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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.**

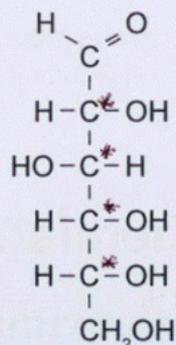
Merit

**TOTAL 17**

### 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.

Enantiomers rotate polarised light in a direction dependent on their structure. Which means by using polarised light and detecting the direction the rays are rotated you know which enantiomer it is.

- (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 functional group which undergoes an oxidation reaction with Tollens' reagent to produce a silver mirror and the formation of a carboxylic acid.



- (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,  $\text{KMnO}_4/\text{H}^+$ , 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.

The purple solution with  $\text{KMnO}_4/\text{H}^+$  will turn colourless as the butan-1-ol is oxidised.

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

The student oxidised butan-1-ol under reflux which sped up the rate of reaction, and ensuring the volatile mixture completely reacted in 20 minutes to produce only butanoic acid. The reason why no butanal fraction was collected at  $73\text{--}76^\circ\text{C}$  was because there is no butanal left as it was completely oxidised to butanoic acid, which has a much higher boiling point.

- (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.

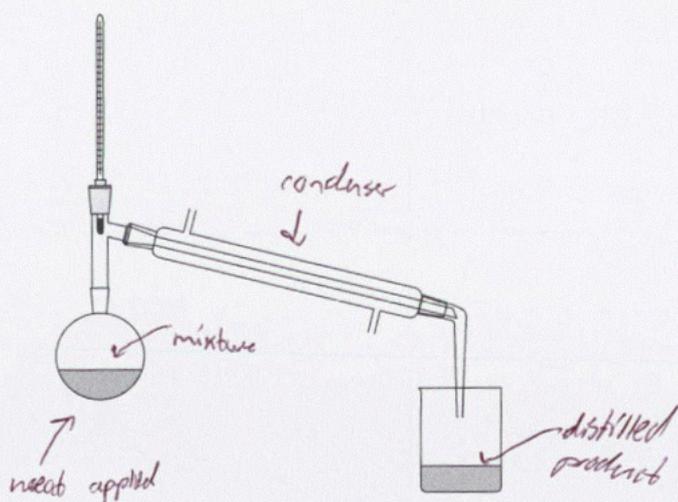


Fig. 1

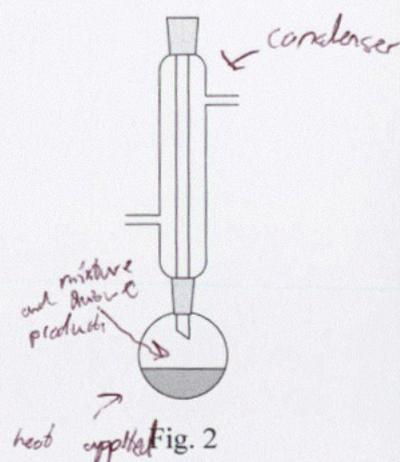


Fig. 2

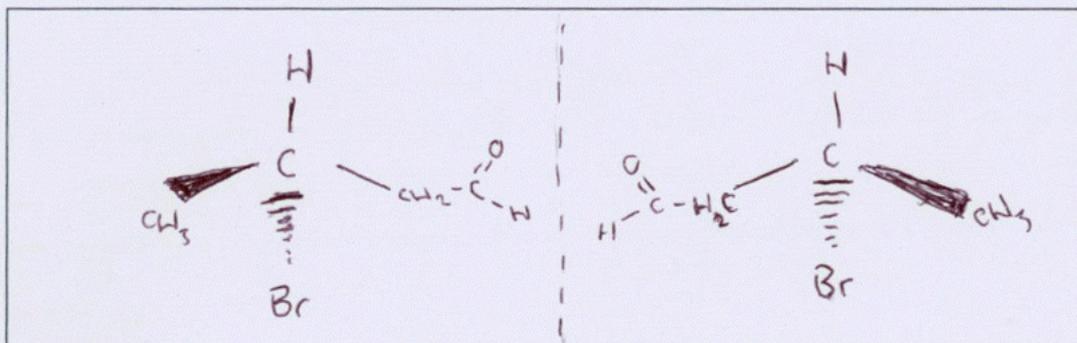
in the process of distillation a mixture is heated to usually the boiling point of the fraction with the lowest boiling point, where it changes state to a gas and enters a chilled tube called a condenser which condenses the fraction back into a liquid so it can be contained. However in reflux the mixture is continuously heated so the rate of reaction is faster and the chilled condenser acts to prevent loss of product and ensure the volatile reactant remains in the process so it can be further reacted. Fig. 2 is the reflux apparatus, as seen the condenser leads back to the point of reaction, whereas Fig. 1 is the distillation apparatus and the condenser leads to a separate container.

