ANSWERS

Note: This paper is a relatively simple practice exam paper.

Level 3 Chemistry

91391 Demonstrate understanding of the properties of organic compounds

Credits: Five

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of the properties of organic compounds.	Demonstrate in-depth understanding of the properties of organic compounds.	Demonstrate comprehensive understanding of the properties of organic compounds.

You should attempt ALL the questions in this booklet.

A periodic table is provided in the Resource Sheet.

If you need more room for any answer, use the extra space provided at the back of this booklet and clearly number the question.

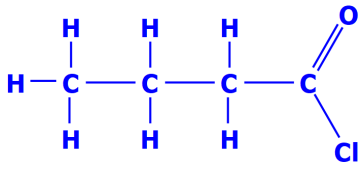
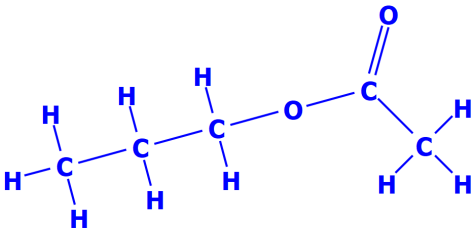
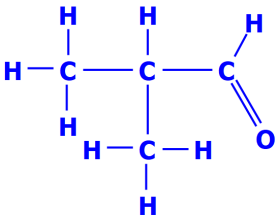
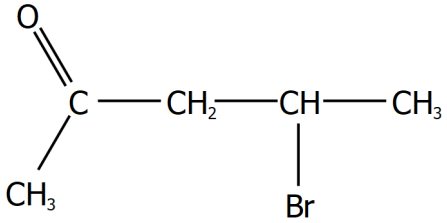
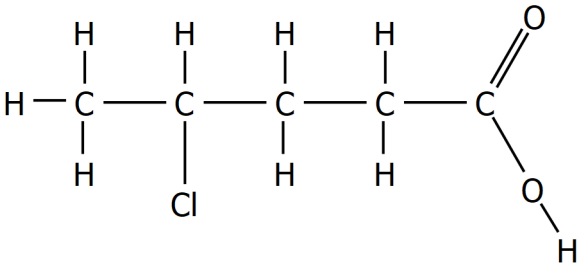
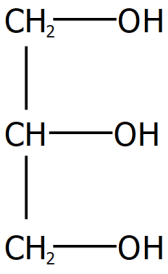
Check that this booklet has pages 1–12 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

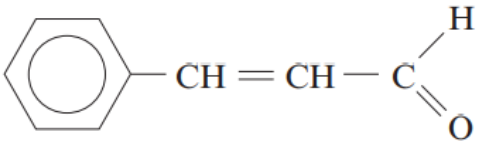
TOTAL

QUESTION ONE

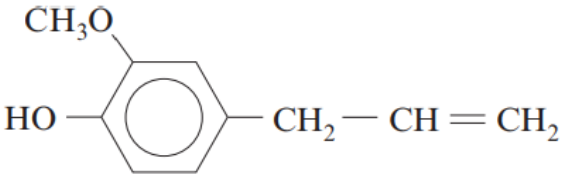
(a) (i) Complete the table below to indicate the IUPAC name, or the structural formula.

IUPAC systematic name	Structural formula
butanoyl chloride	
propyl ethanoate	
2-methylpropanal *error! The 2 would be unnecessary – sorry!	
4-bromopentan-2-one	
4-chloropentanoic acid	
propane-1,2,3-triol	

(b) Cinnamon is a spice obtained from the bark of tree species from the genus Cinnamomum. It is used as an aromatic flavouring additive in a wide variety of cookery, sweet and savory. The familiar smell and flavour of cinnamon oil is mostly due to cinnamaldehyde, and smaller amounts of a chemical called eugenol.



