

SAMPLE PAPER



NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Chemistry

3.5: Demonstrate understanding of structure and reactivity of organic compounds

Credits: Five

Check that you have completed ALL parts of the box at the top of this page.

Check that you have been supplied with the resource sheet for Chemistry 3.5.

You should answer ALL parts of ALL questions in this booklet.

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

Check that this booklet has pages 2–15 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO YOUR TEACHER AT THE END OF THE ALLOTTED TIME.

EXEMPLAR FOR LOW MERIT

NOTE: These exemplars do not fully show Grade Score Marking (GSM) because of the small sample of student scripts involved, and the absence of a cut score meeting to determine grade boundaries. GSM can be seen in the level 1 and level 2 exemplars from the 2012 examinations, which will be published on the NZQA website when the assessment schedules are published.

You are advised to spend 60 minutes answering the questions in this booklet.

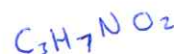
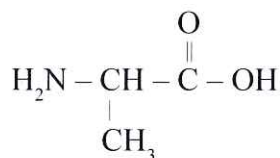
QUESTION ONE

- (a) Give the IUPAC systematic names for the following compounds.

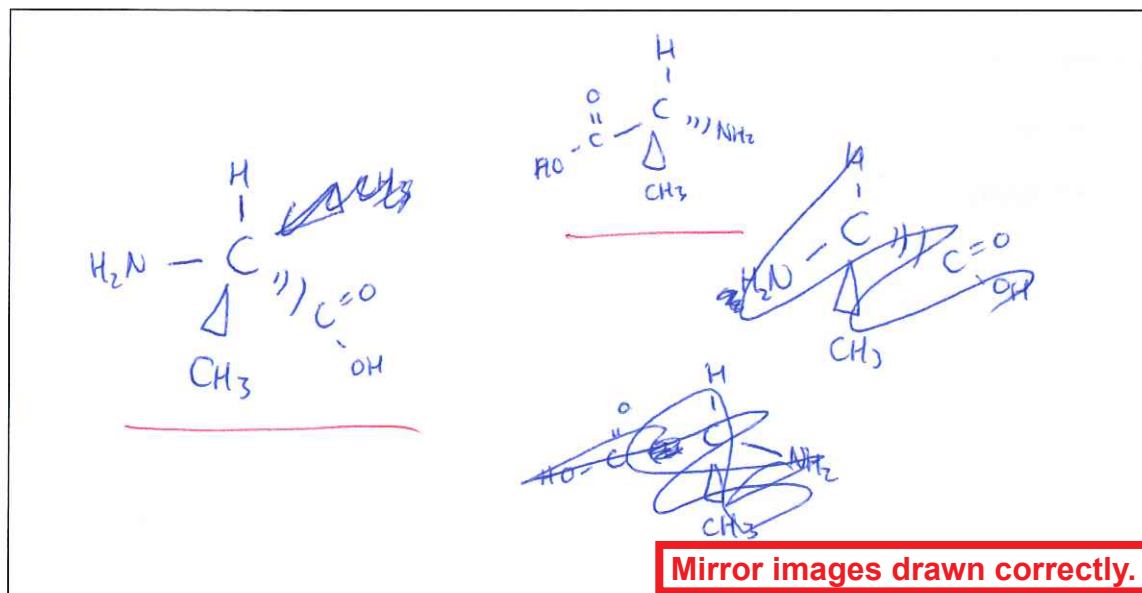
Compound	IUPAC systematic name
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} - \text{Cl} \\ \text{acyl chloride} \end{array}$	<p><u>ethanoyl chloride</u> methyl chloride acetyl chloride</p>
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{CH}_2 - \text{CH} - \text{C} - \text{OH} \\ \\ \text{Cl} \end{array}$	<p>2-chloro acid <u>2-chlorobutanoic acid</u></p>
$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{NH}_2 \\ \\ \text{CH}_3 \\ \text{amine} \end{array}$	<p>2-methyl propan <u>1-amino 2-methyl propane</u></p>

Correct names.

- (b) The amino acid alanine below can exist as two enantiomers (optical isomers).

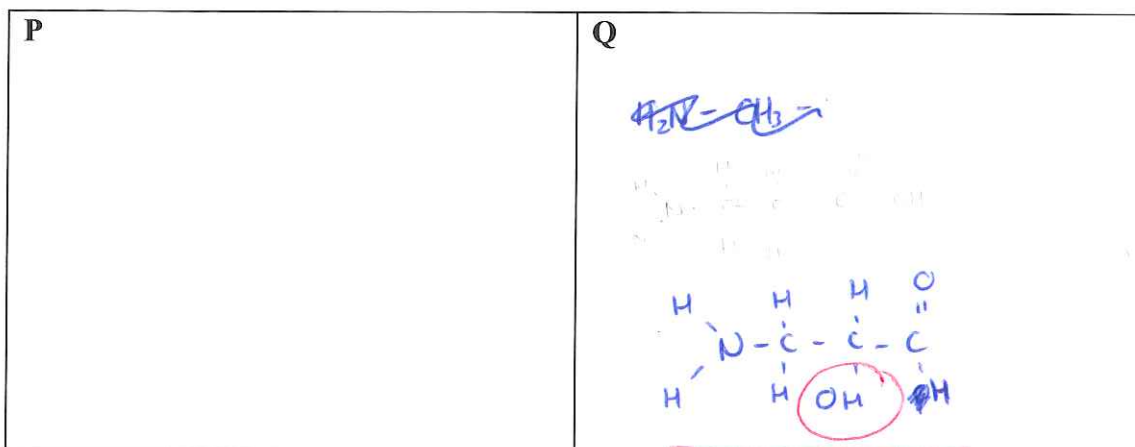


- (i) Draw three-dimensional structures for the two enantiomers that clearly show the relationship between them.



- (ii) Alanine has two straight chain isomers that do not show acidic properties. One of these isomers, P, can exist as an enantiomer, the other isomer, Q, cannot.

Draw P and Q.



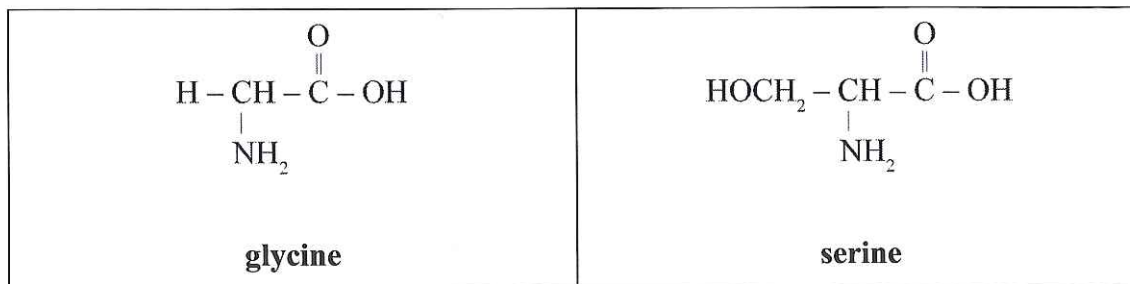
Correct isomer. Poor connectivity for P not Q.