## QUESTION TWO

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

	Structural formula	IUPAC name
A	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{CH}_3$	pentan-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	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\overset{\text{CH}_3}{\underset{ }{\text{CH}}}-\overset{\text{O}}{\parallel}{\text{C}}-\text{NH}_2$	2-methylpentanamide
D	$\text{CH}_3-\underset{\text{Br}}{\underset{ }{\text{CH}}}-\text{CH}_2-\overset{\text{O}}{\parallel}{\text{C}}-\text{H}$	3-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	One liquid has a volatile reaction and produces a HCl gas the other two liquids do nothing	Hydrolysis	ethanoyl chloride
2	One of the liquids turns Fehling's solution from blue to red. The others do nothing	Oxidation	ethanal
3	<del>The two</del> of the solutions turn the $K_2Cr_2O_7/H^+$ from orange to green the others do nothing	Oxidation	ethanol

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

The ethanol and ethanal will both be oxidised by  $K_2Cr_2O_7/H^+$  causing the colour change which is why using Fehling's solution should be done first as it only reacts with aldehydes, so you know not to put  $K_2Cr_2O_7/H^+$  in the ethanol liquid. Ethanoyl chloride is also a very volatile substance that vigorously reacts with water, eliminating it first is important as <sup>the water in</sup> Fehling's solution will react with the acyl chloride giving random results.

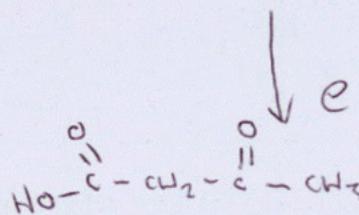
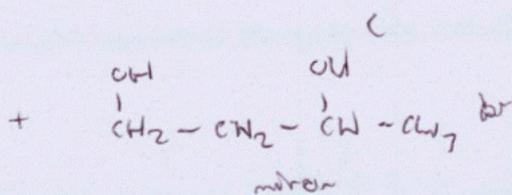
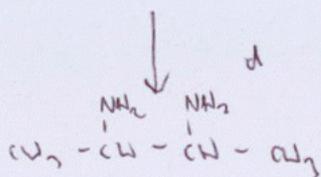
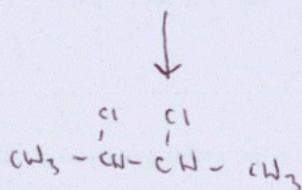
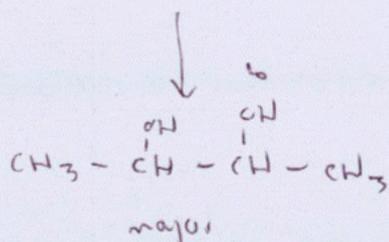
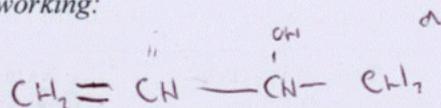
- (c) Compound A has the molecular formula  $C_4H_8O$ , and exists as enantiomers (optical isomers). When dilute sulfuric acid,  $H_2SO_4$ , is added, two organic compounds are formed: Compound B and Compound C. Compound B is present in the higher proportion.

