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91391



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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Chemistry 2025

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 the margins (✂/✂/✂). 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.

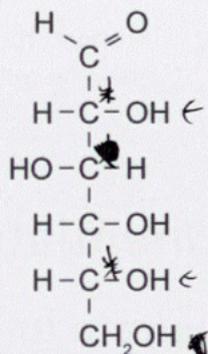
Achievement

TOTAL 12

QUESTION ONE

There are two enantiomers (optical isomers) of glucose, called D-glucose and L-glucose.

- (a) (i) Label **all** the ~~asymmetric carbon atoms~~ with an asterisk (*) in the structural formula of D-glucose shown below.



- (ii) Explain how D-glucose and L-glucose could be distinguished.

D-glucose and L-glucose could be distinguished as they rotate plane polarised light in opposite directions.

- (iii) When D-glucose is heated with Tollens' reagent, a silver mirror forms.

Explain this observation with reference to the functional group involved and the type of reaction occurring.

D-glucose has an aldehyde group attached to the first carbon. Hence when Tollen's reagent is added with heat, an oxidation occurs where an O atom is attached to form an acid. Simultaneously, the Ag^+ from Tollen's gets reduced to Ag^0 which is how a silver mirror is produced.

- (c) A student wanted to make some butanal, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$, in the school laboratory. The student heated some butan-1-ol and excess acidified potassium permanganate, KMnO_4/H^+ , under reflux for 20 minutes. The student then distilled the reaction mixture to collect the butanal fraction. However, no fraction was collected at 73–76 °C.

Compound	Boiling point/ °C
Butan-1-ol	118
Butanal	74.8
Butanoic acid	163

- (i) Describe the colour change that would be observed as the reaction is heated, and link this observation to the type of reaction occurring.

There will be a colour change from purple to colourless, due to the oxidation reaction between butan-1-ol and acidified potassium permanganate under reflux.

- (ii) Explain why no fraction was collected at 73–76 °C.

No fraction was collected at 73–76 °C because the boiling point of butanal is reached ~~at~~ within that region and

- (iii) Outline why the student should have used distillation instead of heat under reflux to produce butanal.

You should include an explanation of the process of distillation, and compare the position of the condenser between distillation and heat under reflux.

Refer to the diagrams provided below.

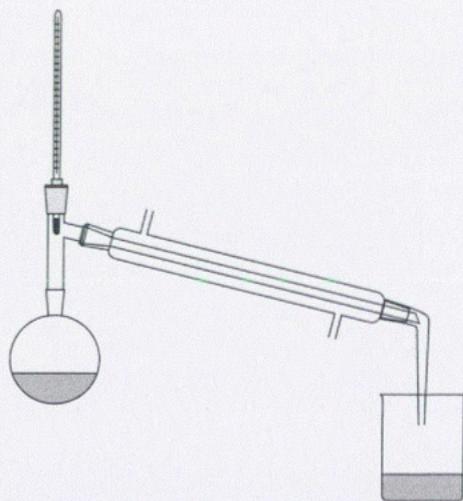


Fig. 1



Fig. 2

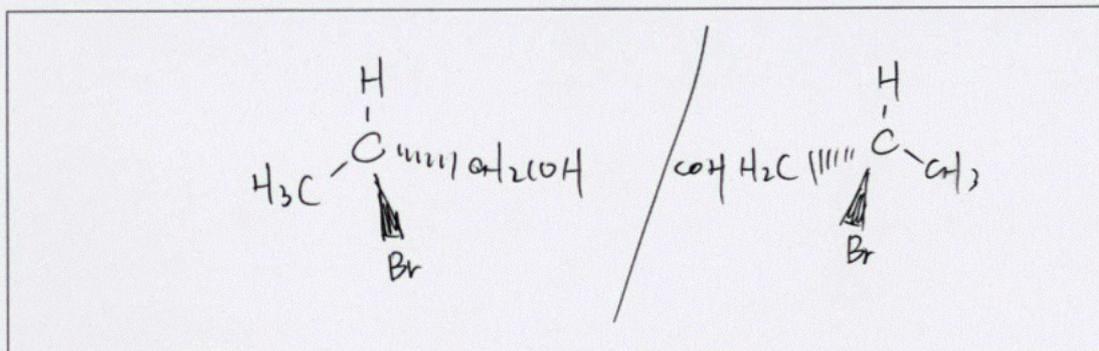
Distillation is a process of separating substances by their boiling points so that the desired substance can be collected at its boiling point as soon as it forms, without losing any volatile substances. In this case,

QUESTION TWO

(a) (i) Complete the table below by either naming or drawing the structural formula.