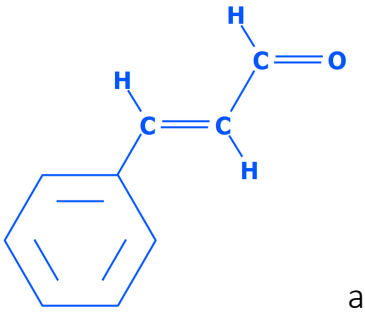
cinnamaldehyde



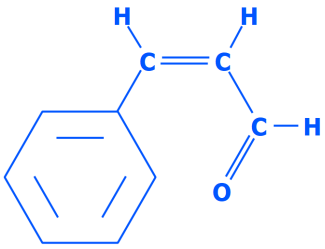
eugenol

(i) Identify, with reasons, which ONE of these molecules can exist as geometrical isomers. In your answer you should include:

- A drawing of both isomers of the molecule
- The structural feature(s) necessary for your chosen molecule to exist as geometrical isomers



and

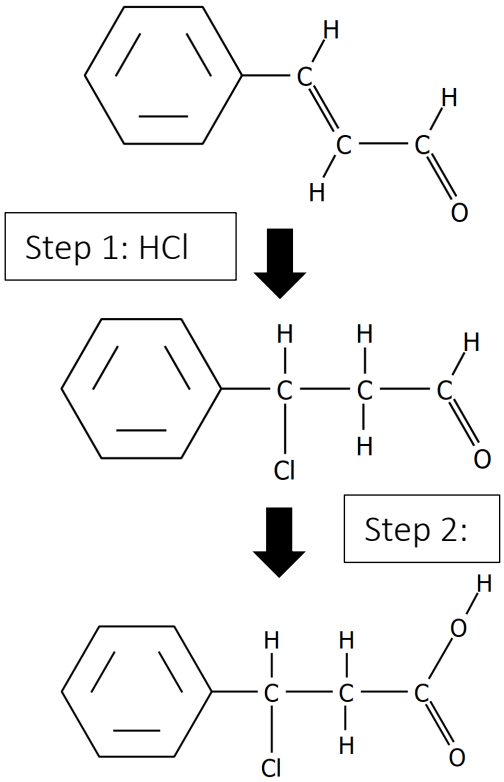


To show geometrical isomerism there must be a C=C double bond which prevents free rotation, and each C of the C=C must be bonded to 2 different atoms / groups. (This is usually examined at Level 2 but there is no reason why it couldn't be asked @ Level 3).

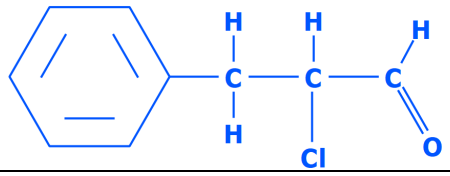
(ii) Describe a chemical test that gives a positive result with cinnamaldehyde but not with eugenol.

Cinnamaldehyde contains an aldehyde functional group that eugenol does not possess. Adding blue Benedict's solution to a sample of the aldehyde and heating it will cause a (brick) red colour to form. This happens because the aldehyde has been oxidised to a carboxylic acid (red colour is copper(I) oxide). OR… The aldehyde will form a silver mirror when warmed with Tollens' reagent. Eugenol will not react with Tollens' reagent.

(c) An organic chemist suggested the following method for producing compound X from cinnamaldehyde.



(i) Draw the structural formula of another product that may be formed when hydrogen chloride is added across the double bond in step 1. Explain why this can occur.



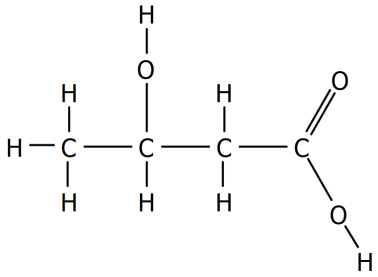
Reaction of HCl is an addition reaction. A hydrogen atom joins to one of the carbon atoms originally in the double bond, and a halogen atom to the other. ... Two products are possible here as the **alkene** functional group was unsymmetrical.

