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91391

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

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.

Merit

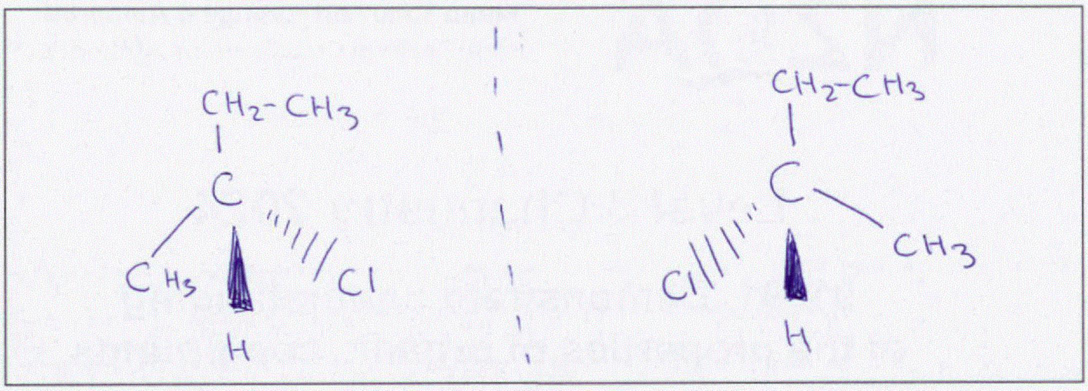
TOTAL 15

QUESTION ONE

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

$$\underset{}{CH_3}-CH_2-\underset{\substack{|\\ Cl}}{CH}-CH_3$$

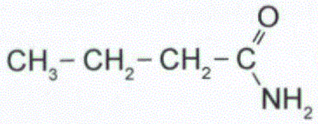
(i) Draw the enantiomers of 2-chlorobutane in the box below.



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

2- chlorobutane contains a chiral carbon which allows it to exist as enantiomers. Chiral carbon is a carbon atom with 4 different atoms or groups of atoms attached.

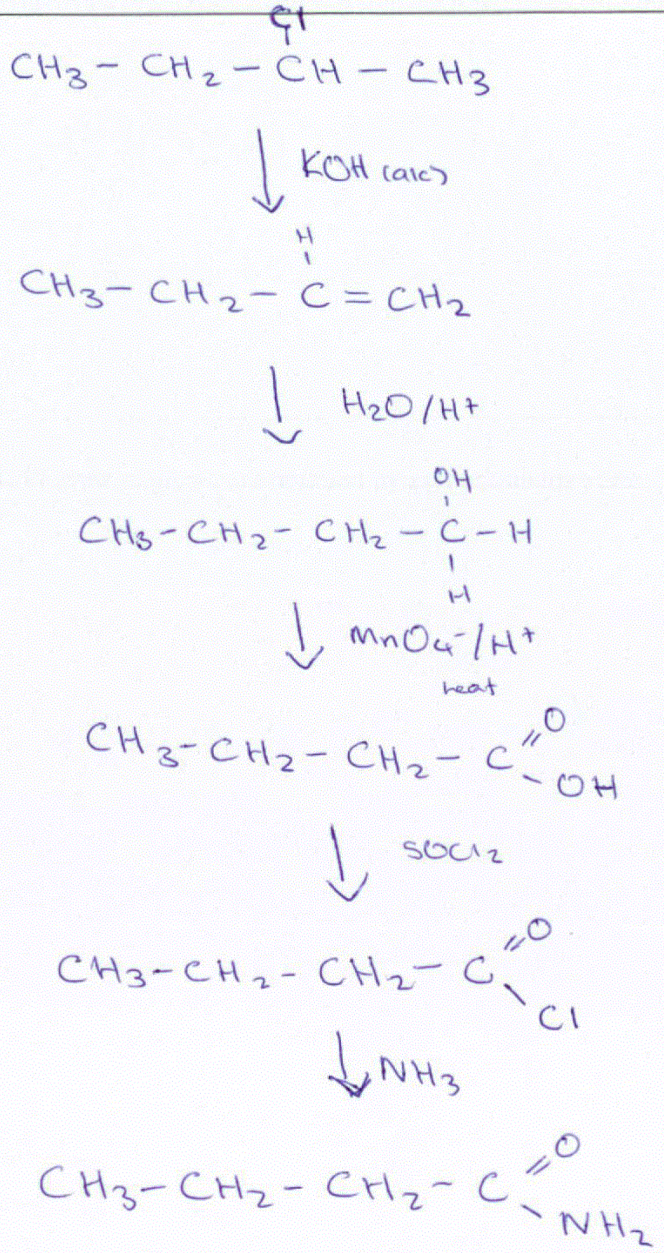
(iii) Devise a reaction scheme to convert 2-chlorobutane into butanamide.