	Structural formula	IUPAC name
A	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$	hexan-2-one
B	$\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\text{O}-\text{CH}_2-\text{CH}_2-\text{CH}_3$	propyl ethanoate
C	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\underset{\text{CH}_3}{\text{CH}}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$	2-methylpentanamide
D	$\text{CH}_3-\underset{\text{Br}}{\text{CH}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	2-bromobutanal

(ii) Draw the enantiomers (optical isomers) of Compound D in the box below.



- (b) Three bottles, each containing a different colourless liquid, have not been labelled. The laboratory technician confirms they are:

• ethanol • ethanoyl chloride • ethanal

A student devised the following procedure to positively identify each of the three colourless liquids:

Step 1: Add water to all three colourless liquids.

Step 2: Add Fehling's solution to the remaining two colourless liquids, and heat.

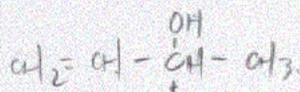
Step 3: Add acidified potassium dichromate, $K_2Cr_2O_7/H^+$, to the remaining colourless liquid, and heat.

- (i) Complete the table below for each step, **only** including observations for reactions that occur.

Step	Observations	Type of reaction occurring	Name of Organic Compound identified
1	White fumes of HCl (g)	Substitution r	Ethanoyl chloride
2	Brick-red precipitate	Oxidation	Ethanal
3	Colour change from orange to green.	Oxidation	Ethanol.

- (ii) Justify why the three steps should be followed in the order given to positively identify each of the three colourless liquids.

~~Water~~ ^{Adding} water must be the first step to identify ethanoyl chloride. This is because if either ^{adding a} Fehling's ^{solution} and acidified potassium dichromate was the first step, ethanoyl chloride will also form white fumes with these reagents as they are ~~the~~ aqueous solutions that ~~will~~ trigger a reaction with acyl chloride. This will cause a confusion in the observation as more than one liquids will react to the reagent at the same. Other than that, Adding Fehling's must be the second step to identify ethanal because ~~it~~ ethanal ^{also} undergoes oxidation with acidified ^{potassium} dichromate to cause a colour change from orange to green like ethanol. Hence adding the acidified dichromate solution should be the last step to ensure that the colourless liquids ~~are~~ can be identified smoothly without a hassle.



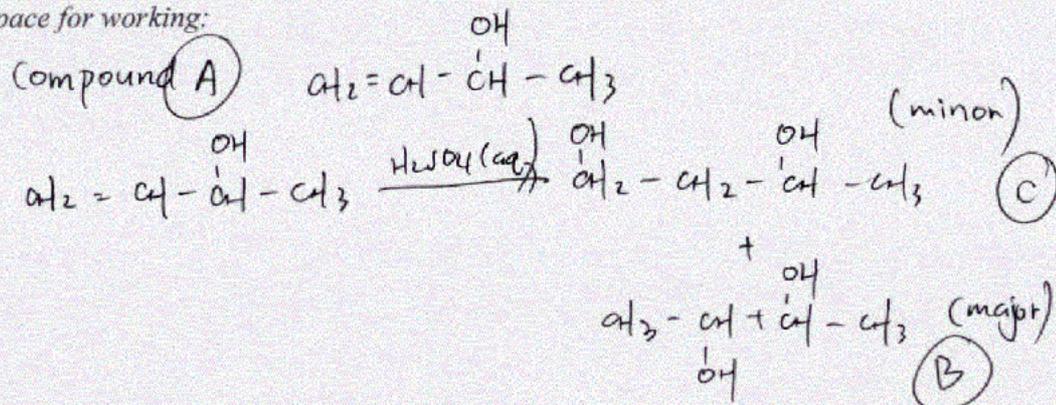
- (c) Compound A has the molecular formula C_4H_8O , and exists as enantiomers (optical isomers). When dilute sulfuric acid, H_2SO_4 , is added, two organic compounds are formed: Compound B and Compound C. Compound B is present in the higher proportion.