(iii) State the name of a suitable reagent, and conditions for step 2. Give any observations and state the type of reaction occurring.

This reaction is an oxidation reaction. Heat with acidified dichromate solution, $Cr_2O_7^{2-}/H^+$. Colour change from orange dichromate $Cr_2O_7^{2-}$ as it is reduced to green chromium (III), Cr^{3+}.

QUESTION TWO

3-hydroxybutanoic acid is a white solid. It can form enantiomers (optical isomers).



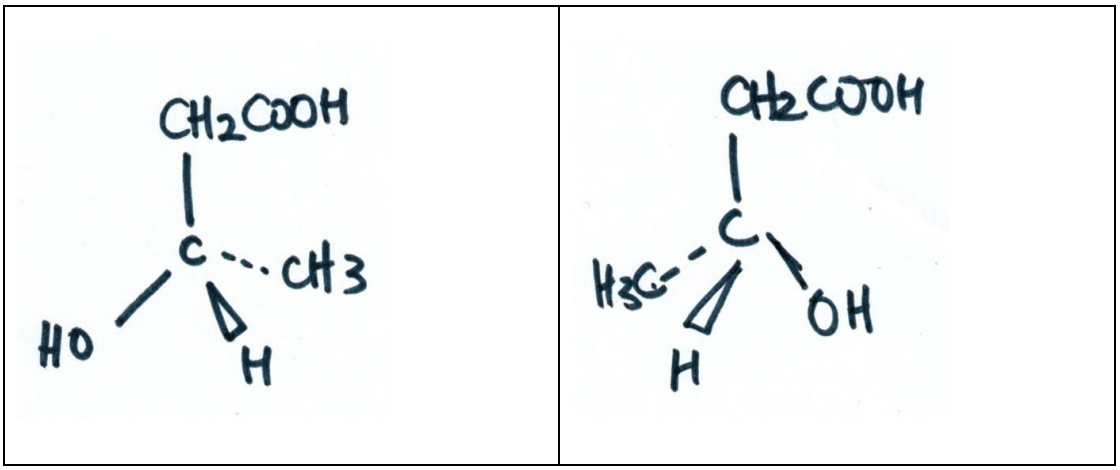
(a) (i) Is the alcohol group in this molecule primary, secondary or tertiary? Explain your answer.

It is secondary as the OH group is bonded to a c atom that is bonded to 2 carbon atoms

(ii) Describe the structural feature necessary for a compound to exist as enantiomers (optical isomers).

It needs to be a chiral compound, containing a carbon atom with 4 different atoms /groups attached.

(iii) Draw 3-D structures of the enantiomers (optical isomers) of 3-hydroxybutanoic acid in the boxes below.



(iv)

(v) Identify one physical property that is the same for both enantiomers of 3-hydroxybutanoic acid, and one that is different, clearly describing how this property could be used to distinguish between the enantiomers.

Same property: The different isomers will have the same melting point / boiling point / solubility in water
Different property: The different isomers will rotate (plane)-polarised light in opposite directions. This will distinguish the isomers.

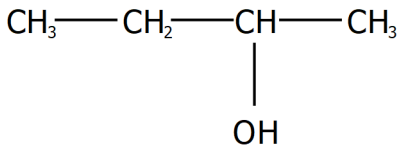
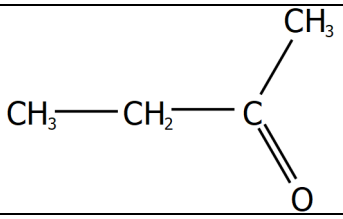
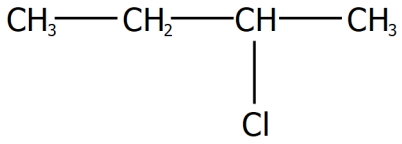
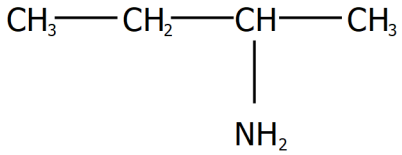
(b) Compound F has a molecular formula $C_4H_{10}O$. Compound F can form enantiomers (optical isomers). When compound F was reacted with *reagent 1*, a mixture of three isomers formed. All three of these isomers rapidly decolourised bromine water.

