

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 EXCELLENCE

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.

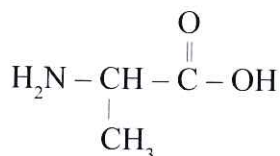
You are advised to spend 60 minutes answering the questions in this booklet.

QUESTION ONE

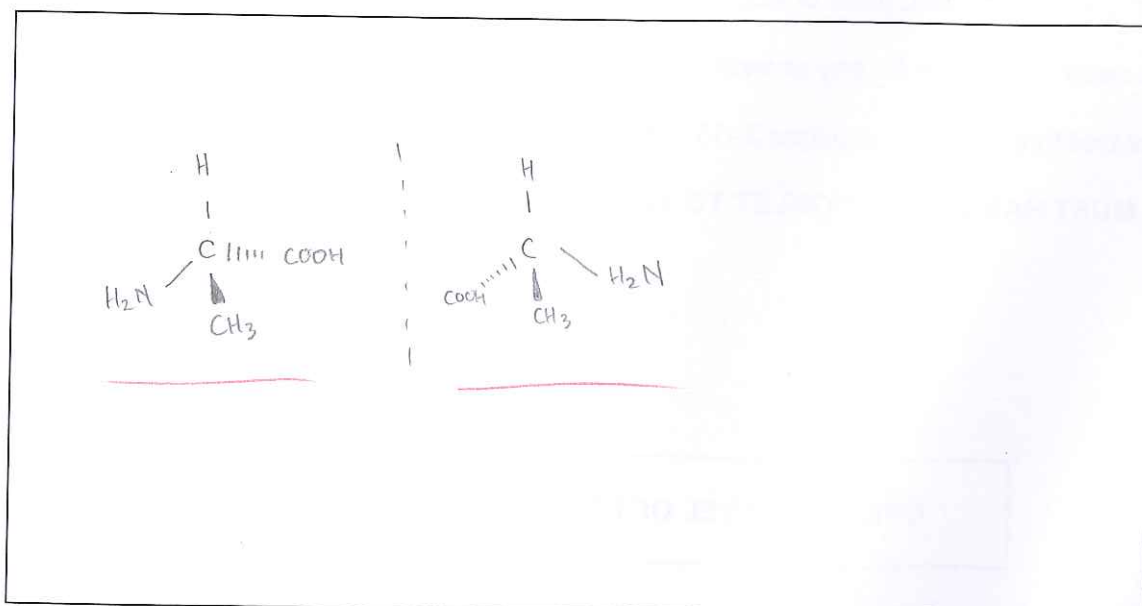
- (a) Give the IUPAC systematic names for the following compounds.

Compound	IUPAC systematic name
$\begin{array}{c} \text{O} \\ \parallel \\ \text{CH}_3 - \text{C} - \text{Cl} \end{array}$	<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>
$\begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{NH}_2 \\ \\ \text{CH}_3 \end{array}$	2-methylpropano- <u>1-amino-2-methyl propane</u>