Explain why P exists as an enantiomer.

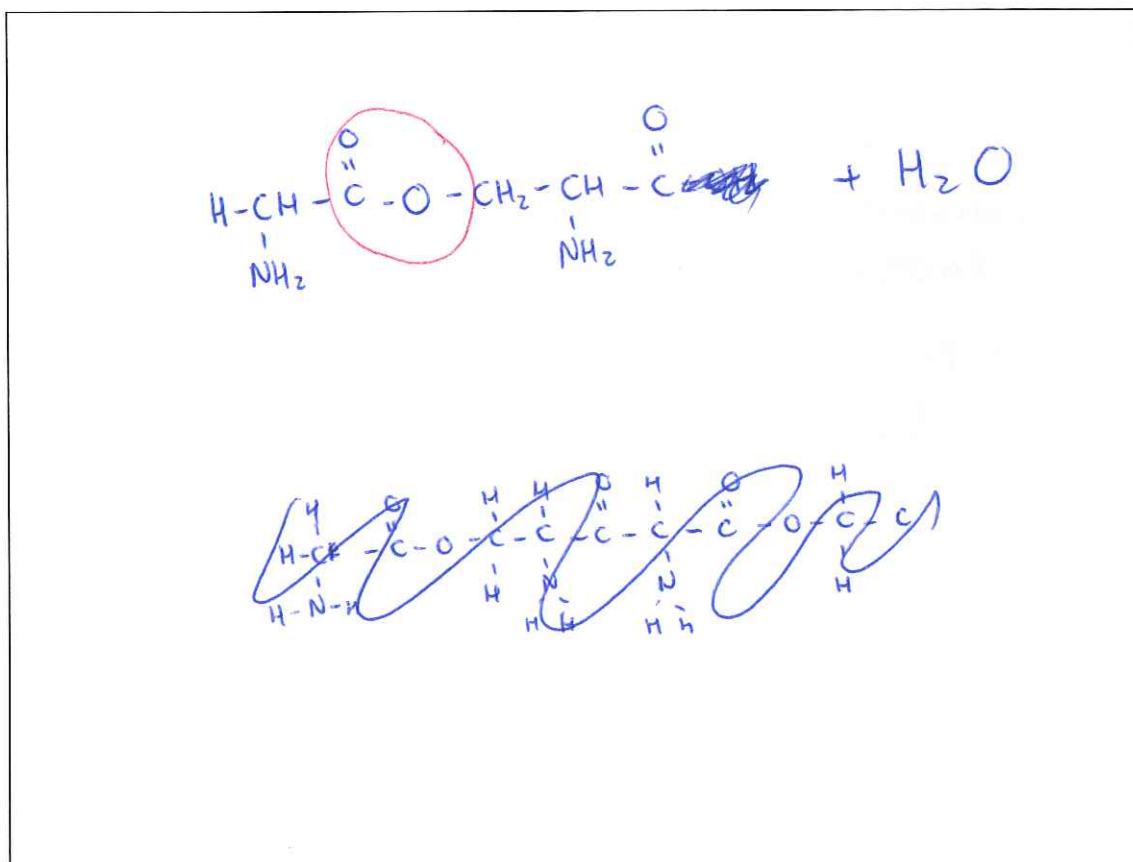
There is a chiral carbon with four different groups attached and therefore is an enantiomer which ~~ref~~ rotates the plane of polarized light.

Correct explanation for enantiomers.

- (c) Glycine and serine are two amino acids, which can combine to form dipeptides.



- (i) Draw the structure(s) of the possible dipeptide(s) formed from a combination of glycine and serine.



- (ii) Explain your answer in terms of the structure and functional groups present in the amino acids and in the dipeptide(s).

There is a peptide bond within the amino acids.

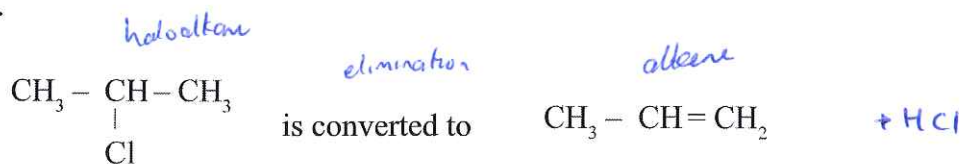
When the two form a dipeptide, a molecule of water is removed so that two smaller molecules can form a bigger molecule. //

No amide or peptide linkage drawn.

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QUESTION TWO

- (a) For the following conversion, identify the reagent required and state the type of reaction occurring. You should give a reason for your answer in terms of the structure of the reactants and products.



Reagent required: KOH^- (aq)

Type of reaction: Elimination

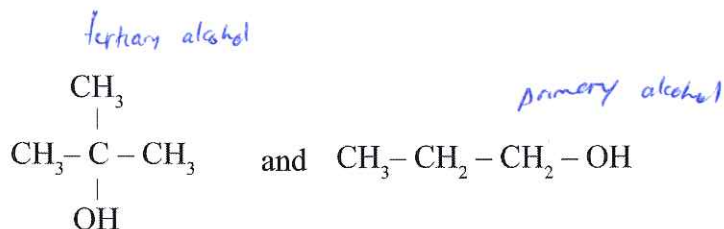
Reason: The alkene is formed by removing the Cl^- and combining it with H^+ to form HCl from the haloalkane.

Recognises elimination of Cl and H to form HCl.

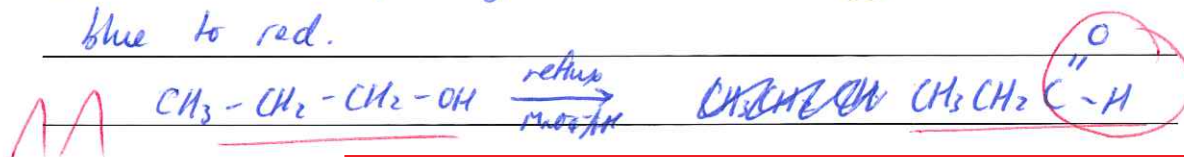
(b) Explain a laboratory procedure that would allow the following pairs of compounds to be distinguished. In your answers, you should include:

- the reagent used
- the expected result for any reactions that may or may not occur
- the structural formulae of the organic product(s) formed when the reaction(s) occur.