Compound B is reacted with excess thionyl chloride, $SOCl_2$, followed by concentrated ammonia, NH_3 , to form Compound D. Compound D turns damp red litmus paper blue.

Compound C is heated with excess acidified potassium permanganate, $KMnO_4/H^+$, to form Compound E. Compound E forms bubbles when sodium carbonate, Na_2CO_3 , solution is added.

Draw the structural formulae for Compounds A, B, C, D, and E in the table on the next page.

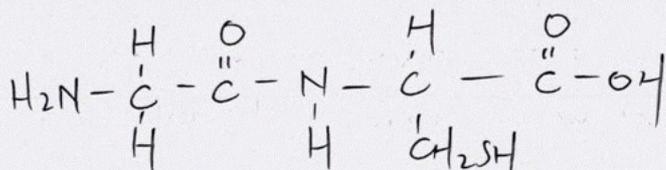
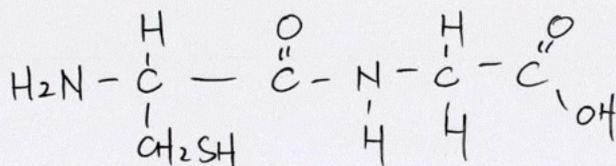
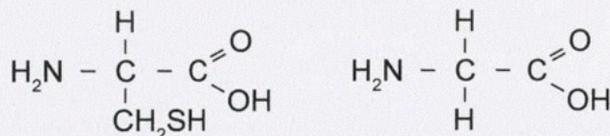
Space for working:



Compound	Structural formula
A	$\text{CH}_2 = \text{CH} - \overset{\text{OH}}{\underset{ }{\text{CH}}} - \text{CH}_3$
B	$\text{CH}_3 - \underset{\text{OH}}{\underset{ }{\text{CH}}} - \overset{\text{OH}}{\underset{ }{\text{CH}}} - \text{CH}_3$
C	$\overset{\text{OH}}{\underset{ }{\text{CH}_2}} - \text{CH}_2 - \overset{\text{OH}}{\underset{ }{\text{CH}}} - \text{CH}_3$
D	$\text{CH}_3 - \underset{\text{Cl}}{\underset{ }{\text{CH}}} - \overset{\text{NH}_2}{\underset{ }{\text{CH}}} - \text{CH}_3$
E	$\text{CH}_3 - \overset{\text{OH}}{\underset{ }{\text{CH}}} - \text{CH}_2 - \overset{\text{O}}{\parallel}{\text{C}} - \text{H}$

QUESTION THREE

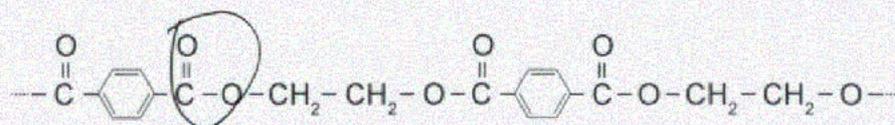
- (a) (i) Using the following two amino acids, draw the structural formulae for the two possible dipeptides that could be formed.



- (ii) Identify and explain the type of reaction occurring to form the two dipeptides.

The type of reaction occurring is a chemical process called condensation, where ~~two~~ small ^{organic} molecules join together to form a large organic molecule with water released as a byproduct of each link.

Dacron is a polymer used in the furniture industry. Two repeating units of Dacron are shown below:

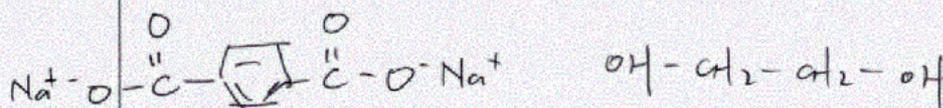


Note:  is a benzene ring, and does not change when Dacron is heated in part (iv).