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

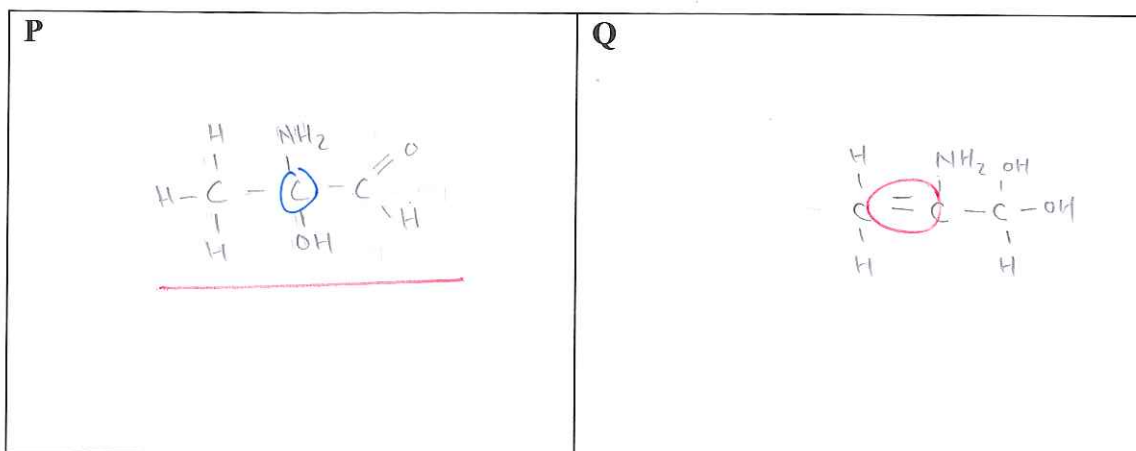


- (i) Draw three-dimensional structures for the two enantiomers that clearly show the relationship between them.



- (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.

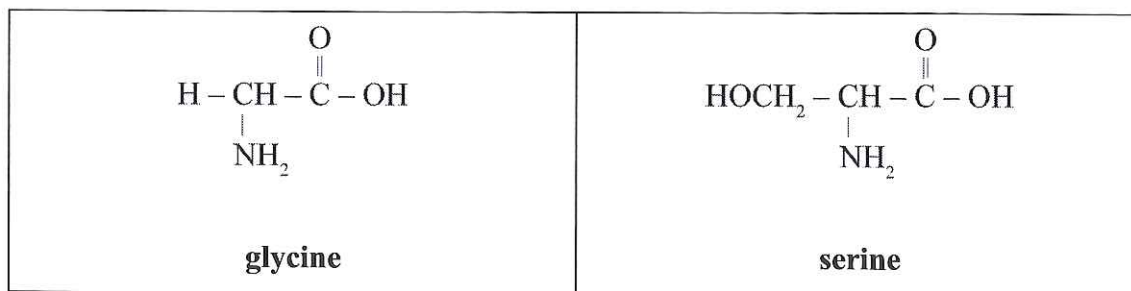
Draw **P** and **Q**.



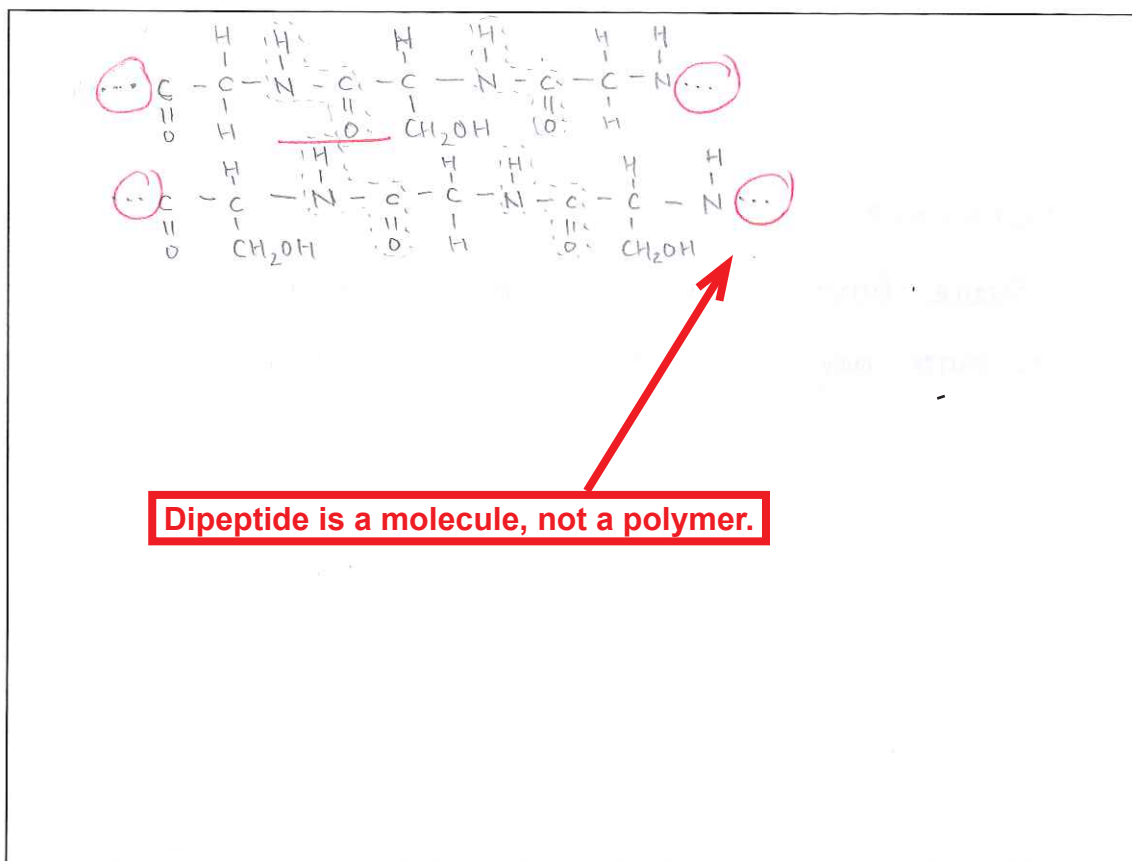
Explain why **P** exists as an enantiomer.