(i)

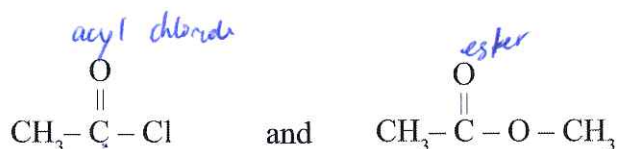


~~Oxidise the primary alcohol~~
 Oxidise to find the primary alcohol as tertiary alcohols do not oxidise. This can be done with $\text{MnO}_4^-/\text{H}^+$. The primary alcohol will turn into an aldehyde if distilled but will turn into a carboxylic acid using reflux. Test for the acid by using litmus and turning it from blue to red.

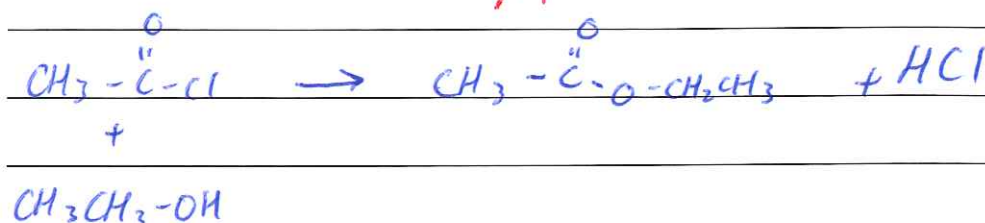


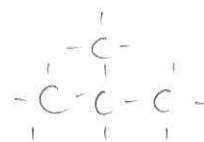
Correct reagent, possible product but no observation.

(ii)



The acyl chloride can be distinguished by adding alcohol to it to form an ester. This reaction does not require a catalyst or heat. The acyl chloride will react with the alcohol so the test tube will show effervescence and become warm.





(c) Use the following information to answer this question.

Compound W is a branched chain molecule with a molecular formula $C_4H_{10}O$.

When **Compound W** is heated with excess acidified potassium dichromate it is readily oxidised to **Compound X**, which has acidic properties.

A substitution reaction occurs when **Compound X** is reacted with $SOCl_2$. The molecular formula of **Compound Y** is C_4H_7OCl .

When **Compound Y** reacts with aminomethane, CH_3-NH_2 , a substitution reaction occurs and **Compound Z** forms.

W = pp butanol X = butanoic acid Y = butanoyl chloride Z = butanamide

Determine the structural formulae of **Compounds W, X, Y, and Z**.

Justify your answer by explaining how you arrived at these structures from the information given above. In your answer, you should:

- include other possible structural formulae you considered
- give your reasons for rejecting the other structural formulae.

Compound W is an ^{primary} alcohol which oxidises to a carboxylic acid

$$CH_3(CH_2)CH_2\overset{H}{\underset{OH}{C}} \xrightarrow[\text{Cr}_2O_7^{2-}/H^+]{\text{heat}} CH_3CH_2CH_2\overset{O}{\underset{OH}{C}} + H$$

Compound X
The carboxylic acid then performs substitution with $SOCl_2$ and becomes an acyl chloride.

$$CH_3CH_2CH_2\overset{O}{\underset{OH}{C}} \rightarrow CH_3(CH_2)CH_2\overset{O}{\underset{Cl}{C}}$$

Substitution occurs and an ~~acyl chloride~~ amide forms and HCl

- Tertiary alcohols don't oxidise so were ~~not~~ rejected. Secondary alcohols oxidise but form ketones so would not have acidic properties.

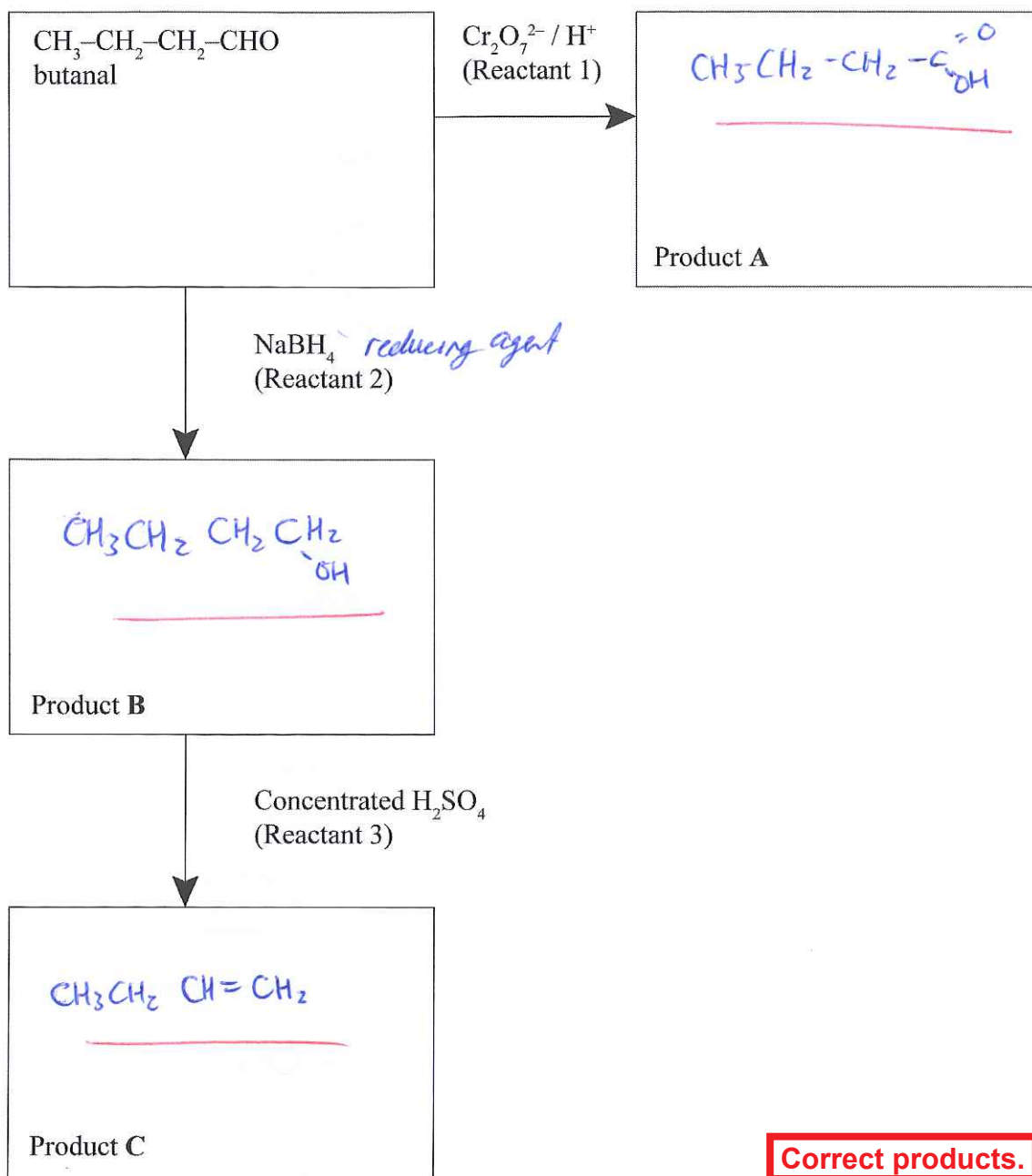
- Compound X ~~could~~ might have been an aldehyde as primary alcohols oxidise to an intermediate stage but aldehydes wouldn't have acidic properties. //

