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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.

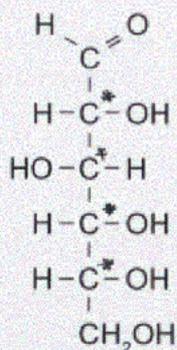
Excellence

TOTAL 20

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.



plane polarised
light

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

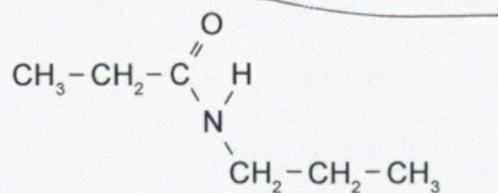
D-glucose and L-glucose can be distinguished through the use of ~~as~~ plane polarised light. Depending on the optical isomer, this will cause the light to rotate left or rotate right.

- (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.

The ~~type~~ type of reaction is oxidation as D-glucose contains an aldehyde group, $\text{C}^{\text{=O}}\text{H}$, this aldehyde can be oxidised ^{with heat} further to form a COOH ($\text{C}^{\text{=O}}\text{H}$) carboxylic group. ~~When~~ When a Tollens reagent is used, a silver mirror precipitate solid can be observed.

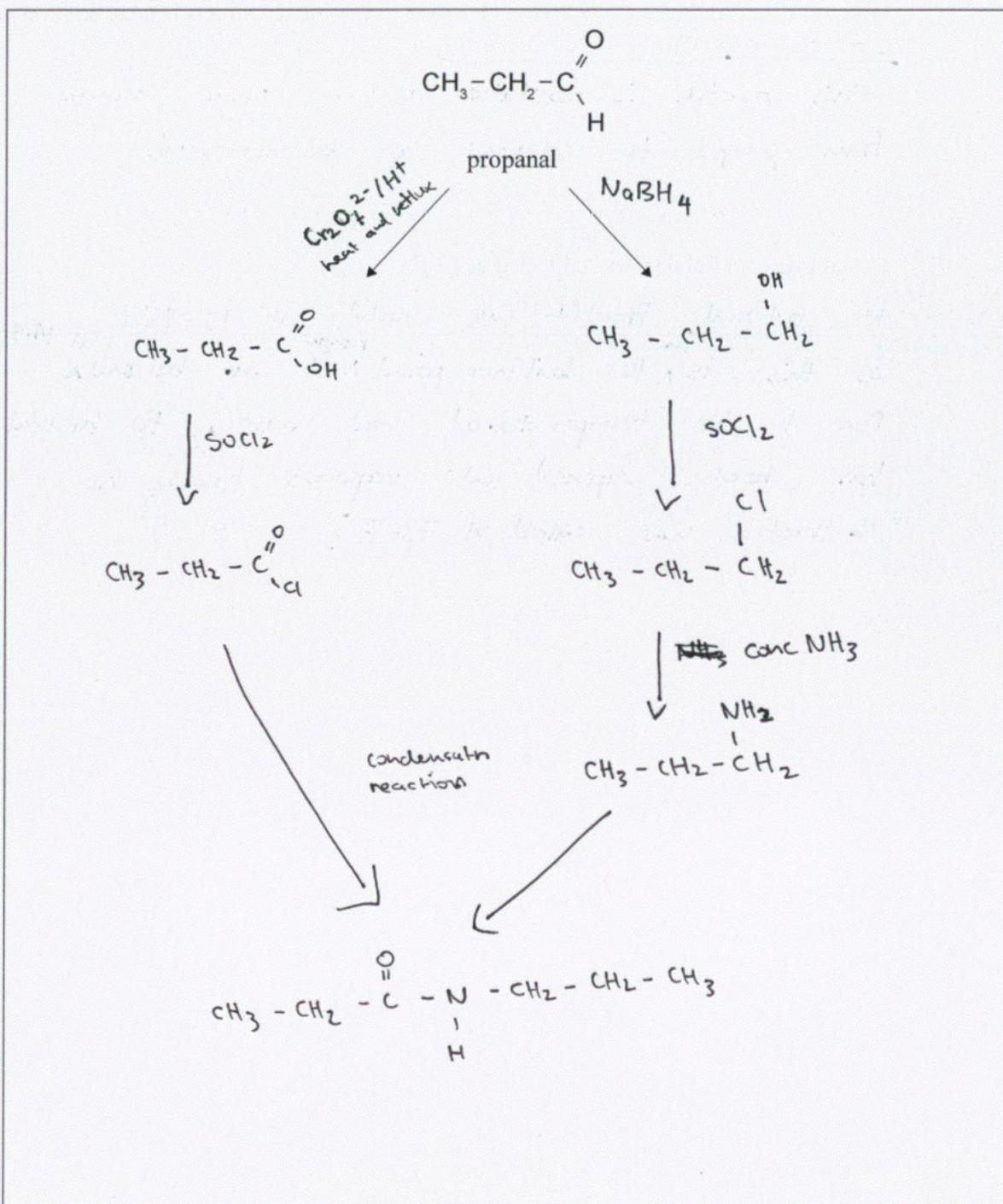
- (b) Devise a reaction scheme to convert propanal into N-propylpropanamide.



