SUPERVISOR'S USE ONLY

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91391

913910

Draw a cross through the box (☒) if you have NOT written in this booklet

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NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

# Level 3 Chemistry 2024

## 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. |

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

**You should attempt ALL the questions in this booklet.**

A periodic table and other reference material are provided in the Resource Booklet L3–CHEMR.

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

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

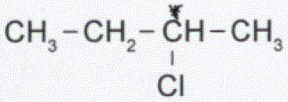
Do not write in any cross-hatched area (▨). This area will be cut off when the booklet is marked.

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

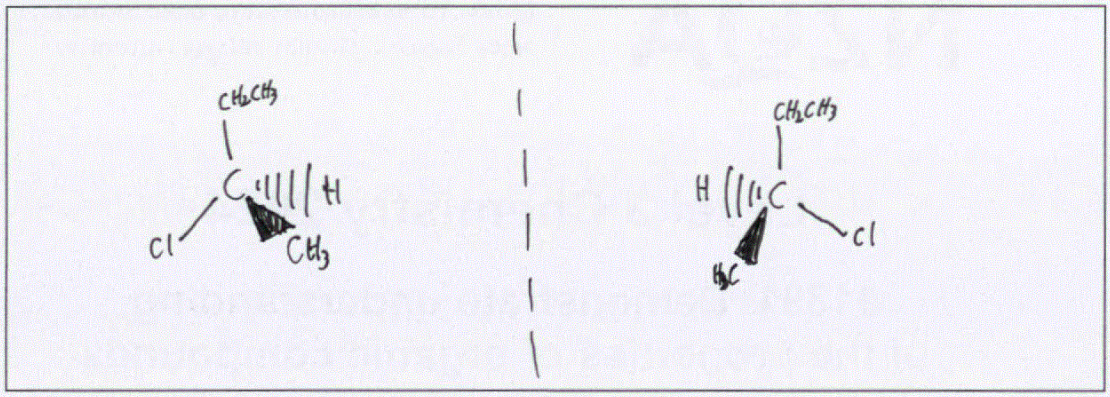
Achievement TOTAL 13

## QUESTION ONE

(a) 2-chlorobutane exists as enantiomers (optical isomers).



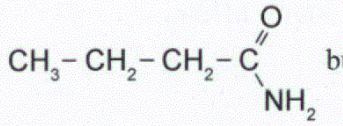
(i) Draw the enantiomers of 2-chlorobutane in the box below.




(ii) Explain why 2-chlorobutane can exist as enantiomers.

2-Chlorobutane exists as enantiomers because it has a chiral carbon. This is a carbon with 4 different groups attached to it. This allows it to have two mirrored versions.