**Two correct structures but not branched chain. One reason oxidation from primary alcohol to carboxylic acid.
Three Achieved answers.**

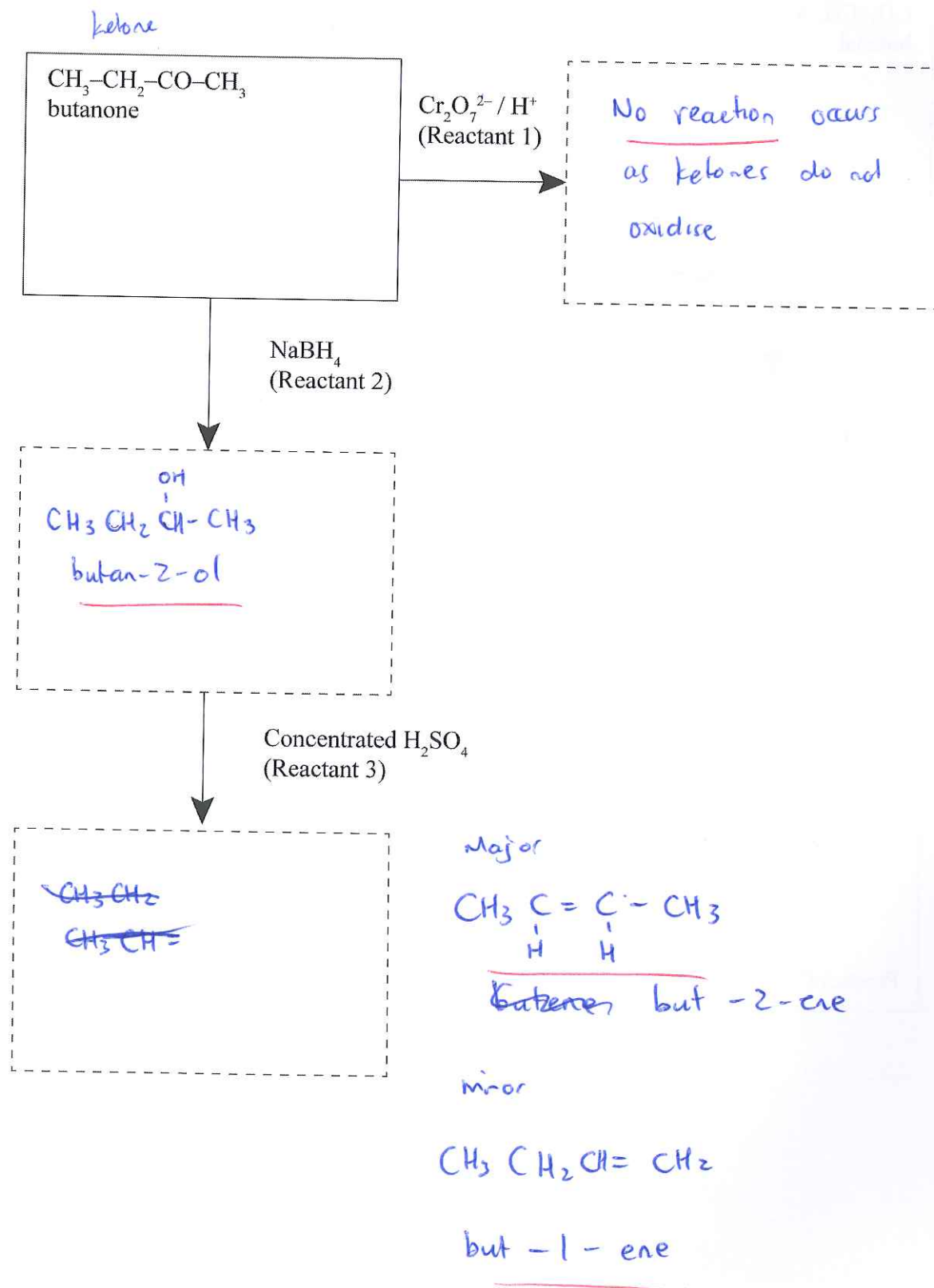
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QUESTION THREE

- (a) Complete the following reaction scheme that shows some reactions starting with butanal. Give the structural formulae of the organic products A, B, and C.



- (b) Devise and complete the reaction scheme starting with butanone in place of butanal to show how butanone would react with the reactants 1–3. In your answer, you should:
- identify the products formed in each reaction step; state if no reaction occurs
 - write the structural formula for each product formed, including major and minor products (if any).



(c) Compare and contrast the two reaction schemes. In your answer, justify the reasons for:

- the similarities and the differences between these two schemes
- the products formed in each reaction.

Aldehydes and Ketones, the starting solutions are both products of alcohols through oxidation. Whilst aldehydes, oxidised from primary alcohols, can oxidise again to form carboxylic acids, ketones cannot. Both alcohols formed are reduced into alkenes but ~~the~~ the secondary alcohol, through elimination, turns into a alkene with a major and minor ~~product~~ product, whilst the primary alcohol, through elimination has only one possible alkene product.

Both alkenes formed have lower T_b boiling and melting points than the original solutions as the alkenes have no hydrogen bonds. //

Difference in oxidation of aldehydes and ketones.
Difference in reduction to 1° and 2° alcohols.
No discussion of elimination reaction.

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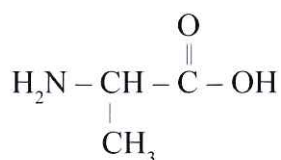
QUESTION ONE

- (a) Give the IUPAC systematic names for the following compounds.