N-propylpropanamide

Assume that you are provided **only** with the following reagents:

SOCl_2 , $\text{Cr}_2\text{O}_7^{2-}/\text{H}^+$, NaBH_4 , conc NH_3 (reagents can be used more than once).



- (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 $73\text{--}76^\circ\text{C}$.

Compound	Boiling point/ $^\circ\text{C}$
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.

This reaction is oxidation as a colour change from purple to colourless can be observed.

- (ii) Explain why no fraction was collected at $73\text{--}76^\circ\text{C}$.

No butanal fraction was collected at $73\text{--}76^\circ\text{C}$ as this is ⁱⁿ the boiling point ^{range} of ~~the~~ butanal ^{at 74.8°} .
 Due to the temperature, at heat energy, the butanal has been vapourised into vapours. Hence, no fraction was collected at $73\text{--}76^\circ\text{C}$.

- (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.

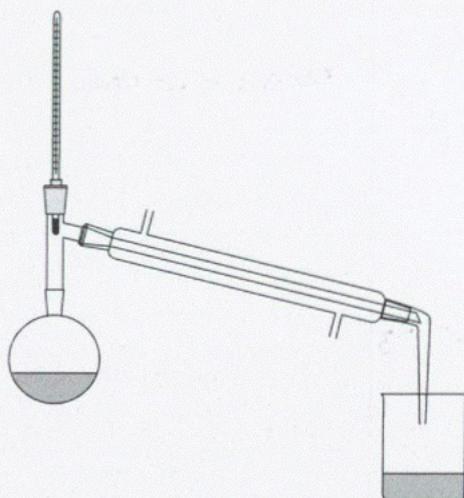
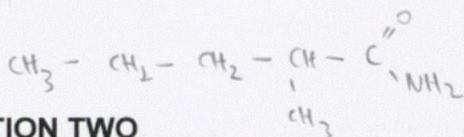


Fig. 1

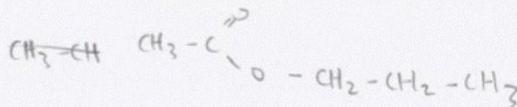


Fig. 2

The student should have used distillation ^{with heat} instead of heat ^{with heat} with reflux to produce butanal. This is because, distillation ^{with heat} uses the difference in boiling points to prevent the further oxidation of butanal into butanoic acid. Which is the process that the student should use as the student wants to make butanal. Since butanal has a lower boiling point (74.8°C) than butan-1-ol (118°C), when the butanal is produced it will be vapour when it enters the condenser it will be condensed ~~then~~ ~~to prevent~~ it the butanal will be collected to prevent it from further oxidation into butanoic acid which is exactly what the student wants. In contrast, reflux under heat prevents the loss of volatile components by cooling and condensing the vapour (butanal) so that it is returned back into the reaction mixture for another chance to react ensuring a greater yield and that the reaction goes to completion to produce butanoic acid which the student does not want. Heat also increases the rate of reaction which cause the reaction to speed up and cause the student to miss timing using reflux. Thus distillation overall, is the much better choice.



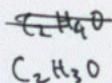
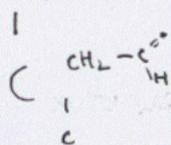
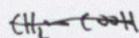
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QUESTION TWO