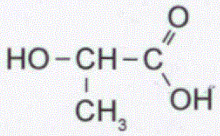
butanamide

For each step include:

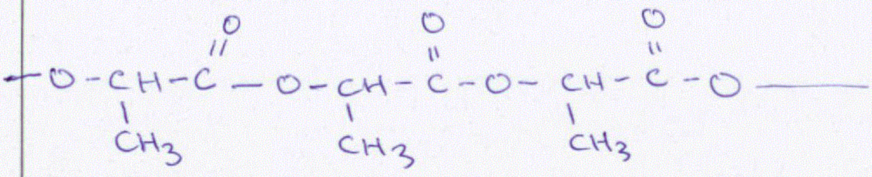
- the reagents
- the structural formula of the organic product after each step.



(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:



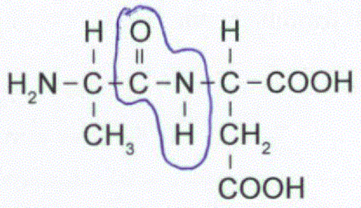
(i) In the box below, draw a section of the PLA chain to show THREE repeating units.



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

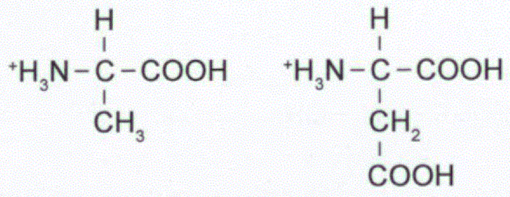
Condensation ~~[illegible]~~ polymerisation. ~~For~~ The small lactic acid molecules are joined together to form a ~~[illegible]~~ larger molecule. For each unit formed, a small molecule (H_2O) is released as a waste product, as an -OH group from one molecule is released, and a H atom from the other ajoining molecule is released when the ester link is formed.

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



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

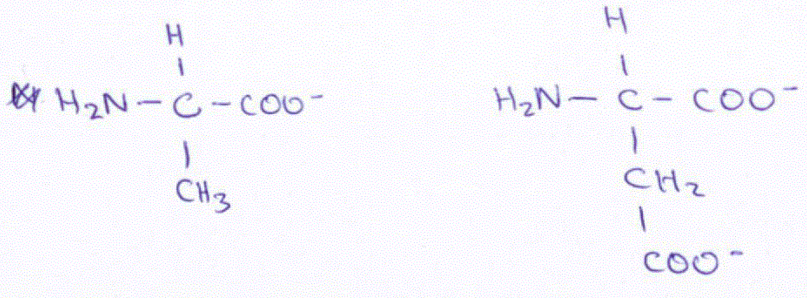
(ii) The dipeptide can undergo a chemical reaction to form the following products:



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

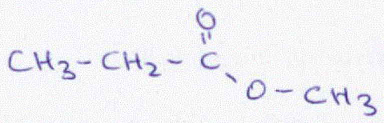
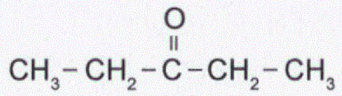
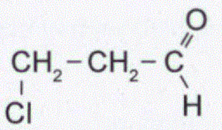
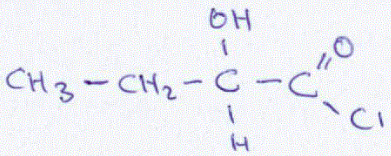
The dipeptide has undergone acidic hydrolysis. Acidic hydrolysis uses a dilute acid, such as $H_2SO_{4(aq)}$ to break the amide link and seperate the ~~d~~ larger molecule (dipeptide) into two smaller molecules ~~ran~~ above. The amine group is protonated and becomes NH_3^+ as it gains a H atom.