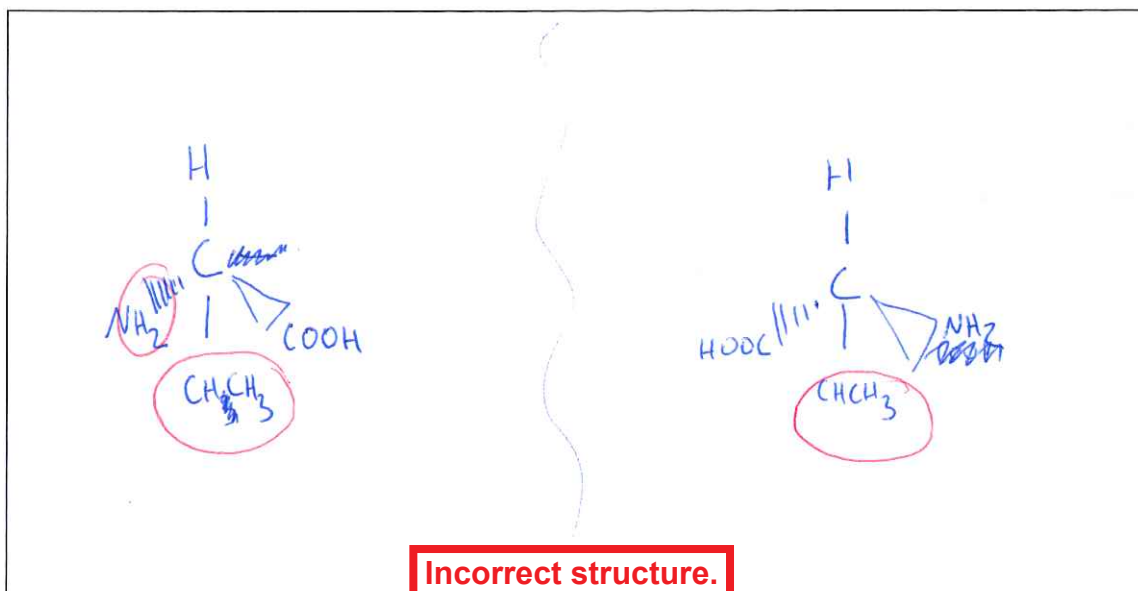
Compound	IUPAC systematic name
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} - \text{Cl} \end{array}$	<u>ethanoyl chloride</u>
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{CH}_2 - \text{CH} - \text{C} - \text{OH} \\ \\ \text{Cl} \end{array}$	<u>2-chlorobutanoic acid</u>
$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{NH}_2 \\ \\ \text{CH}_3 \\ \text{amine} \end{array}$	2 methyl amino butane

Two correct names. One missing from 1-amino methylpropane.

- (b) The amino acid alanine below can exist as two enantiomers (optical isomers).

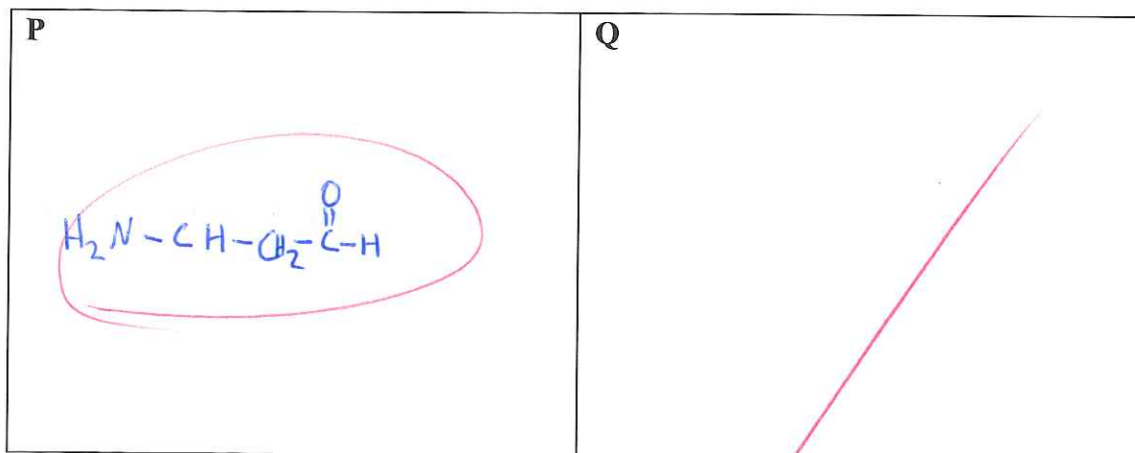


- (i) Draw three-dimensional structures for the two enantiomers that clearly show the relationship between them.



- (ii) Alanine has two straight chain isomers that do not show acidic properties. One of these isomers, **P**, can exist as an enantiomer, the other isomer, **Q**, cannot.

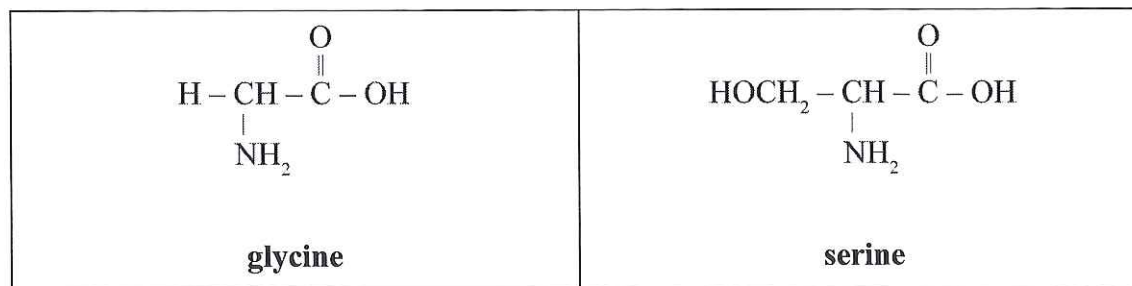
Draw **P** and **Q**.



