Organic Synthesis

Question Paper 4

Level	International A Level
Subject	Chemistry
Exam Board	CIE
Topic	Organic Synthesis
Sub-Topic	
Paper Type	Theory
Booklet	Question Paper 4

Time Allowed: **71 minutes**

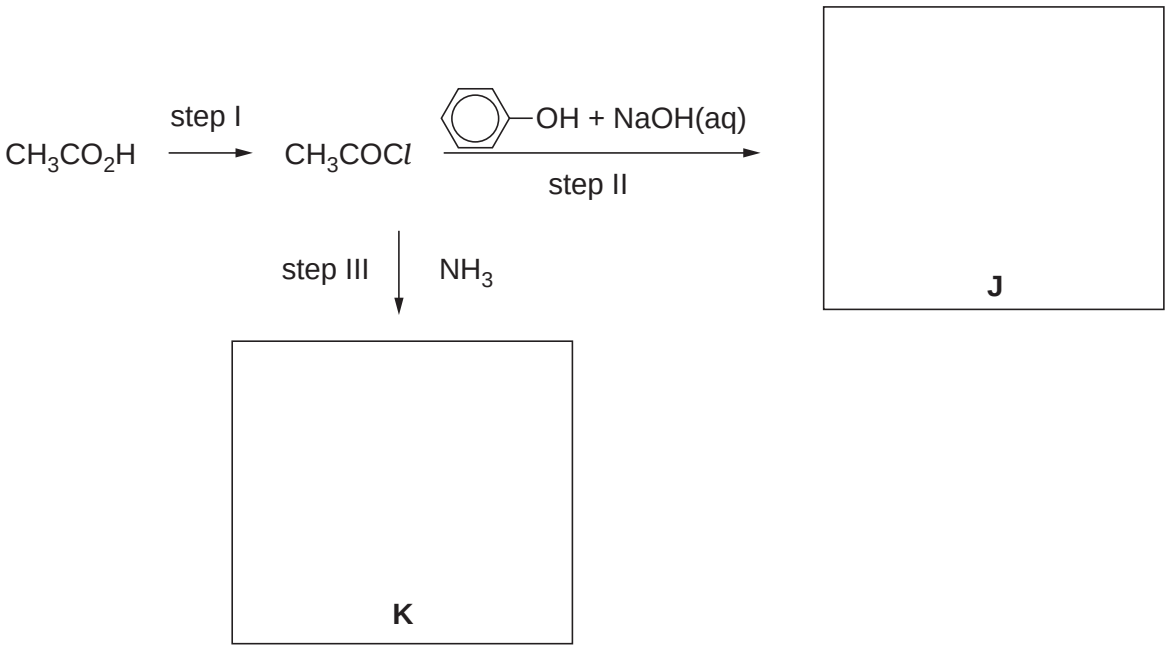
Score: **/59**

Percentage: **/100**

Grade Boundaries:

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

1 **(a)** Acyl chlorides are useful intermediates for making various acid derivatives. The following reaction scheme shows some of the reactions of ethanoyl chloride.



(i) Suggest a reagent for step I.

.....

(ii) Write an equation showing the reaction between phenol and NaOH(aq), the reagents in step II.

.....

(iii) Draw the structural formulae of products **J** and **K** in the boxes above.

[4]

(b) The diacid **L** occurs naturally and is used as a food additive to enhance the acidic flavour in some fruit drinks.

$HO_2CCH_2CH_2CO_2H$
L

When the diacyl chloride of **L** is reacted with $HOCH_2CH_2OH$, a polymer is formed.

(i) What type of polymerisation is occurring here?

.....

(ii) Write an equation showing the reaction between **one** mole of the diacyl chloride of **L** and **two** moles of $HOCH_2CH_2OH$.

[3]

(c) The following formula represents a section of another polymer.

(i) What type of polymer is this?

.....

(ii) Draw the structural formula of each of the monomers that make up this polymer.

[3]

[Total : 10]

2 **(a)** Describe and explain how the acidities of $CHCl_2CO_2H$ and CH_2ClCO_2H compare to each other, and to the acidity of ethanoic acid.

.....

.....