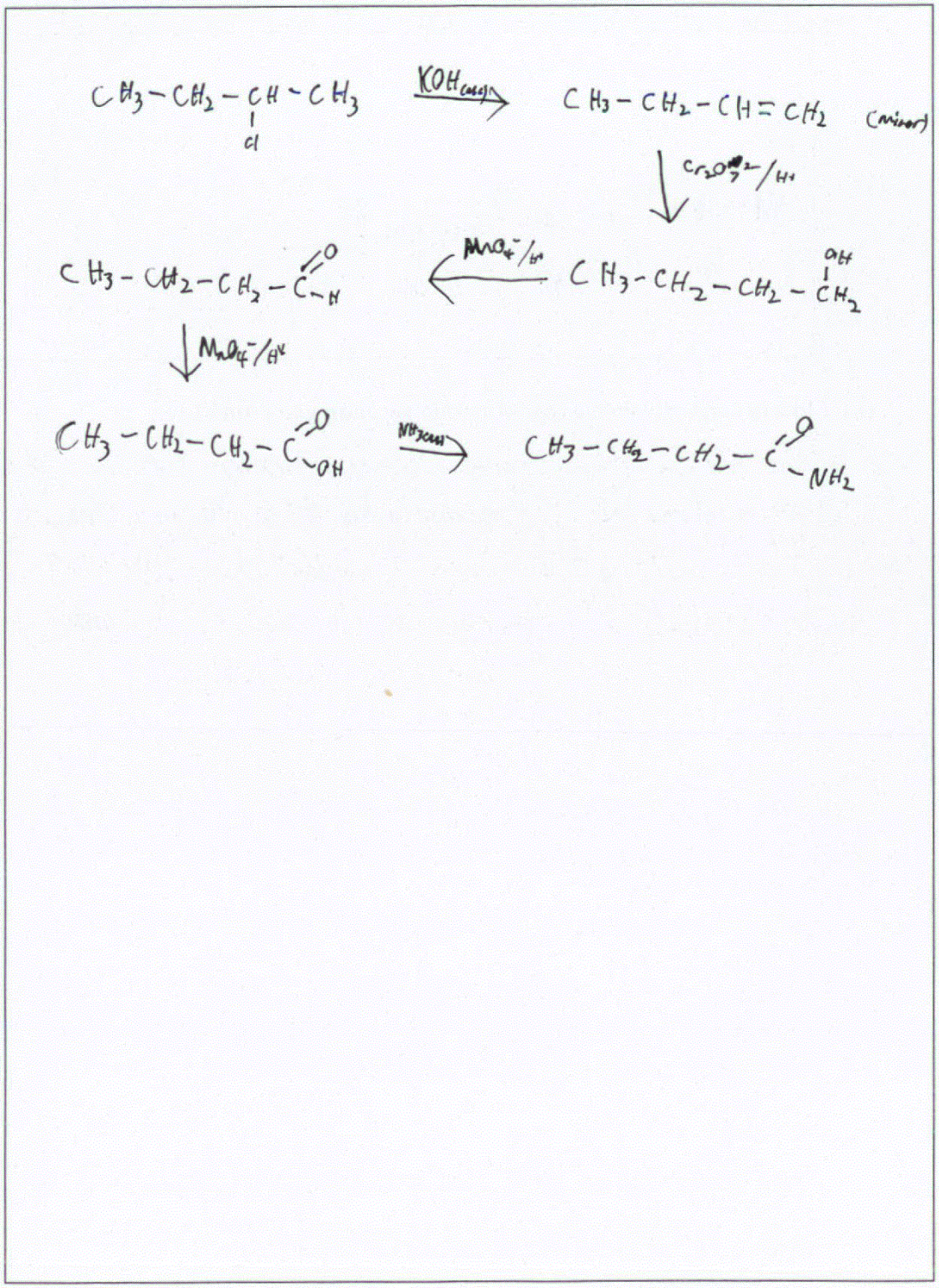
(iii) Devise a reaction scheme to convert 2-chlorobutane into butanamide.



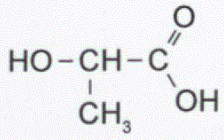
butanamide

For each step include:

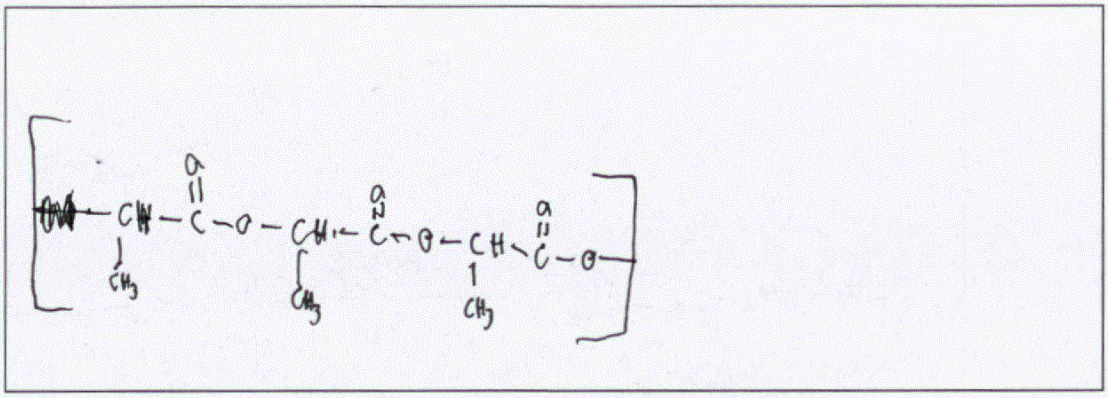
- the reagents
- the structural formula of the organic product after each step.