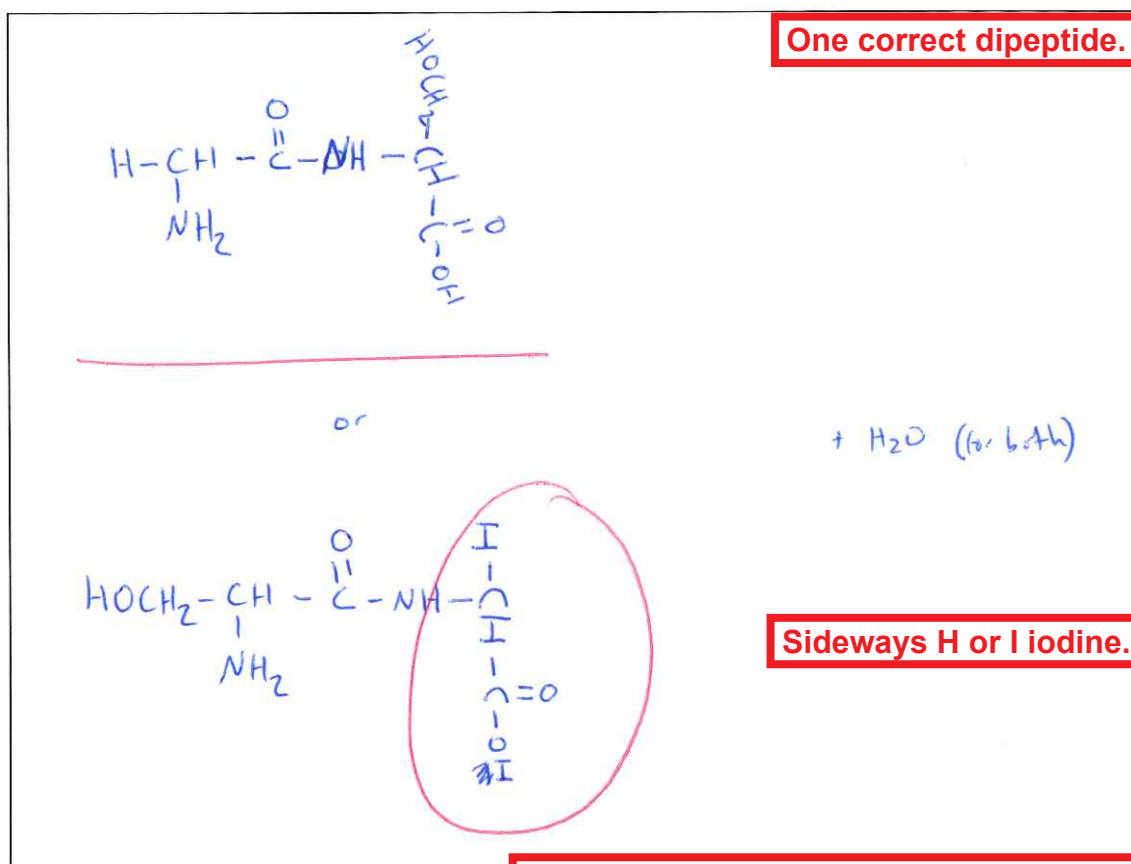
Explain why **P** exists as an enantiomer.



- (c) Glycine and serine are two amino acids, which can combine to form dipeptides.



- (i) Draw the structure(s) of the possible dipeptide(s) formed from a combination of glycine and serine.



Correct explanation of amide formation.

- (ii) Explain your answer in terms of the structure and functional groups present in the amino acids and in the dipeptide(s).

Both glycine and serine have functional groups of an amine and a carboxylic acid. When joining together, the amino acids will either lose the -OH from the carboxylic acid functional group or an -H from the amine functional group. The remaining O (from carboxylic group) and NH (from amine group) will form a bond (O-NH-) that allows the two amino acids to form an ~~amide~~ dipeptide. The lost atoms (-OH and -H) will join together to form a by product of H₂O.

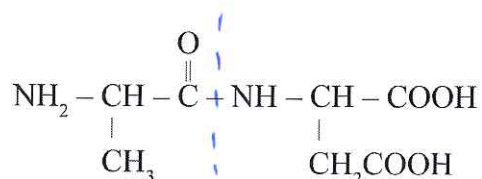
Carboxylic acid functional group



amine functional group



- (d) Determine the products of hydrolysis of the molecule shown below in BOTH acidic and basic conditions.



NH_3^+ Acidic conditions	$\text{H}_3^+\text{N} - \text{CH} - \text{C} \begin{array}{l} \text{O} \\ \parallel \\ \vdots \end{array} - \text{OH}$ $\qquad \qquad $ $\qquad \qquad \text{CH}_3$	$\text{H}_3^+\text{N} - \text{CH} - \text{COOH}$ $\qquad \qquad $ $\qquad \qquad \text{CH}_2\text{COOH}$
COO^- Basic conditions	$\text{NH}_2 - \text{CH} - \text{COO}^-$ $\qquad \qquad $ $\qquad \qquad \text{CH}_3$	$\text{NH}_2 - \text{CH} - \text{COO}^-$ $\qquad \qquad $ $\qquad \qquad \text{CH}_2\text{COO}^-$

Justify your answer in terms of structure and reactivity.

Hydrolysis under acidic conditions is done with hydrochloric acid, hydrolysis under alkaline conditions is done with sodium hydroxide (both dilute). In acidic conditions the amine functional groups will form the ion NH_3^+ .

In basic conditions the carboxylic functional groups will form the ion COO^- , which then a sodium ion will attach to to form a salt.

This is the same with the basic alkaline conditions, as an ammonium salt is formed.

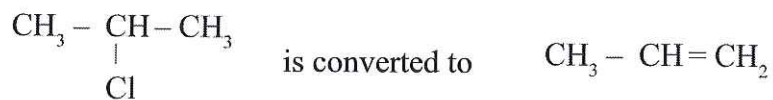
Does not clearly identify amide link.

M5

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QUESTION TWO

- (a) For the following conversion, identify the reagent required and state the type of reaction occurring. You should give a reason for your answer in terms of the structure of the reactants and products.



Reagent required: _____

~~PCl₅~~ ^{conc} H₂SO₄

Type of reaction: _____

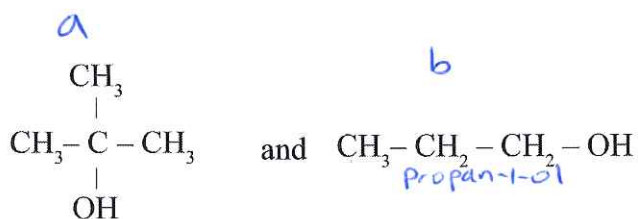
substitution

Reason: _____

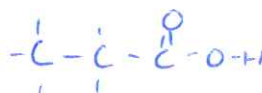
(b) Explain a laboratory procedure that would allow the following pairs of compounds to be distinguished. In your answers, you should include:

- the reagent used
- the expected result for any reactions that may or may not occur
- the structural formulae of the organic product(s) formed when the reaction(s) occur.