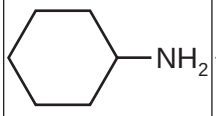
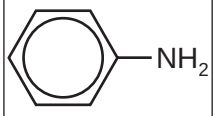
.....

.....

.....

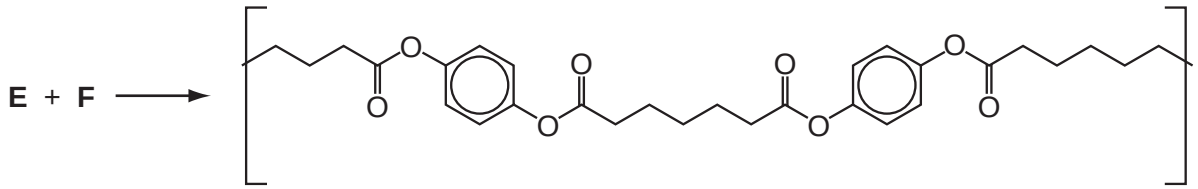
[3]

(b) For each of the following pairs of compounds, suggest one chemical test (reagents and conditions) that would distinguish between them.
State the observations you would make with each compound, writing 'none' if appropriate.

first compound	second compound	test (reagents and conditions)	observation with first compound	observation with second compound
				
CH_3CH_2COCl	CH_3COCH_2Cl			
CH_3CH_2CHO	CH_3COCH_3			

[7]

(c) The following diagram shows a section (not a repeat unit) of a polymer, **G**, that can be made from the two monomers **E** and **F**.



polymer **G**

(i) What *type of polymerisation* made this polymer?

.....

(ii) Draw the structures of the two monomers **E** and **F**.

E

F

(iii) Suggest the conditions needed to make polymer **G** from **E** and **F** in the laboratory.

.....

.....

.....

(iv) One of the monomers, **E** or **F**, could be changed to make a more rigid polymer of a similar chemical type to **G**.
Suggest which of your two monomers could be changed, and suggest a structure for the new monomer.

Monomer to be changed (**E** or **F**) .....

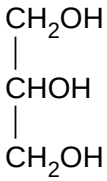
Structural formula of the new monomer

[6]

[Total: 16]

3 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, $CH_3(CH_2)_{16}CO_2H$.

Vegetable oils often contain esters of oleic acid, $CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H$.

(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, $C_{17}H_{33}CO_2H$, from the glyceryl ester present in a vegetable oil?

.....

[1]

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

$$CH_3(CH_2)_7CH{=}CH(CH_2)_7CO_2H.$$

(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.

$$CH_3(CH_2)_7CH{=}CH(CH_2)_7X$$

(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 .....

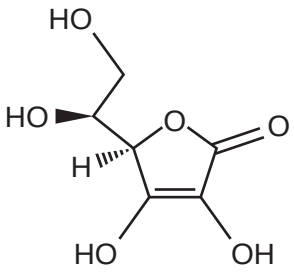
observation .....

[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.



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]

4 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]

5 A student obtained the following results when analysing an organic compound, **H**.

test		observation
test 1	relative molecular mass	72
test 2	% composition by mass	C, 66.7%; H, 11.1%; O, 22.2%
test 3	reactions with $Br_2(aq)$	Br_2 decolourised
test 4	reaction with Na(s)	$H_2(g)$ evolved
test 5	reaction with warm $Cr_2O_7^{2-}/H^+$	green colour observed

The student allowed test 5 to go to completion and then investigated the **product** of test 5 with the following result.

test 6	reaction with 2,4-dinitrophenylhydrazine	no reaction

(a) Calculate the molecular formula of **H**.

[2]

(b) What can be deduced about the nature of **H** by the following tests?

(i) test 3 .....

(ii) test 4 .....
[2]

(c) **(i)** What functional group would have given a positive result in test 6?

.....

(ii) What functional group is shown to be present in **H** by tests 5 and 6?

.....
[2]

(d) On testing a sample of **H**, the student found that it was not chiral.

H did, however, show *cis-trans* isomerism.

How does *cis-trans* isomerism arise in an organic molecule?

.....

.....

..... [2]

(e) Use all of the information above to draw labelled, displayed formulae of the stereoisomers of compound **H**.

[2]

[Total: 10]