unsaturated fatty acid?

reagent .....

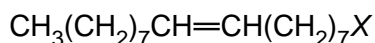
condition(s) .....

[3]

In cooking, unsaturated fats are often oxidised to give aldehydes or ketones.

(e) (i) Give the structural formulae of the two aldehydes formed by the partial oxidation of the unsaturated fat below.

In the structure, X, represents the rest of the fat molecule.



(ii) Name the reagent you would use to show that the product contained **either** an aldehyde **or** a ketone. What change would be seen?

reagent .....

observation .....

(iii) What reagent would you use to **confirm** the presence of an aldehyde? What change would be seen?

reagent .....

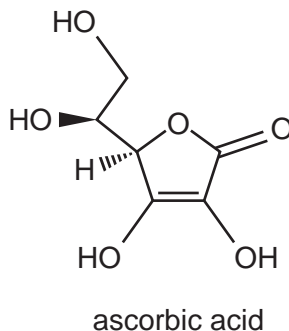
observation .....

[6]

Animal fats and vegetable oils can become rancid because of oxidation. The rancid fat or oil has an unpleasant smell and taste.

Antioxidants are used to prevent the spoilage of many foodstuffs by oxidation.

One antioxidant that is widely used is vitamin C, ascorbic acid.



- (f) (i) How many chiral carbon atoms are present in one molecule of ascorbic acid?  
If none, write 'none'.

.....

- (ii) The ascorbic acid molecule contains three functional groups.

Two of these are alcohol (primary and secondary) and alkene.

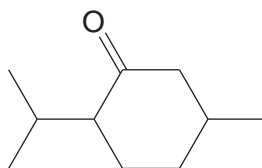
What is the name of the third functional group?

.....

[2]

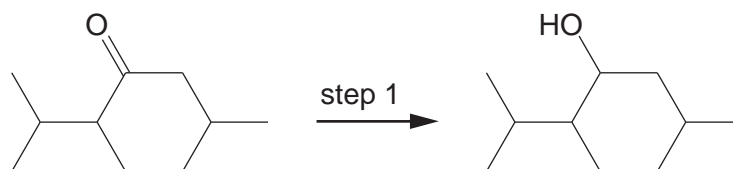
[Total: 14]

- 3 Menthone,  $C_{10}H_{18}O$ , is a cyclic ketone that occurs in oil of peppermint.



menthone

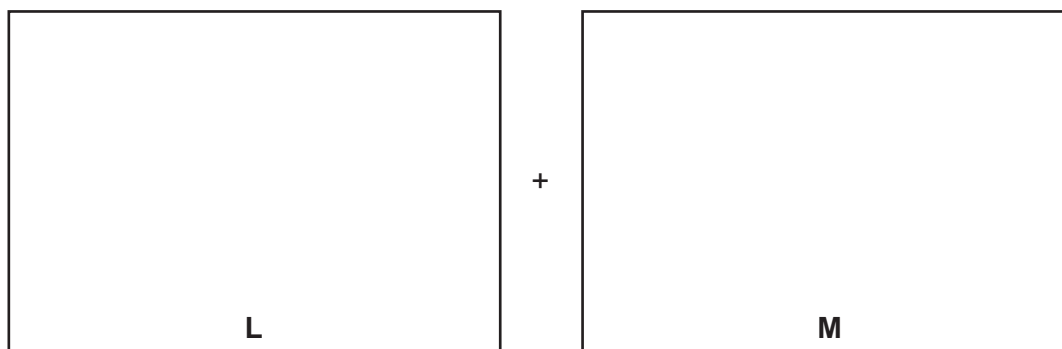
- (a) Use asterisks (\*) on the formula above to identify any chiral centres in the molecule of menthone. [2]
- (b) Menthone can be reduced to menthol, which can be dehydrated to a mixture of two alkenes, **L** and **M**.



menthone

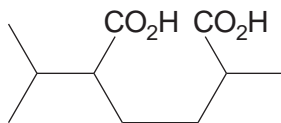
menthol

step 2



- (i) Suggest reagents for  
 step 1, .....
- step 2. ....
- (ii) Suggest structures for **L** and **M** and draw them in the boxes above. [4]

- (c) When heated with concentrated, acidified  $\text{KMnO}_4(\text{aq})$ , one of the two alkenes **L** or **M** produces the dicarboxylic acid **N**.

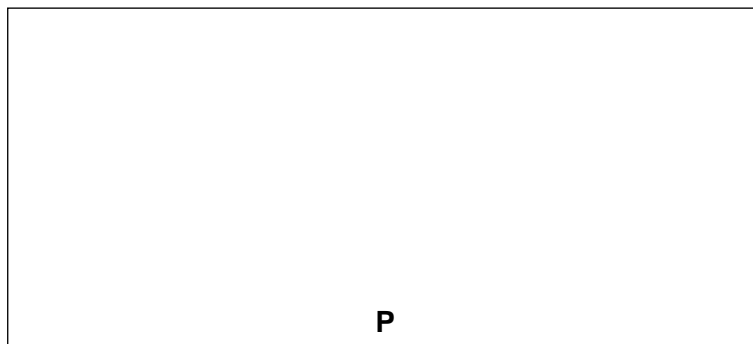


**N**

- (i) Give the letter of the alkene that produced **N** by this reaction.

.....

- (ii) Suggest the structure of the product, **P**, of the reaction between the other alkene you have drawn and hot concentrated acidified  $\text{KMnO}_4$ .