(b) Polylactic acid (PLA) is a polyester with various uses, including medical implants, tissue engineering, and 3D printing. It is made from lactic acid, shown below:



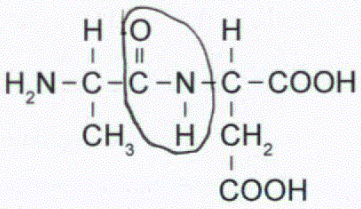
(i) In the box below, draw a section of the PLA chain to show THREE repeating units.



(ii) Identify and explain the type of reaction occurring to form PLA.

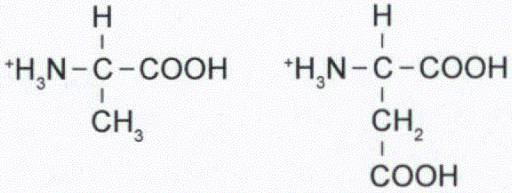
The reaction which occurs when forming PLA is called condensation. This is because when the OH group reacts with the COOH group when forming this polyester, the by-product of the reaction is water. As water is formed, the reaction is called condensation

(c) Below is the structural formula of a dipeptide:



(i) Circle the amide (peptide) linkage on the dipeptide above.

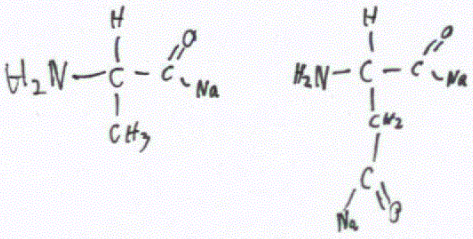
(ii) The dipeptide can undergo a chemical reaction to form the following products:



Identify and justify the type of chemical reaction that has occurred to form the above products.

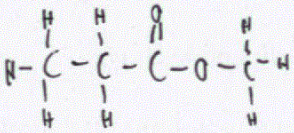
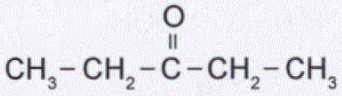
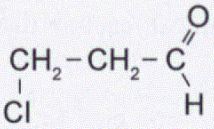
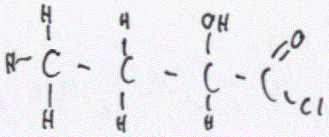
The reaction used to form the above products is called hydrolysis. This means water is used to break the molecule apart. The $H_2O$ splits into $H^+$ and $OH^-$. The $OH^-$ becomes part of the COOH group and the $H^+$ goes to the $NH_2$ group. This reaction is performed under acidic conditions. This is seen as the basic $NH_2$ groups have further reacted in a neutralisation reaction to form $NH_3^+$.

(iii) Draw the structural formulae of the organic products formed when the dipeptide is heated under reflux with sodium hydroxide solution.



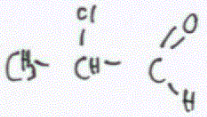
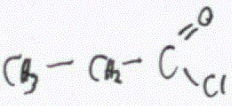
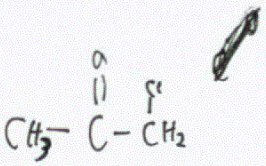
## QUESTION TWO

(a) (i) Complete the table below to show the structural formula or the IUPAC (systematic) name for each compound.