(i)



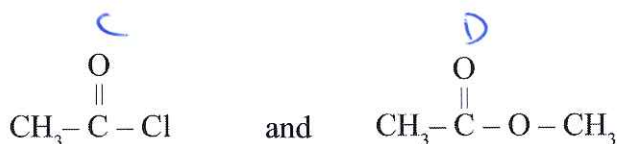
2, dimethyl
ethanol



Both substances are alcohols. ~~Product~~ ^{compound} A is a tertiary alcohol and compound B is a primary. To find this out the reagent used would be acidified dichromate $\text{H}^+/\text{Cr}_2\text{O}_7^{2-}$. Compound A would not react with the dichromate, and the dichromate would remain orange. Compound B would react quickly with the dichromate, causing the color change of orange to green. Compound A would not form any products with the dichromate. Compound B would form a carboxylic acid ~~an aldehyde~~ with the dichromate. Propanoic acid - $\text{CH}_3\text{CH}_2\text{COOH}$ //

All points covered.

(ii)



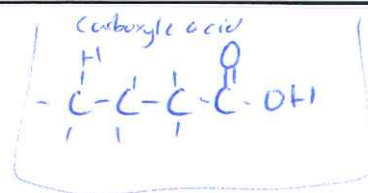
Compound ~~Product~~ C is an acyl chloride. Compound D is an ester.

To distinguish compound C as an ^{acyl} chloride, the vapour of the compound will turn damp blue litmus red. To get the vapour, ~~the~~ ^{add} water to ~~each~~ each compound, acyl chlorides will react with the water and a vapour will be let off, test this with the damp litmus.

Esters do not react with water and therefore there would be no vapour to test - meaning the damp ^{blue} litmus would remain blue.

No structure
for the
product.

Both answers logically answer the question.



(c) Use the following information to answer this question.

Compound W is a branched chain molecule with a molecular formula $\text{C}_4\text{H}_{10}\text{O}$.

When **Compound W** is heated with excess acidified potassium dichromate it is readily oxidised to **Compound X**, which has acidic properties.

A substitution reaction occurs when **Compound X** is reacted with SOCl_2 . The molecular formula of **Compound Y** is $\text{C}_4\text{H}_7\text{OCl}$.

When **Compound Y** reacts with aminomethane, $\text{CH}_3\text{-NH}_2$, a substitution reaction occurs and **Compound Z** forms.

Determine the structural formulae of **Compounds W, X, Y, and Z**.

Justify your answer by explaining how you arrived at these structures from the information given above. In your answer, you should:

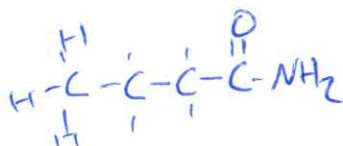
- include other possible structural formulae you considered
- give your reasons for rejecting the other structural formulae.

Compound X will be an carboxylic acid, as ~~oxidation~~ carboxylic acids ^{is} the ^{only} products of oxidation that has acidic properties. The structural formula for the carboxylic acid that has 4 carbon chains will be butanoic acid, is $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$.

Because compound X readily ~~reacts~~ is oxidised from compound W and acidified potassium dichromate this means that the possible organic compounds W could be ^{is an} alcohol or an aldehyde, as both readily oxidise w the dichromate. But as aldehydes have a double bond to an oxygen, this means there would only be 8 hydrogens in butanal - so the compound has to be butan-1-ol, as the amount of hydrogen (10) is correct, and it has to be a primary alcohol as only primary alcohols oxidise to form carboxylic acids.

Compound W structural formula is ~~$\text{CH}_3(\text{CH}_2)_2\text{COH}$ ($\text{CH}_3\text{CH}_2\text{CH}_2\text{COH}$)~~
 $\text{CH}_3(\text{CH}_2)_2\text{CH}_2\text{OH}$ ($\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$). A substitution reaction of compound X with SOCl_2 means that an acid chloride is formed. ($\text{C}_4\text{H}_7\text{OCl}$).

Compound Z will be an amide as a substitution w $\text{CH}_3\text{-NH}_2$ will form a amide ~~from~~ with the acid chloride. This formula for compound Z will be $\text{CH}_3\text{CH}_2\text{CH}_2\text{CONH}_2$.