- (iii) Circle ONE ester linkage in the above diagram of Dacron.
- (iv) Identify and explain the type of reaction that would occur when Dacron is heated under reflux with sodium hydroxide, NaOH, solution.

Draw the structural formulae of the organic products in the box below to support your answer.

When Dacron is heated under reflux with NaOH , basic hydrolysis occurs, where water is used to split up a large organic molecule to small organic molecules with a dilute base as a reagent. In this case as Dacron gets split up, the COOH gets deprotonated to a salt (COO^-) and further reacts with the Na^+ from NaOH to form a sodium salt. Other than that, a diol is also produced as a product.



Question Three continues
on the next page.

(b) (i) Consider compounds W, X, and Y, shown below:

Compound W	Compound X	Compound Y
$\text{CH}_3-\text{CH}_2-\text{CH}=\text{CH}-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	$\text{CH}_2=\text{CH}-\text{CH}_2-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$	$\text{CH}_3-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}=\text{CH}-\overset{\text{O}}{\parallel}{\text{C}}-\text{OH}$

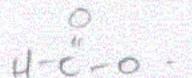
Identify the ONE compound that has ALL the following properties:

- exists as *cis-trans* (geometric) isomers
- reacts with thionyl chloride, SOCl_2 , to produce steamy fumes
- can be reduced by sodium borohydride, NaBH_4 .

Compound (W, X, or Y):

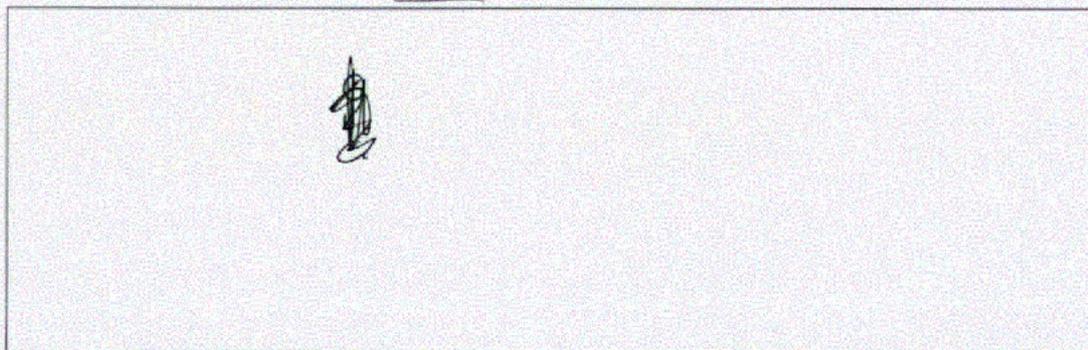
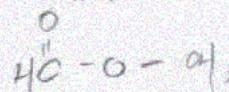
Explain your choice, including why the other two compounds were eliminated.

Compound Y is chosen for having all the properties. It exists as *cis-trans* isomers, because it contains a rigid carbon double bond that does not allow for rotation, and the carbons of the double bond are attached to different atoms or groups of atoms. This ^{property} eliminates compound X because one of the carbons from C=C are attached to 2H's meaning that it cannot be a geometric isomer. ~~Compound Y can undergo~~ Although both compound W and compound Y can be reduced by NaBH_4 to form an alcohol and an aldehyde respectively, compound W does not react with SOCl_2 to produce steamy fumes while compound Y ~~and~~ contains a carboxylic acid group that allows the molecule to undergo substitution to form an acyl chloride and white fumes of HCl gas. Therefore compound Y is the only compound that satisfies all of the properties.