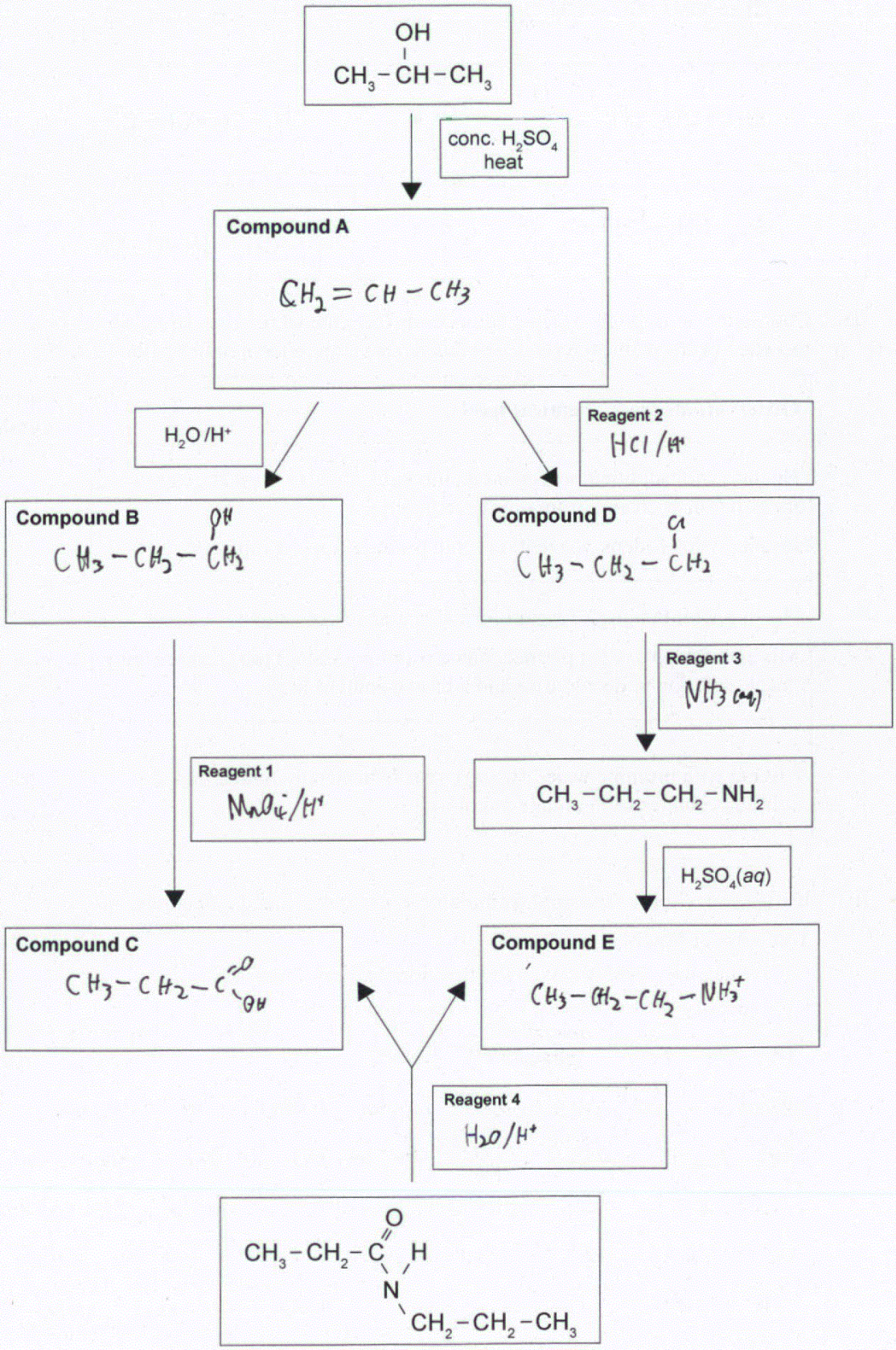
| Compound | Structural formula | IUPAC (systematic) name |
|---|---|---|
| **A** |  | methyl propanoate |
| **B** |  | pent-3-one |
| **C** |  | 3-chloropropanal |
| **D** |  | 2-hydroxybutanoyl chloride |

(ii) Draw THREE constitutional (structural) isomers of **Compound C** that contain a carbonyl group (C=O).