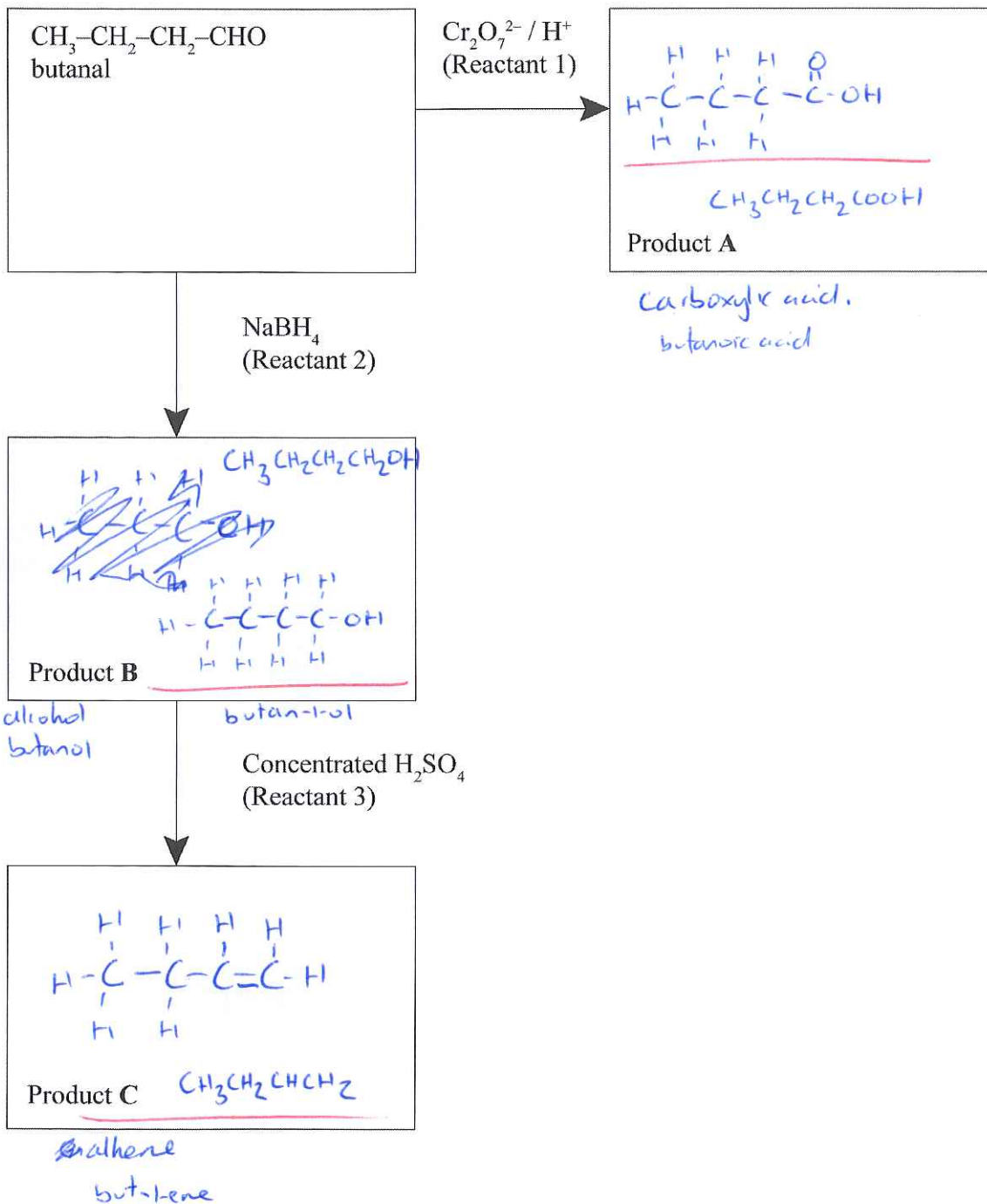


Three correct structures with reasons but not branched chain.
Two Merit statements.

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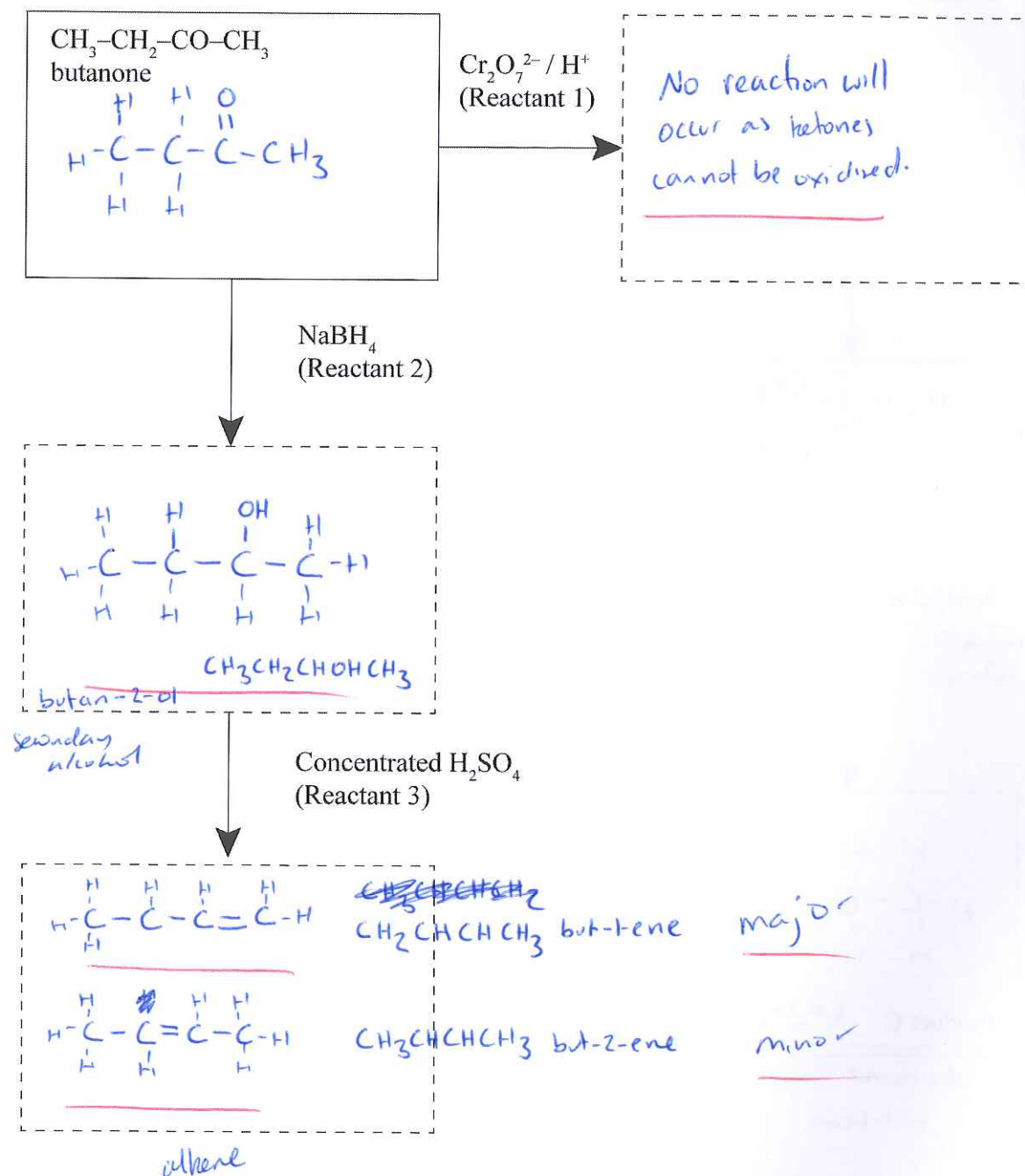
QUESTION THREE

- (a) Complete the following reaction scheme that shows some reactions starting with butanal. Give the structural formulae of the organic products A, B, and C.



(b) Devise and complete the reaction scheme starting with butanone in place of butanal to show how butanone would react with the reactants 1–3. In your answer, you should:

- identify the products formed in each reaction step; state if no reaction occurs
- write the structural formula for each product formed, including major and minor products (if any).



(c) Compare and contrast the two reaction schemes. In your answer, justify the reasons for:

- the similarities and the differences between these two schemes
- the products formed in each reaction.

butanal can be oxidised further to the carboxylic acid of butanoic acid, as it was formed from a primary alcohol. But butanone is a ketone, formed from a secondary alcohol, and cannot be oxidised any further. Meaning no reaction will occur between butanone and reactant one.

NaBH_4 is a reducing agent, and will reduce butanal and butanone both back into alcohols, but butanal will be reduced into a primary alcohol, and butanone into a secondary alcohol.

Both alcohols (butan-2-ol and butan-1-ol) will react with reactant 3 in that water, will be taken out of each molecule.

For butan-1-ol this will create but-1-ene. But butan-2-ol will create either but-1-ene or but-2-ene because the double bond could be created between either the first and second carbon, or the second and third carbon.