

Alcohols

Question Paper 4

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Hydroxy Compounds
Sub-Topic	Alcohols
Paper Type	Theory
Booklet	Question Paper 4

Time Allowed: 76 minutes

Score: /63

Percentage: /100

Grade Boundaries:

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

1 Alcohols are widely used as solvents and in the manufacture of esters.

Butan-1-ol, $C_4H_{10}O$, is an example of a primary alcohol.

(a) What is meant by the term *primary alcohol*?

..... [1]

(b) There are three more alcohols with molecular formula $C_4H_{10}O$ that are **structural** isomers of butan-1-ol.

Complete the table below by drawing displayed formulae of **each** of these three compounds.

For **each** isomer, state whether it is a primary, secondary, or tertiary alcohol.

$ \begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{OH} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $			
primary			
butan-1-ol	isomer 2	isomer 3	isomer 4

[6]

(c) Butan-1-ol can be oxidised to a carboxylic acid by heating with an acidified solution of potassium dichromate(VI).

(i) What colour change would be seen during this reaction?

from to



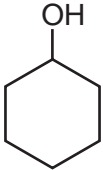
(ii) State which of the isomers you have drawn in **(b)** could also be oxidised to form a carboxylic acid.

.....

[3]

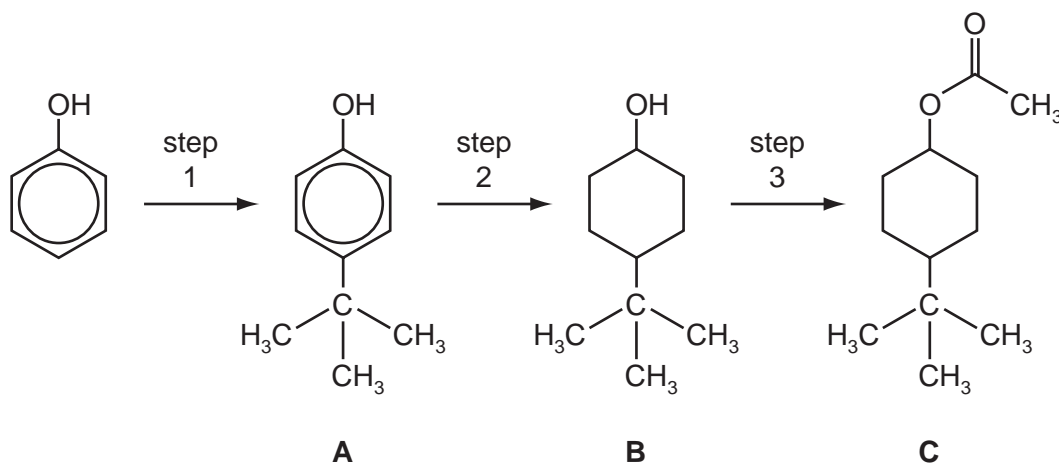
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- 2 (a) A series of experiments is carried out in which the reagent shown at the top of the column of the table is mixed, in turn, with each of the reagents at the side. Complete the following table by writing in each box the formula of any gas produced. Write **x** in the box if no gas is produced. The first column has been completed as an illustration.

	H ₂ O			
Na	H ₂			
KOH(aq)	x			
Na ₂ CO ₃ (aq)	x			

[5]

- (b) Compound **C** is responsible for the pleasant aroma of apples. It can be prepared from phenol by the following 3-step synthesis.



- (i) The only by-product of step 1 is HCl. Suggest the reagent that was used to react with phenol to produce compound **A**.
-
- (ii) What *type of reaction* is occurring in step 2?
-
- (iii) What reagents and conditions are required for step 3?
-
- (iv) State the reagent and conditions needed to convert **C** back to **B**, the reverse of step 3.
-

[5]

- (c) (i) Either compound **A** or compound **B**, or both, react with the following reagents. For each reagent draw the structure of the organic product formed with **A**, and with **B**. If no reaction occurs, write 'no reaction' in the relevant box.

reagent and conditions	product with A	product with B
an excess of Br ₂ (aq)		
heat with HBr		
pass vapour over heated Al ₂ O ₃		
heat with acidified K ₂ Cr ₂ O ₇		

- (ii) Choose **one** of the above reactions to enable you to distinguish between **A** and **B**.