$C_3H_5OCl$

| | | |
|---|---|---|
|  |  |  |

(b) Complete the flowchart below by drawing the structural formulae for **Compounds A**, **B**, **C**, **D**, and **E**, and identifying **Reagents 1**, **2**, **3**, and **4**.



(c) The following table lists the structural formulae for six different organic compounds.

| | | | |
|---|---|---|---|
| 1 | $CH_3-CH_2-CH_2-CH_2OH$ | 2 | $CH_3-CH_2-CH_2-C(=O)-H$ |
| 3 | $CH_2=CH-CH_2-C(=O)-H$ | 4 | $CH_3-CH=CH-C(=O)-Cl$ |
| 5 | $CH_3-CH_2-CH_2-C(=O)-Cl$ | 6 | $CH_2=CH-C(=O)-CH_3$ |

(i) Choose the appropriate organic compounds from the table above to match the observations recorded from chemical tests. Enter the chosen compound number in the table below.

| **Observations from chemical tests** | **Compound number** |
|---|---|
| Heating with acidified potassium dichromate, $K_2Cr_2O_7(aq)/H^+$, causes the solution to change from orange to green.<br>Heating with Tollens' reagent does not produce a silver mirror. | 1 |
| Heating with Fehling's reagent forms an orange-red solid.<br>Mixing with potassium permanganate solution, $KMnO_4(aq)$, causes the purple solution to decolourise and a brown solid to form. | 3 |
| Mixing with bromine water, $Br_2(aq)$, results in steamy fumes, and the solution changes from orange to colourless. | 4 |

(ii) Justify your chosen structural formula for each of the three compounds.

Your answer should:

- relate the observations to the functional groups identified
- identify and explain the types of reaction involved.

The first observations says that the compound can be oxidised by $K_2Cr_2O_{7(aq)}/H^+$. This means that compounds 4, 5, 6 do not match. Acyl chlorides and ketones cannot be oxidised. This left two aldehydes and a 1° alcohol. The observations also said that it will not react with Tollen's reagent. This means it is the 1° alcohol because Tollen's isn't strong enough to oxidise alcohols.

The observations of the second compound told that it reacts with Fehling's reagent. This is only strong enough to react with aldehydes which left compounds 2 and 3. By mixing with $KMnO_{4(aq)}$, it caused the decolourisation of the purple solution, and the formation of brown solid. This shows the breaking of a double bond by oxidation into a diol. Therefore the answer is compound 3.

The observation of the final compound tells us that the $Br_{2(aq)}$ is breaking a double bond as seen from the orange to colourless change. This leaves compounds 3, 4, 6. The steamy fumes are a violent reaction meaning that it is compound 4, as acyl chlorides react violently with water.

## QUESTION THREE

(a) A student followed the procedure outlined below to prepare a pure sample of ethyl propanoate in the laboratory:

Step 1: Add propanoic acid, ethanol, and concentrated $H_2SO_4$ to a round-bottomed flask.
Step 2: Heat the reaction mixture under reflux for 30 minutes.
Step 3: Add sodium carbonate until the bubbling stops.
Step 4: Add water and separate the layers.
Step 5: Add a drying agent to the organic layer.
Step 6: Distill the organic layer to purify the ethyl propanoate.

(i) Describe the function of the concentrated $H_2SO_4$ added in step 1.

The conc. $H_2SO_4$ acts as a catalyst which allows the reaction to occur. It lowers the energy required to react.

(ii) Give TWO reasons to explain why the reaction mixture was heated under reflux in step 2.

(1) To ensure that the reaction occurs fully by cycling the mixture round so it can all react. This also prevents any thing outside the system from interfering

(2) To not lose energy to heat as the energy keeps cycling through the closed system.

(iii) Why was sodium carbonate added in step 3?