When compound F was warmed with acidified potassium permanganate solution, the solution changed from purple to colourless and compound G, with a molecular formula C_4H_8O, was formed. Compound G was purified; it had no effect on Fehling's reagent.

When compound F reacts with *reagent 2*, compound H is formed which has the formula $C_4H_{10}Cl$. Compound H reacts with concentrated NH_3 to form compound I, which turns moist red litmus paper blue.

Use the information above to identify compounds F to I, and reagents 1 and 2. Complete the table on the following page.

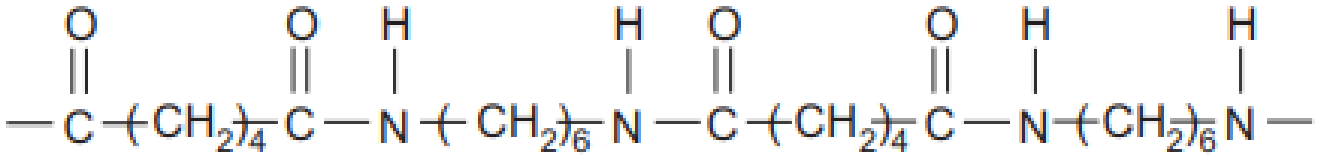
Space for planning / working is provided in the space below

Compound	Structure
F	
G	
H	
I	

Reagent 1	Concentrated H_2SO_4
Reagent 2	$SOCl_2$

QUESTION THREE

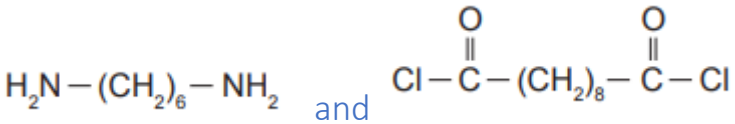
Nylon-6,6 is made by a reaction between two different monomers. Below is a section of the polymer showing two repeating units.



(a) (i) Describe the type of reaction that had occurred to make this polymer, and explain why this reaction resulted in this type of polymer.

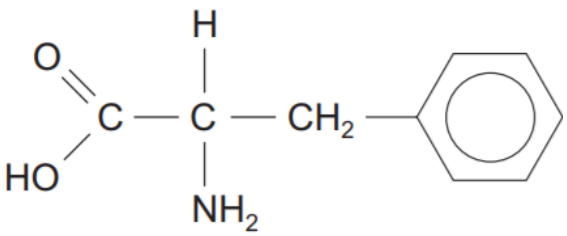
This is a condensation polymerization reaction that has occurred to produce a polyamide. The monomers join and an amide (peptide) link forms and a molecule of water or HCl is released during the reaction.
Each monomer is di-functional or has a reactive site at each end (allowing polymerisation to be ongoing.)

(ii) Draw the structures of the two monomers used to make Nylon-6.6.

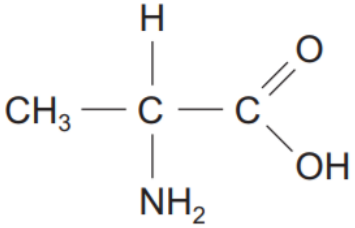

and

(or HOOC-$(CH_2)_8$-COOH)

(b) The reaction between amino acid J and amino acid K forms two different dipeptides.