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

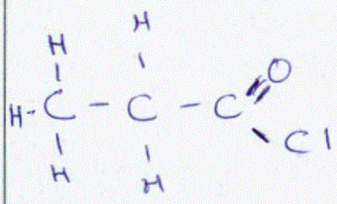
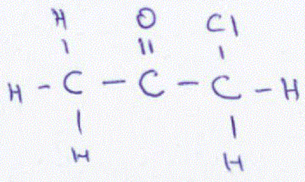
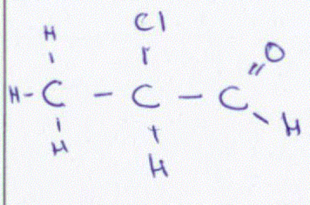


QUESTION TWO

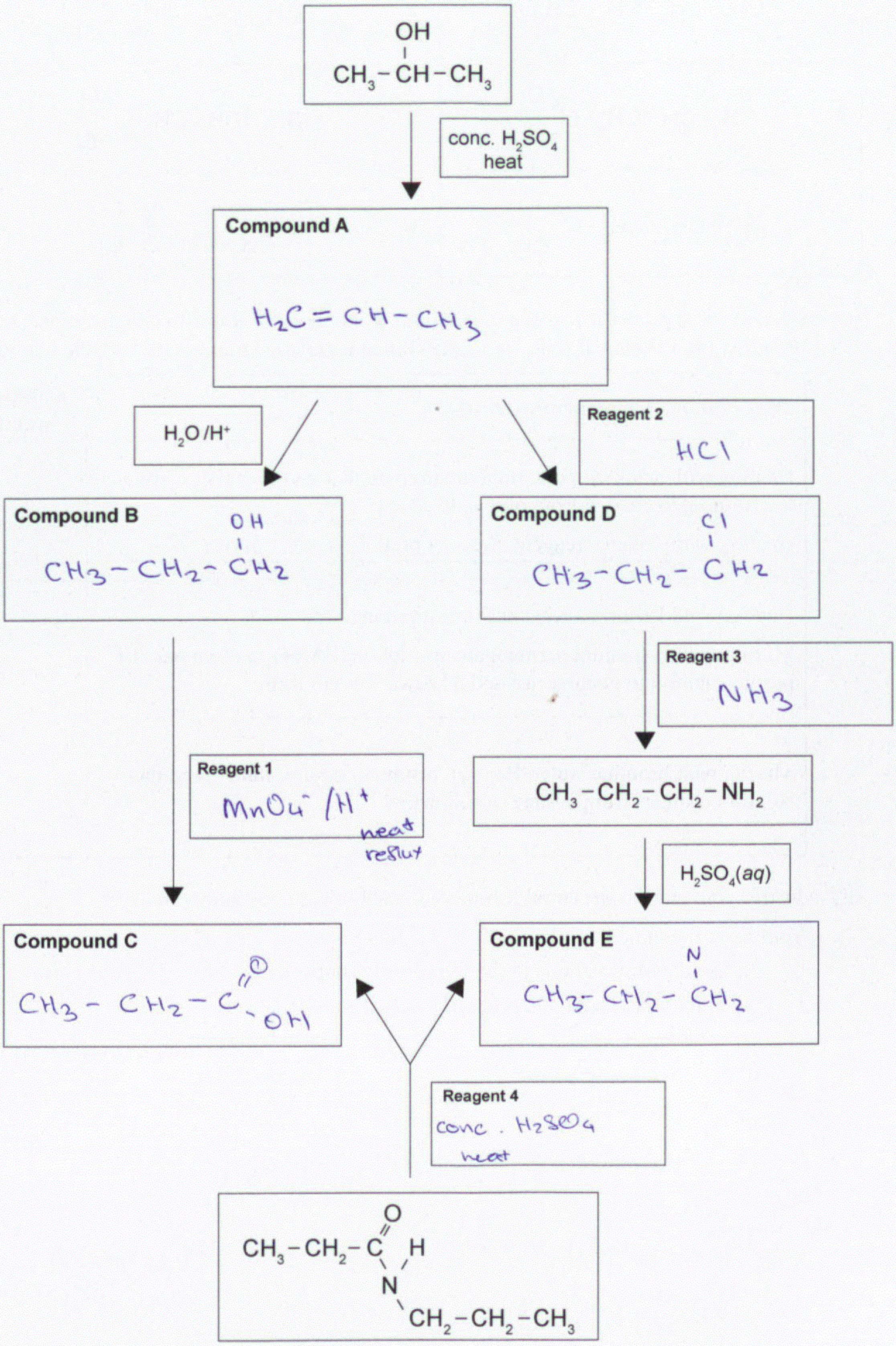
(a) (i) Complete the table below to show the structural formula or the IUPAC (systematic) name for each compound.