To neutralise the conc. $H_2SO_4$ and prevent it from causing any further reactions.

(iv) Explain how distillation was used in step 6 to purify the ethyl propanoate from the organic layer.

Your answer should refer to relevant boiling point(s) from the table below.

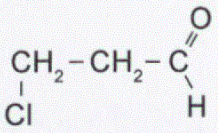
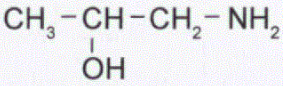
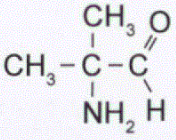
| Compound | Boiling point / °C |
|---|---|
| Propanoic acid | 141 |
| Ethanol | 78.3 |
| Ethyl propanoate | 99.1 |

The system was heated to somewhere between 78.3°C and 99.1°C. This causes the ethanol to boil and become gas which is then collected. After it is collected, the temperature is risen between 99.1°C and 141°C allowing the Ethyl propanoate to become gas which is collected separately to the ethanol. The ethyl propanoate can the reverted back to liquid where it is now pure

The other compounds remain liquid.

Question Three continues on the next page.

(b) (i) Consider Compounds A, B, and C, shown below:

| Compound A | Compound B | Compound C |
|---|---|---|
|  |  |  |

Choose the ONE compound that has ALL the following properties:

- cannot exist as enantiomers (optical isomers)
- forms a silver mirror when heated with Tollens' reagent
- turns damp red litmus paper blue.

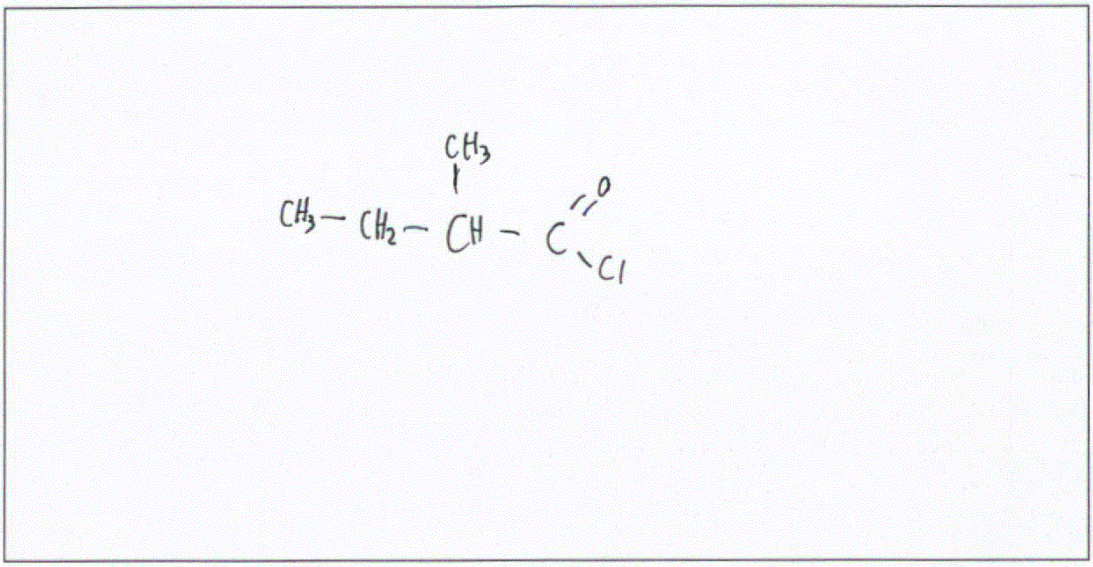
Compound (A, B, or C): C

Explain your choice.

Compound C does not have a chiral carbon and therefore it cannot exist as an enantiomer. To form a silver mirror it must be an aldehyde which compound C is. Compound C also is an amine which is basic and therefore it will turn red litmus blue. Compound B has a chiral carbon and is an enantiomer. Compound A is neutral and cannot change the colour of litmus paper.