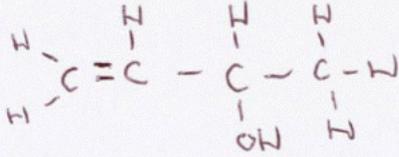
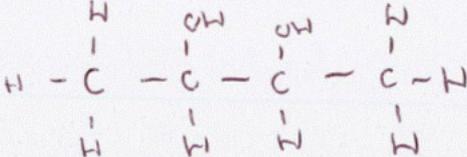
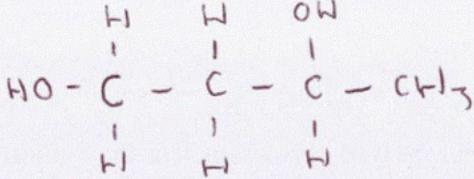
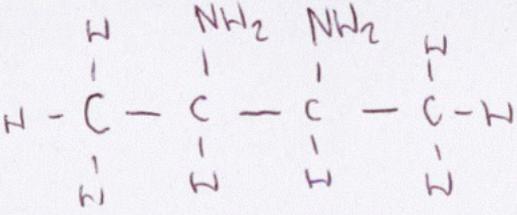
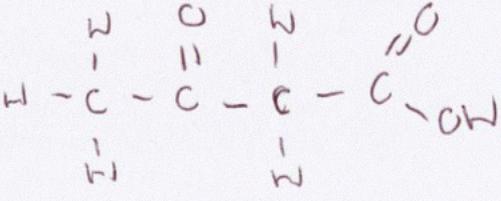
Compound B is reacted with excess thionyl chloride,  $SOCl_2$ , followed by concentrated ammonia,  $NH_3$ , to form Compound D. Compound D turns damp red litmus paper blue.

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.

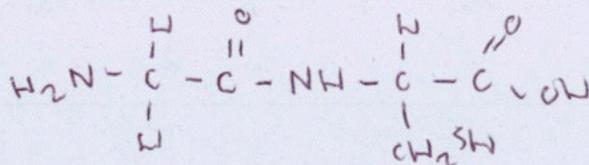
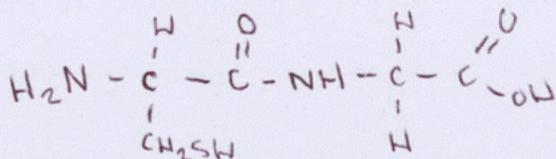
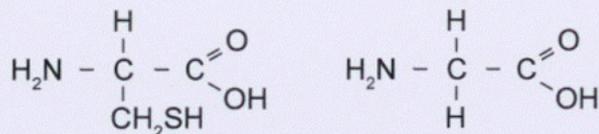
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Compound	Structural formula
A	
B	
C	
D	
E	

## QUESTION THREE

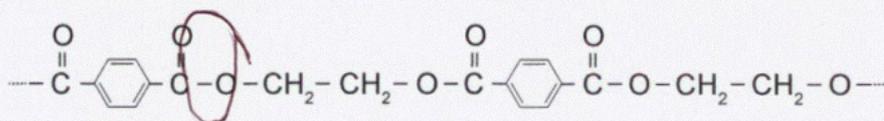
- (a) (i) Using the following two amino acids, draw the structural formulae for the two possible dipeptides that could be formed.



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

This is a condensation reaction as a large molecule is formed from two smaller molecules and HCl or H<sub>2</sub>O is produced depending if the reaction happens in acidic or basic conditions. In this reaction the carboxylic acid functional group on one amino acid undergoes a condensation reaction with the amine functional group on another amino acid to form a peptide bond / amide functional group.

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

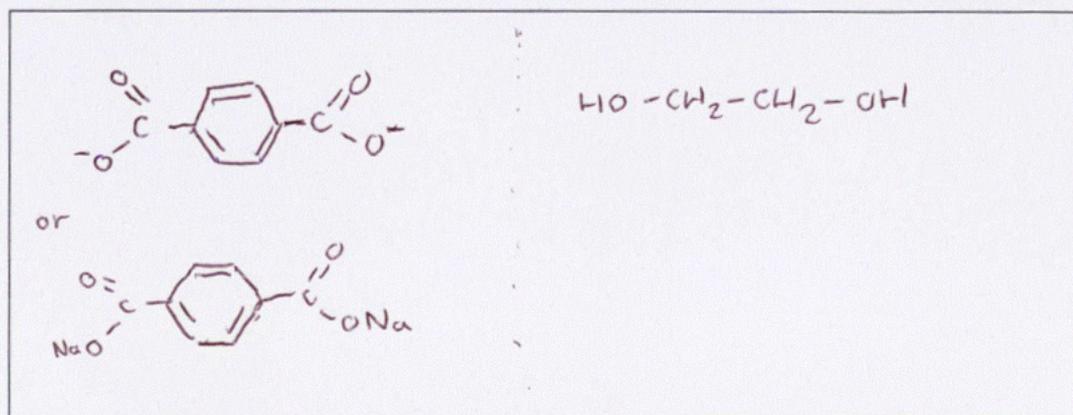


Note:  is a benzene ring, and does not change when Dacron is heated in part (iv).