Compound	Structural formula	IUPAC (systematic) name
A		methyl propanoate
B		pentan-3-one
C	 C_3H_5OCl	3-chloropropanal
D		2-hydroxybutanoyl chloride

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

(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**
test 1.	Heating with acidified potassium dichromate, $K_2Cr_2O_7(aq)/H^+$, causes the solution to change from orange to green. ~~[illegible]~~ Heating with Tollens' reagent does not produce a silver mirror.	1
test 2.	Heating with Fehling's reagent forms an orange-red solid. Mixing with potassium permanganate solution, $KMnO_4(aq)$, aldehyde causes the purple solution to decolourise and a brown solid to form.	3
test 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.

~~when compo~~. The compound from the first chemical tests must be compound 1 because ~~it~~ its -OH group undergoes an oxidation reaction with $Cr_2O_7^{2-}/H^+$ to produce butanoic acid, this oxidation reaction can be observed as the colour of the solution will change from orange to green. Compound 1 does not contain an aldehyde functional group & so will not react wit Tollens reagent to form a Silver mirror. Thus must be compound 1 which contains an -OH functional group.

The second organic compound must be compound 3. This is because it reacts with Fehlings reagent in an oxidation reaction to form a orange-red solid, and so must contain an aldehyde functional group. When mixed with $KMnO_4$ (aq) the solution will decolourise from purple to colourless & a brown solid forms, thus the compound must have a C=C functional group. So must be compound 3 which contains both a C=C group & a $C\overset{O}{\underset{H}{\lesssim}}$ group.

The third / final organic compound is compound 4, because when reacted with bromine water the solution changes from orange to colourless, ~~there this is an addition reaction so~~ the compound must have a C=C double bond which reacts with Br_2(aq) in an addition reaction to form a di-haloalkane. The reaction also produces steamy fumes which indicates it has an acid chloride functional group -COCl, which reacts vigorously with the water molecules in bromine water in a hydrolysis reaction to form a ~~propano~~ ~~oc~~ carboxylic acid. Therefore the compound must be compound 4 which contains both a C=C and a COCl group.

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.

concentrated H_2SO_4 acts as a reagent for the condensation of propanoic acid and ethanol into an ester : ethyl propanoate.

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

(1) Mixture was heated under reflux to increase the rate of the reaction, as temperature increases, particles gain kinetic energy, move around faster, therefore collide more, ~~&~~ increasing the rate of the reaction.