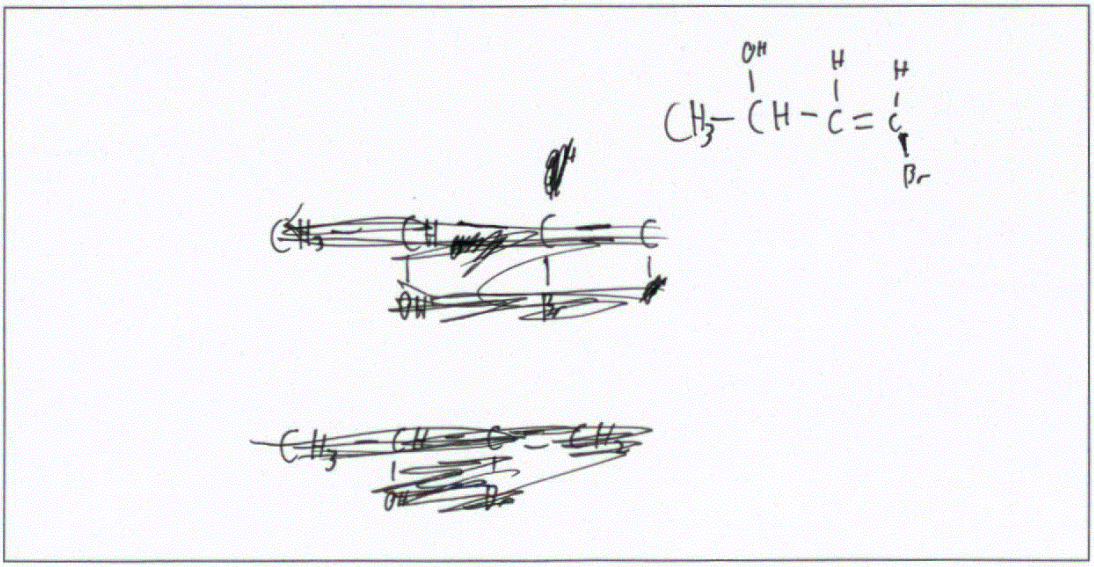
(ii) Draw the structural formula for the constitutional (structural) isomer of $C_5H_9OCl$ that has the following properties:

- exists as enantiomers (optical isomers)
- branched carbon chain
- produces steamy fumes upon addition of water.



(iii) Draw the structural formula for the constitutional (structural) isomer of $C_4H_7OBr$ that has the following properties:

- exists as cis-trans (geometric) isomers
- straight chain arrangement
- causes a colour change of orange to green when heated with acidified potassium dichromate to produce an organic product that does not react with Benedict's solution.



# Achievement

**Subject:** Chemistry

**Standard:** 91391

**Total score:** 13

| Q | Grade score | Marker commentary |
|---|---|---|
| One | A4 | This response provided enough evidence for achievement because the candidate could draw some chemical structures correctly. They have some understanding of how enantiomers form, able to devise part of a reaction scheme to convert 2-chlorobutane to butanamide, and how a condensation reaction joins up but omits the ester linkage.<br>They fully discussed the acidic hydrolysis of the dipeptide. To gain a higher grade for this part they needed to draw correct structures for basic hydrolysis. |
| Two | A4 | This response provided enough evidence for achievement because the candidate could draw and name a selection of organic compounds. Correctly draw three isomers of compound C. Reaction scheme complete with correct reagents; to gain a high grade they need to have all conditions included. Chemical observations were linked to functional groups to identify the three compounds. Some understanding of observations linked to functional groups – all observations needed plus reactant/product and reaction types need greater depth – C=C bond break for addition and oxidation, for a substitution reaction what atom/group is removed and what atom/group is replaced. |
| Three | M5 | This response provided enough evidence for merit because the candidate had a reasonable understanding of distillation to separate volatile substances but did not understand the reasons why a reaction is carried under reflux. Selected the correct compound from the properties given but not all properties fully explained for excellence with parts (ii) and (iil). |