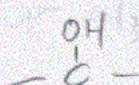
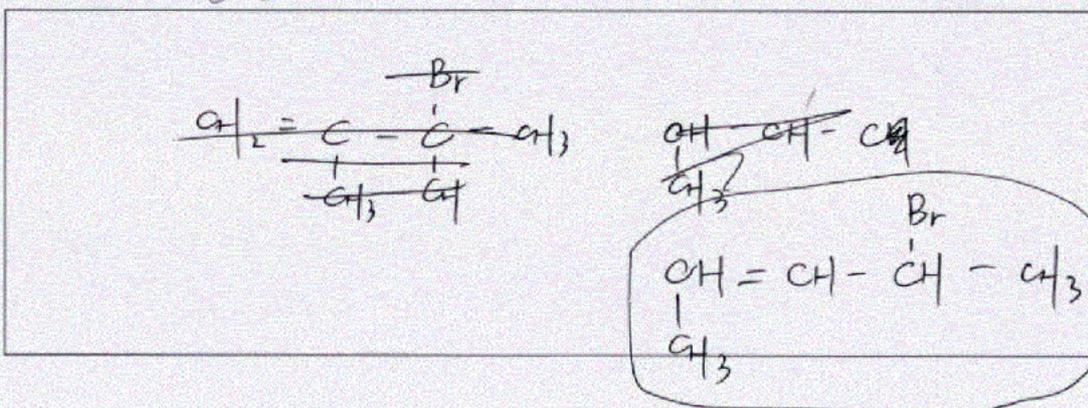
(ii) Draw the structural formula of Compound S, given its molecular formula is $C_5H_{10}O_3$, and it has the following properties:

- can be oxidised to a ketone *Secondary alcohol*
- can form a cyclic ester with four carbon atoms in the ring when heated with concentrated sulfuric acid, H_2SO_4 .



(iii) Draw the structural formula of Compound T, given its molecular formula is C_5H_9Br , and it has the following properties:

- branched carbon chain
- exists as enantiomers (optical isomers)
- classified as a secondary haloalkane
- causes a colour change of orange to colourless when mixed with bromine water, $Br_2(aq)$.



Extra space if required.
Write the question number(s) if applicable.

QUESTION
NUMBER

91391

Achievement

Subject: L3 Chemistry

Standard: 91391

Total score: 12

Q	Grade score	Marker commentary
One	A3	<p>This response provided enough evidence for A3.</p> <p>Although the candidate did not identify all chiral carbons, they explained how to identify the two forms of glucose enantiomers. The explanation for reaction with Tollen's reagent does not identify the type of acid.</p> <p>To gain a higher grade in the reaction scheme, an amine rather than an amide and acyl chloride are needed to form propylpropanamide. Steps after the propan-1-ol incorrect / missing.</p> <p>The candidate correctly stated the colour change and type of reaction.</p> <p>To gain a higher grade, the candidate needed to identify that butan-1-ol under reflux formed butanoic acid, with supporting data.</p> <p>The candidate defined distillation. To gain a higher grade for this part, the candidate needed to relate the process of distillation to oxidation of butan-1-ol to butanal, and how the horizontal position of condenser allows the purified butanal to be collected compared to the vertical position of the condenser in reflux.</p>
Two	M5	<p>This response provided enough evidence for M5.</p> <p>The structural formulae appear correct. For a higher grade, the handwriting is not distinct enough, as C and H joined together and inconsistent sizing.</p> <p>Enantiomers drawn in a tetrahedral shape, to obtain a higher grade a CHO functional group needed to be drawn, rather than a COH.</p> <p>Three types of reaction and compounds identified. The colour change for Fehling's solution is incomplete.</p> <p>The candidate explained why the order must be followed; a more complete answer would recognise that acidified potassium dichromate solution is a stronger oxidising agent than Fehling's solution, and that if acidified potassium dichromate or Fehling's solutions were added first then either ethanal or ethanol would also react.</p> <p>Three correct structures are drawn from the molecular formula and information of the reactions. A higher grade for this question would recognise that both alcohol groups form the amine and that both alcohol groups reacted completely with acidified potassium dichromate.</p>

Three	A4	<p>This response provided enough evidence for A4.</p> <p>Two correct dipeptides are drawn. For a higher grade, the answer needed to use the terms related to the question rather than a generic answer.</p> <p>The ester link and type of reaction are correct.</p> <p>For a higher grade, the candidate needed an explanation of how the water molecule is added to the broken ester link to form the alcohol and the carboxylic acid.</p> <p>The candidate selected Compound Y and supported the three properties of Y and eliminated W and X with reasons.</p> <p>The candidate recognised that Compound S has a secondary alcohol, though no structure is drawn, and that Compound T has a carbon double bond and a secondary haloalkane; to gain a higher grade, a chiral carbon is required to form enantiomers.</p>
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