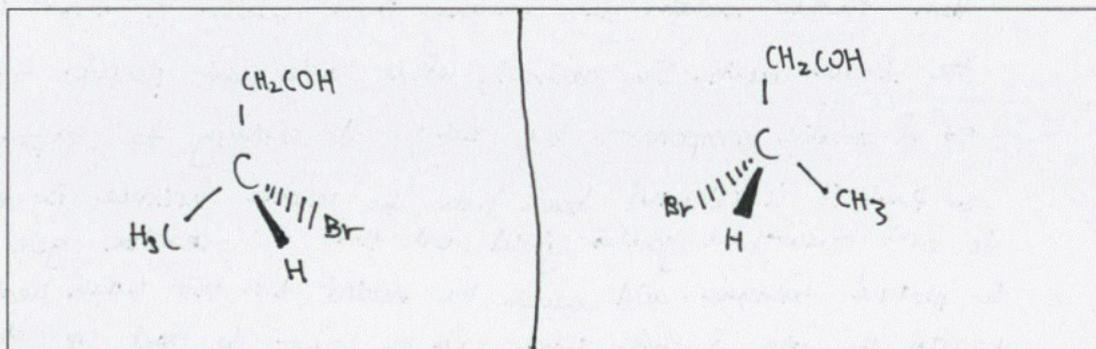
(a) (i) Complete the table below by either naming or drawing the structural formula.

	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	$\text{CH}_3 - \underset{\text{Br}}{\text{CH}} - \text{CH}_2 - \overset{\text{O}}{\parallel} \text{C} - \text{H}$	3-bromobutanal



C

(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	Vigorous/vident reaction with steamy fumes	Substitution	ethanoic acid
2	colour change blue solution to brick red solid precipitate	Oxidation	ethanoic acid
3	colour change from orange change to green	oxidation	ethanoic acid

- (ii) Justify why the three steps should be followed in the order given to positively identify each of the three colourless liquids.
 * Thus by adding water ensures that any ethanoyl chloride reacts
 water must be used first to eliminate the ethanoyl chloride this is because ethanoyl chloride is highly reactive to any (aq) solution.
 Next, adding any other solution ~~with~~ other than water will make the ethanoyl chloride react along with another substance which will make the distinction between the two solutions significantly difficult. *
 Next, Fehling's solution is used. since both ethanol and ethanal undergo oxidation, ~~using~~ $K_2Cr_2O_7/H^+$ will oxidise both solutions with the same ~~orange~~ ^{orange} to ~~green~~ ^{green} observation. Thus, Fehling's reagent ~~was~~ was used to only oxidise ethanol into ethanoic acid to positively identify the ethanol. This is because, Fehling's solution is not a strong oxidant to oxidise an alcohol like ethanol; thus ethanol ^{will only react and} can be identified. Finally, ~~the~~ $K_2Cr_2O_7/H^+$ is used to oxidise and identify ethanal due to it being the last solution ^{with a colour change from orange to green.}
 Chemistry 91391, 2025

hydr?

H₂O/H⁺

8

C C C C

- (c) Compound A has the molecular formula C₄H₈O, and exists as enantiomers (optical isomers). When dilute sulfuric acid, H₂SO₄, 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, SOCl₂, followed by concentrated ammonia, NH₃, to form Compound D. Compound D turns damp red litmus paper blue.

Compound C is heated with excess acidified potassium permanganate, KMnO₄/H⁺, to form Compound E. Compound E forms bubbles when sodium carbonate, Na₂CO₃, 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:

~~CH₃-CH₂-CH₂-CH₃~~ CH₃-CH₂-CH(OH)-CH₃

CH₃-CH(OH)-CH=CH₂ CH₃-CH(OH)-CH₂-CH₃ (major)

A) CH₃-CH(OH)-CH=CH₂ B) CH₃-CH(OH)-CH(OH)-CH₃

B) CH₃-CH(OH)-CH(OH)-CH₃ (minor)

C) CH₃-CH(OH)-CH₂-CH₂-CH₃ (minor)