- (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.

Dacron will be split into two products (<sup>carboxylic</sup> ~~carboxylic~~ acid and a diol) through hydrolysis. Which is a reaction involving the splitting of water molecules to produce products. It can be done in acidic or basic conditions and produce different products dependent on the conditions. In this scenario, basic hydrolysis occurs, splitting the polyester into carboxate ions and diols.



Question Three continues  
on the next page.

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

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

Identify the ONE compound that has ALL the following properties:

- exists as *cis-trans* (geometric) isomers
- reacts with thionyl chloride,  $\text{SOCl}_2$ , to produce steamy fumes
- can be reduced by sodium borohydride,  $\text{NaBH}_4$ .

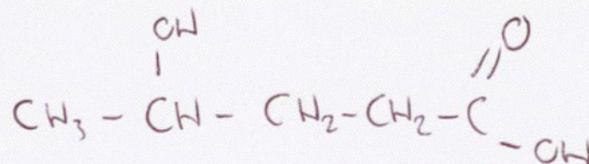
Compound (W, X, or Y): Y

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

Compound X can be eliminated as it doesn't have different groups/atoms about the double bonded carbon and therefore can't have *cis-trans* isomers, furthermore it can't be. Both compound Y and W can be reduced using  $\text{NaBH}_4$ , however, compound W won't react with  $\text{SOCl}_2$  to produce steamy fumes. This leaves compound Y which has a reducible ketone group, possesses geometric isomers and has a carboxylic acid functional group which can react with  $\text{SOCl}_2$ .

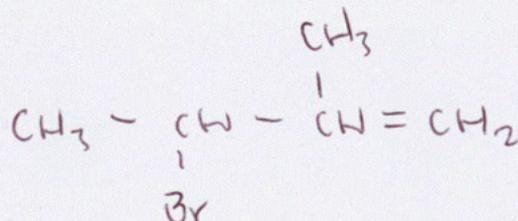
(ii) Draw the structural formula of Compound S, given its molecular formula is  $C_5H_{10}O_3$ , and it has the following properties:

- 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,  $Br_2(aq)$ .







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

QUESTION  
NUMBER

91391

## Merit

**Subject:** L3 Chemistry

**Standard:** 91391

**Total score:** 17

Q	Grade score	Marker commentary
One	M5	<p>This response provided enough evidence for M5.</p> <p>The candidate was able to identify chiral carbons. They included a partial explanation of how enantiomers are distinguished, and that Tollen's reagent tests for aldehydes with a partial explanation of the redox reaction. For a higher grade, either the direction of plane polarised light is in opposite directions, or the aldehyde oxidises to a carboxylic acid and the silver ions are reduced to silver atoms is required.</p> <p>The candidate completed a reaction scheme correctly to convert propanal to N-propylpropanamide.</p> <p>Generic explanation of why the student should have used distillation rather than reflux. To gain a higher grade, the answer needs to use the context given.</p>
Two	E7	<p>This response provided enough evidence for E7.</p> <p>The candidate was able draw structural formulae. They drew enantiomers in a tetrahedral shape with correct functional groups.</p> <p>They justified why the order for testing the three compounds needed to be followed. To gain a higher grade for this part, they needed to say why step 3 is required to confirm the ethanol.</p> <p>The candidate correctly determined the structures of the five compounds.</p>
Three	M5	<p>This response provided enough evidence for M5.</p> <p>The candidate was able to combine two amino acids to form a dipeptide and explain a condensation reaction.</p> <p>A basic hydrolysis reaction explanation was incomplete for the formation of the alcohol, carboxylic acid, and the salt. Correct structures for the two products were drawn.</p> <p>The candidate used the supported properties to eliminate compound X and one supported property for compound Y. To gain a higher grade, the reaction with thionyl chloride needs to identify that the functional group COOH in Y is a substitution reaction, and Y can form cis-trans isomers as Y has a C=C with two different groups bonded to each of these C atoms.</p> <p>They drew two correct structures from properties given.</p>