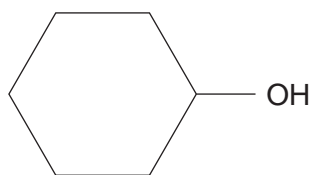
State below the observations you would make with each compound.

reagent	observation with A	observation with B

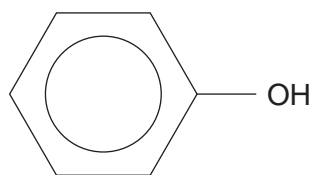
[7]

[Total: 17]

- 3 Cyclohexanol and phenol are both solids with low melting points that are fairly soluble in water.



cyclohexanol



phenol

- (a) Explain why these compounds are more soluble in water than their parent hydrocarbons cyclohexane and benzene.

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

- (b) Explain why phenol is more acidic than cyclohexanol.

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

- (c) For **each** of the following reagents, draw the structural formula of the product obtained for **each** of the two compounds. If no reaction occurs write **no reaction** in the box.

reagent	product with cyclohexanol	product with phenol
Na(s)		
NaOH(aq)		
Br ₂ (aq)		
I ₂ (aq) + OH ⁻ (aq)		
an excess of acidified Cr ₂ O ₇ ²⁻ (aq)		

[7]

- (d) Choose **one** of the above five reagents that could be used to distinguish between cyclohexanol and phenol. Describe the observations you would make with each compound.

reagent

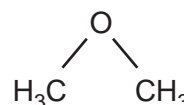
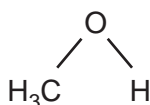
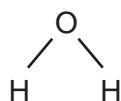
observation with cyclohexanol

observation with phenol

[2]

[Total: 13]

- 4 The structural formulae of water, methanol and methoxymethane, CH_3OCH_3 , are given below.



- (a) (i) How many lone pairs of electrons are there around the oxygen atom in methoxymethane?

.....

- (ii) Suggest the size of the C–O–C bond angle in methoxymethane.

.....

[2]

The physical properties of a covalent compound, such as its melting point, boiling point, vapour pressure, or solubility, are related to the strength of attractive forces between the molecules of that compound.

These relatively weak attractive forces are called intermolecular forces. They differ in their strength and include the following.

- A interactions involving permanent dipoles
- B interactions involving temporary or induced dipoles
- C hydrogen bonds

- (b) By using the letters **A**, **B**, or **C**, state the **strongest** intermolecular force present in **each** of the following compounds.

For each compound, write the answer on the dotted line.

ethanal CH_3CHO

ethanol $\text{CH}_3\text{CH}_2\text{OH}$

methoxymethane CH_3OCH_3

2-methylpropane $\text{C(CH}_3)_3$

[4]

(c) Methanol and water are completely soluble in each other.

(i) Which intermolecular force exists between methanol molecules and water molecules that makes these two liquids soluble in each other?

.....

(ii) Draw a diagram that clearly shows this intermolecular force. Your diagram should show any lone pairs or dipoles present on either molecule that you consider to be important.

[4]

(d) When equal volumes of ethoxyethane, $C_2H_5OC_2H_5$, and water are mixed, shaken, and then allowed to stand, two layers are formed.

Suggest why ethoxyethane does not fully dissolve in water. Explain your answer.

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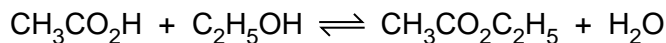
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..... [2]

[Total: 12]

- 5 Alcohols and esters are important organic compounds which are widely used as solvents. Esters such as ethyl ethanoate can be formed by reacting carboxylic acids with alcohols.



This reaction is an example of a dynamic equilibrium.

- (a) Explain what is meant by the term *dynamic equilibrium*.

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

- (b) Write the expression for the equilibrium constant for this reaction, K_c .

[1]

- (c) For this equilibrium, the value of K_c is 4.0 at 298 K. A mixture containing 0.5 mol of ethanoic acid, 0.5 mol ethanol, 0.1 mol ethyl ethanoate and 0.1 mol water was set up and allowed to come to equilibrium at 298 K. The final volume of solution was $V \text{ dm}^3$.

Calculate the amount, in moles, of each substance present at equilibrium.

[4]

Alcohols may be classified into primary, secondary and tertiary. Some reactions are common to all three types of alcohol. In other cases, the same reagent gives different products depending on the nature of the alcohol.

(d) In the empty squares below give the structural formula of the organic compound formed in each of the reactions indicated.

If no reaction occurs, write 'no reaction' in the space.

alcohol reagent(s) and conditions	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$	$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$	$(\text{CH}_3)_3\text{COH}$
red phosphorus and iodine heat under reflux	X		X
concentrated H_2SO_4 heat	X	X	
$\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$ heat under reflux			

[5]

[Total: 11]