C) CH₃-CH₂-CH(OH)-CH₃

D) CH₃-CH(NH₂)-CH(NH₂)-CH₃

D) CH₃-CH(NH₂)-CH(NH₂)-CH₃

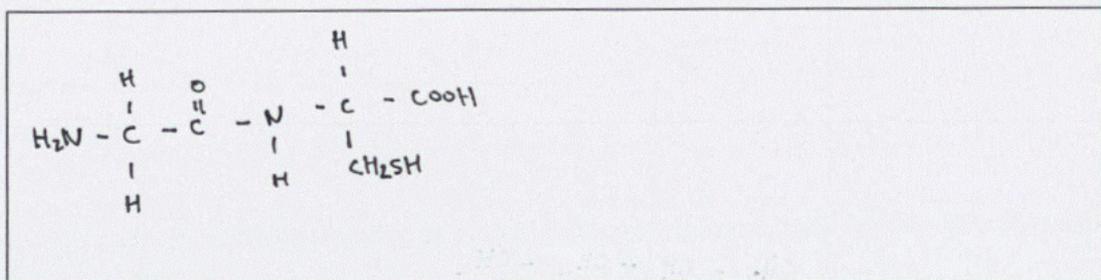
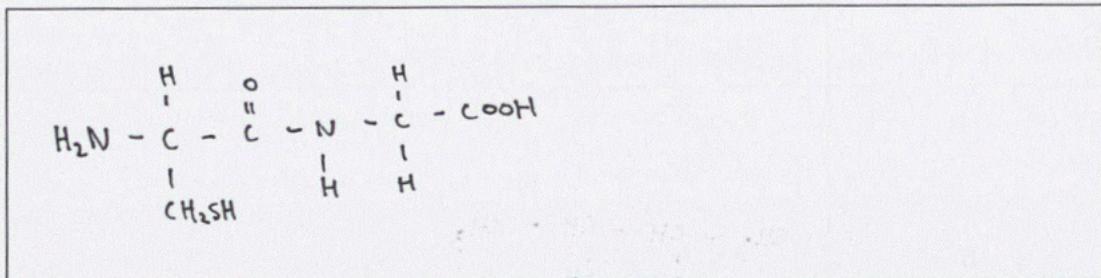
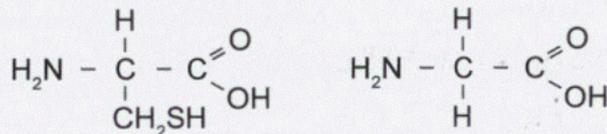
E) CH₃-C(=O)-CH₂-C(=O)OH

E) CH₃-C(=O)-CH₂-C(=O)OH

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

QUESTION THREE

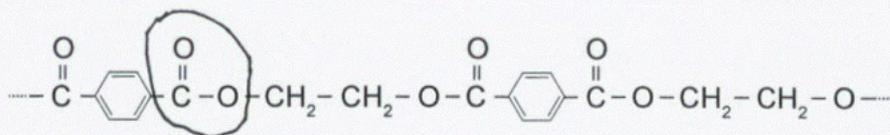
- (a) (i) Using the following two amino acids, draw the structural formulae for the two possible dipeptides that could be formed.



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

The type of reaction occurring to form the two dipeptides is a condensation reaction. A condensation reaction is where two smaller organic molecules (amino acids) combine to form a larger organic molecule (dipeptide) with a loss of a small molecule (H_2O) ~~for every~~ using a catalyst acid such as conc H_2SO_4 with heat at ~~atmos.~~ reflux. In this case, the two amino acids combine to form a dipeptide with the loss of water H_2O molecules for every peptide linkage formed.

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

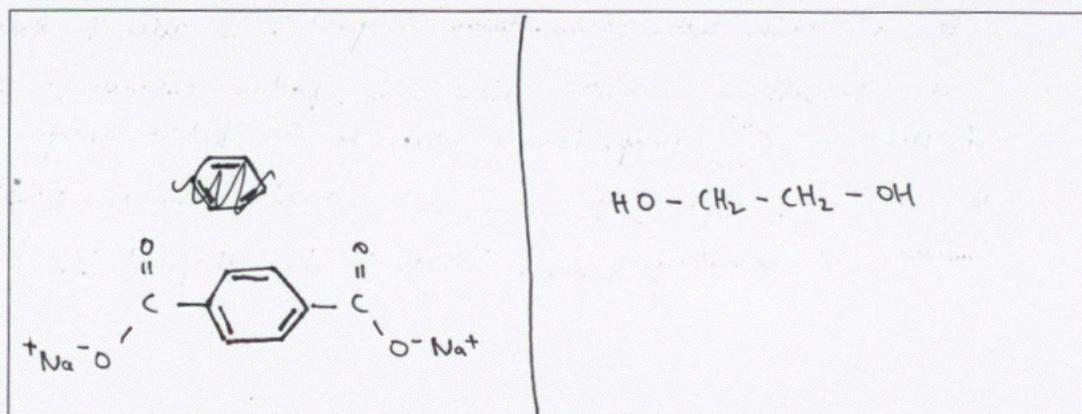


Note:  is a benzene ring, and does not change when Dacron is heated in part (iv).

- (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.