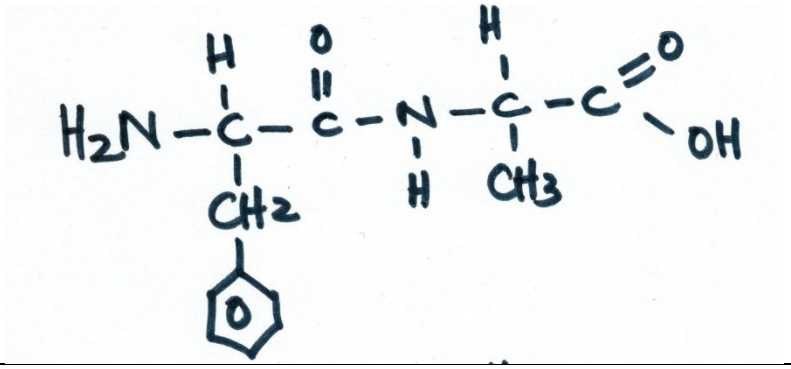
amino acid J



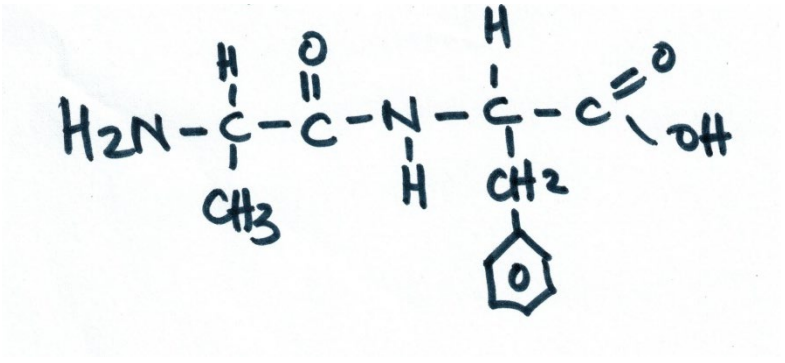
amino acid K

(i) In the boxes below, show two possible dipeptides that can be formed by combining the two amino acids shown above.

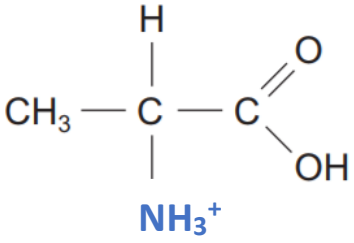
Dipeptide 1:



Dipeptide 2:



(ii) Draw the structure of amino acid K when it is dissolved in an excess of a strong acid.



(c) An old Chemistry work book describes how to make a sample of t-butyl chloride. T -butyl chloride is not its IUPAC systematic name.

A sample t-butyl chloride is easily made from the corresponding alcohol according to the following reaction.

$$(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$$

10 mL of t-butyl alcohol and 25 mL of concentrated hydrochloric acid are shaken from time to time over 10-15 minutes, in a separating funnel until 2 distinct layers are clearly visible. The mixture is allowed to stand for a few minutes and the lower acid layer discarded. The impure t-butyl chloride is shaken with sodium hydrogen carbonate solution. Anhydrous sodium sulfate is swirled with the t-butyl chloride in a conical flask. The liquid is decanted into a round bottomed flask, 2–3 anti-bumping granules are added and a pure sample of t-butyl chloride is collected between 51–52°C.

(i) Deduce the IUPAC systematic name for t-butyl chloride?

2-chloro-2-methylpropane

(ii) Explain why the t-butyl chloride is shaken with sodium hydrogen carbonate solution.

$NaHCO_3$ is used to remove any remaining acid mixed with the liquid product. Gas produced is Carbon dioxide / CO_2

(iii) Explain why the t-butyl chloride is swirled with anhydrous sodium sulfate.

Anhydrous sodium sulfate is added to remove any remaining water mixed with the liquid product.

(iv) Name the process used to purify the organic product.

- Process used: Distillation

- Circle the equipment that a student would use to perform this process from the diagrams below.