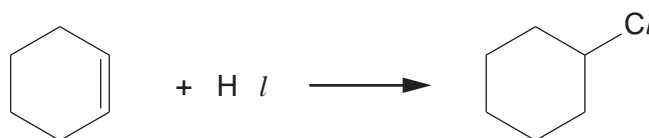
- (iii) Suggest **one** chemical test that would enable you to distinguish between **N** and **P**.

reagent(s).....

observation.....

[3]

- (d) Chlorocyclohexane can be prepared by bubbling  $\text{HCl}(\text{g})$  through a solution of cyclohexene.



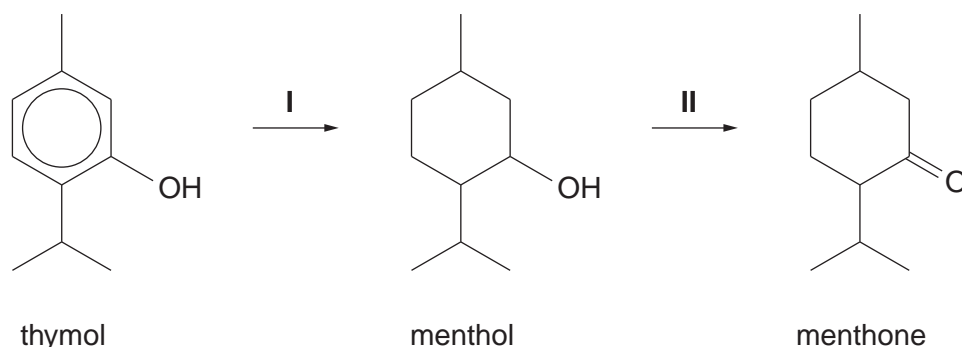
Suggest the mechanism of this 2-stage reaction by means of a diagram. Include all whole or partial charges, and represent the movements of electron pairs by curly arrows.

[3]

[Total: 12]



- 4 Menthol and menthone, the main constituents of oil of peppermint, can be made synthetically from thymol by the following route.



- (a) State the *type of reaction of*

- reaction I, .....
- reaction II. ....

[2]

- (b) Suggest **one** test for **each** of the three compounds that would give a positive result with the stated compound but a negative result with **both** the other two compounds.

***thymol***

test .....

observation .....

***menthol***

test .....

observation .....

***menthone***

test .....

observation ..... [6]

[Total: 8]

- 5 (a) In the following boxes draw the structural formulae of **three** alcohols having straight (i.e. unbranched) chains, with the molecular formula  $C_5H_{12}O$ .

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A

B

C

[2]

Use the letters **A**, **B** or **C** as appropriate when answering the following questions. Each letter may be used once, more than once or not at all.

- (b) Which of the alcohols are chiral?..... [1]

- (c) (i) Which of these alcohols react with alkaline aqueous iodine? .....

- (ii) Describe the observation you would make during this reaction.

.....

- (iii) Draw the structural formulae of the products of this reaction.

[4]

- (d) Draw the structural formula of the product obtained when **each** of the alcohols **A**, **B** and **C** is heated with an excess of acidified  $K_2Cr_2O_7(aq)$ .

A →

--

B →

--

C →

--

[3]

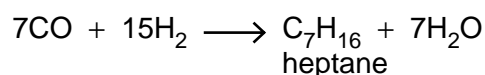
(e) One of the many suggestions for converting biomass into liquid fuel for motor transport is the pyrolysis (i.e. heating in the absence of air) of cellulose waste, followed by the synthesis of alkanes.

(i) In the first reaction, cellulose,  $(C_6H_{10}O_5)_n$ , is converted into a mixture of carbon monoxide and hydrogen. Some carbon is also produced.

Complete and balance the equation for this reaction.



(ii) The second reaction involves the combination of CO and  $H_2$  to produce alkanes such as heptane.



Using the value of  $1080 \text{ kJ mol}^{-1}$  as the value for the  $C\equiv O$  bond energy in CO, and other relevant bond energies from the *Data Booklet*, calculate the  $\Delta H$  for this reaction.

$$\Delta H = \text{.....} \text{ kJ mol}^{-1}$$

[5]

[Total: 15]

6 The fermentation of starch or molasses using the bacterium *Clostridium acetobutylicum*, produces a mixture of propanone and butan-1-ol.

(a) Give the reagent(s) and state what would be observed when **one** test is carried out to confirm the presence of propanone in a mixture of propanone and butan-1-ol.

reagent(s) .....

observation ..... [2]

(b) What will be observed when a small piece of sodium metal is dropped into a dry sample of butan-1-ol? Write an equation for the reaction that takes place.

observation .....

equation ..... [2]

The molecular formula  $C_5H_{12}O$  represents a number of alcohols.  
Three alcohols with molecular formula  $C_5H_{12}O$  are straight chain pentanols.

(c) Draw the following formulae.

(i) the **structural** formula of pentan-1-ol

(ii) the **displayed** formula of pentan-2-ol

(iii) the **skeletal** formula of pentan-3-ol

When one of the three pentanols in (c) is dehydrated, alkenes with **two** different structural formulae are formed.

(d) Identify this alcohol and give the structural formula of **each** alkene.

name of alcohol .....

alkene 1	alkene 2
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[3]

A number of alcohols with molecular formula  $C_5H_{12}O$  are branched chain compounds and may be considered as derivatives of butanol or propanol with alkyl side chains.

(e) (i) Draw the structural formula of the **derivative of propanol** that has the molecular formula  $C_5H_{12}O$ .

(ii) Draw the structural formula of the organic compound that will be present when the derivative of propanol you have given in (i) is heated under reflux with acidified potassium dichromate(VI).

[2]

[Total: 12]