The type of reaction is hydrolysis which is the addition of water to ~~the~~ split a larger organic molecule into two smaller ~~organic~~ organic molecules through dilute base NaOH(aq) or dilute acid H₂SO₄(aq) using heat at reflux. In this context, this reaction is ~~acidic~~ ^{basic} hydrolysis using NaOH(aq) with heat at reflux. Due to the presence of water, the C-O gains an H⁺ ^{from water} to form C-OH, while the C=O group gains OH from water to form COH. Since it is ~~acidic~~ ^{basic} conditions the COH becomes deprotonated as it gives out a proton or H⁺ to form COO⁻.



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):

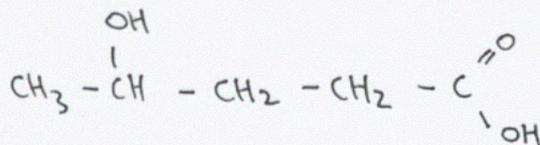
~~W~~ ~~X~~ Y

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

The compound that has all the following properties is compound ~~W~~ ~~X~~ Y. Immediately molecule X is eliminated this is because the requirement states that the compound exists as *cis-trans* isomers. While W and Y have a different atom/group bonded on each carbon on the carbon to carbon double bond, compound X has two same H group bonded to the carbons. With the $\text{C}=\text{C}$ double bond it cannot exist as a *cis-trans*-isomer. Next, compound ~~W~~ is eliminated as it cannot undergo a reaction to produce steamy fumes at a rapid rate due to a reaction with SOCl_2 . Hence, compound Y is able to undergo a substitution reaction with SOCl_2 , producing steamy fumes to produce a C^{O} group. Finally due to the ketone group at $\text{C}=\text{O}$, compound Y can be reduced through NaBH_4 forming a secondary alcohol. Thus it is compound Y.

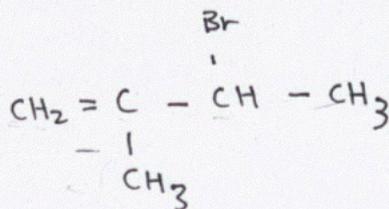
(ii) Draw the structural formula of Compound S, given its molecular formula is $C_5H_{10}O_3$, and it has the following properties:

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

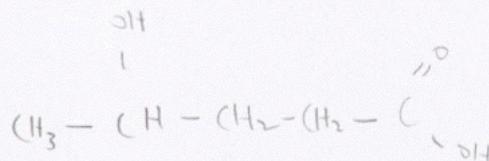
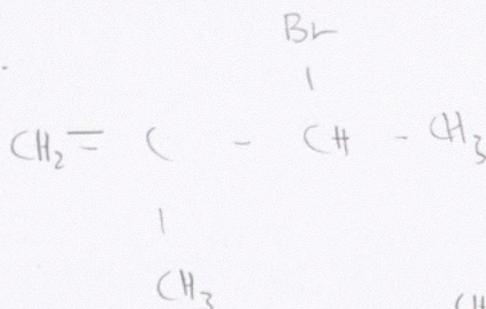


(iii) Draw the structural formula of Compound T, given its molecular formula is C_5H_9Br , and it has the following properties:

- 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, $Br_2(aq)$.



C_5H_9Br



Excellence

Subject: L3 Chemistry

Standard: 91391

Total score: 20

Q	Grade score	Marker commentary
One	M5	<p>This response provided enough evidence for M5.</p> <p>The candidate was identified chiral carbons and how to distinguish between the glucose enantiomers. Tollen's reagent tests for aldehydes and a partially explanation the reaction.</p> <p>They completed a correct reaction scheme to convert propanal to N-propylpropanamide.</p> <p>They discussed the processes of reflux and distillation. To obtain a higher grade, the student needed to compare the position of the condensers in reflux and distillation.</p>
Two	E8	<p>This response provided enough evidence for E8.</p> <p>The candidate named and drew structural formulae.</p> <p>Enantiomers were drawn in a tetrahedral shape. To gain a higher grade, an aldehyde (CHO) needed to be drawn, rather than an alcohol (COH).</p> <p>They justified why the order for testing the three compounds need to be followed.</p> <p>They correctly determined the structures of the five compounds.</p>
Three	E7	<p>This response provided enough evidence for E7.</p> <p>The candidate was able to combine two amino acids to form a dipeptide and explain a condensation reaction.</p> <p>The candidate explained the basic hydrolysis reaction for the formation of alcohol and carboxylic acid. To gain a higher grade they needed to state a salt is formed during basic hydrolysis. Correct structures for the two products were drawn.</p> <p>They fully supported properties of Compound Y, and used the properties of Compound W and Compound X to eliminate them.</p> <p>They drew two correct structures from the properties given.</p>