(2) Reaction was heated under reflux to ~~a more~~ maximise its yield, & ensure any volatile reactants ~~to~~ don't evaporate. If they vaporise & rise, they will be condensed back into a liquid by the condensor & sent back down into the reaction. This makes sure the reaction goes to completion / all reactants are used up to maximise the yield of the products.

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

It reacts with any additional propanoic acid in an acid - base reaction to neutralise any H_3O^+ ions in solution.

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

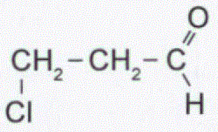
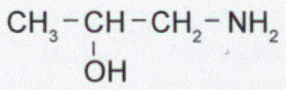
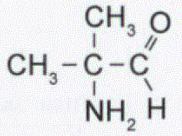
Your answer should refer to relevant boiling point(s) from the table below.

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

In distillation the flask is heated to above the boiling point of ethanol 78.3° C, so that any excess ethanol which has not been used in the reaction is evaporated into a gas. It is then condensed back into a liquid in the condensing tube on its way out of the flask before being collected. The flask is heated to less than the boiling point of ethyl propanoate so the ethyl propanoate remains in the flask / is not evaporated as not heated high enough. Ethyl propanoate is then purified from the organic layer as any excess ethanol is removed, leaving just ethyl propanoate.

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 =O −H
- turns damp red litmus paper blue. $-NH_2$

Compound (A, B, or C): C

Explain your choice.

• Turns damp red litmus blue, so the compound must have a $-NH_2$ group as this produces OH^- ions in an acid-base reaction which turn red litmus blue

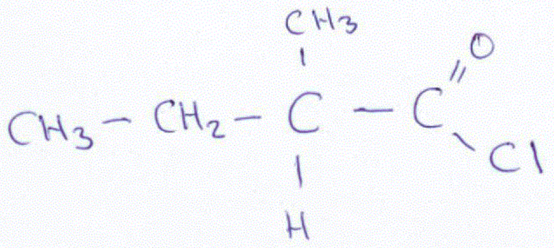
• forms a silver mirror when heated with Tollens, indicates it ~~[illegible]~~ has an aldehyde functional group which is oxidised with Tollens re-agent & forms a silver mirror.

• cannot exist as enantiomers so the compound must not have a chiral carbon (carbon with 4 different groups attached)

There fore must be compound C which meets the criteria as compound A does not have a NH_2 group, compound B does not have an aldehyde functional group.

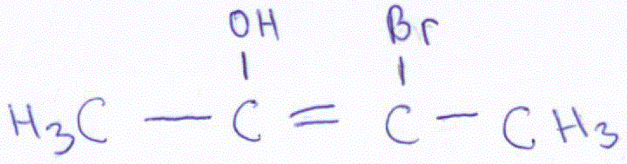
(ii) Draw the structural formula for the constitutional (structural) isomer of C_5H_9OCl that has the following properties:

- 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 2° OH
- 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.



Merit

Subject: Chemistry

Standard: 91391

Total score: 15

Q	Grade score	Marker commentary
One	M5	This response provided enough evidence for merit because the candidate has drawn chemical structures correctly, however convention used to indicate polymer continues in both direction or that it is a section was omitted. Reaction scheme devised with reagents correct, if all conditions included a higher grade would have been awarded. Acidic hydrolysis understood. How water breaks the amide linkage omitted.
Two	A4	This response provided enough evidence for achieve because the candidate could name and draw structures. Correct isomers of compound C drawn. As before reaction scheme incorrect as missing reagents and conditions. Amine plus acid product omitted. Correctly selected 3 compounds from information given on chemical tests. To gain a higher grade more information required for reaction type e.g. C=C breaks, OCl to COOH – Cl replaced by OH from water and all observations linked to the reaction.
Three	M6	This response provided enough evidence for merit because the candidate was able to state reasons why reflux is used in organic reactions but omitted that products as well as reactants are volatile. Distillation to separate reactants and products due to difference in boiling point but omits sufficient data to support method. Able to correctly identify and support choice of compound from properties given. For a higher grade needed to be able to draw both structures correctly from the properties listed.