Because there's a chiral Carbon atom (circled) with 4 different groups attached.
The mirror image of this compound cannot be superimposed, hence it's 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.

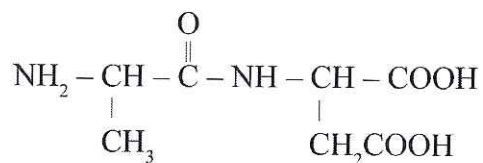


- (ii) Explain your answer in terms of the structure and functional groups present in the amino acids and in the dipeptide(s).

Amino acids contain an amine group and a carboxyl group, Hydrogen and a R group attached to the same Carbon atom. In glycine, the R group is a H atom and in serine it is CH_2OH (alcohol).

In dipeptides, there're monomers (amino acids) ^{joined} ~~linked~~ by peptide linkage (Amide link?) on either side of the monomers in the chain.

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



Acidic conditions	$\text{NH}_2 - \underset{\text{CH}_3}{\text{CH}} - \overset{\text{O}}{\parallel}{\text{C}} - \text{OH} + \text{NH}_2 - \underset{\text{CH}_2\text{COOH}}{\text{CH}} - \text{COOH}$
Basic conditions	$\text{NH}_2 - \underset{\text{CH}_3}{\text{CH}} - \overset{\text{O}}{\parallel}{\text{C}} - \text{O}^- + \text{NH}_2 - \underset{\text{CH}_2\text{COO}^-}{\text{CH}} - \text{COOH}$

Justify your answer in terms of structure and reactivity.

In acid, the products are ~~carboxylic acids~~

In acidic conditions $\text{H}^+/\text{H}_2\text{O}$, OH will attach to the compound with the $\text{C}=\text{O}$ bond to form a $-\text{COOH}$ end and H will attach to the $-\text{NH}$ compound to form $-\text{NH}_2$.

In basic conditions, a salt will be formed $\text{C}=\overset{\text{O}}{\text{O}}^-$ and the H attaches to the $-\text{NH}$ end.

e.g. with NaOH $\text{C}=\overset{\text{O}}{\text{O}}^- \text{Na}$ and $\text{H}-\text{N}$.

Correct hydrolysis products but not recognising reaction of products with the acid and base. Discusses salt formation but does not give structure.

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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: ~~hydroxide ions~~ NaOH (alc.)

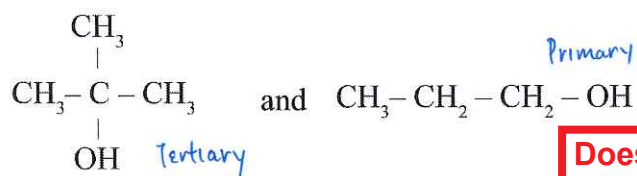
Type of reaction: Elimination.

Reason: The Cl atom and H atom from the haloalkane would react with NaOH (alc.) to form other products, thus resulting in the haloalkane to form an alkene as those 2 atoms are removed.

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

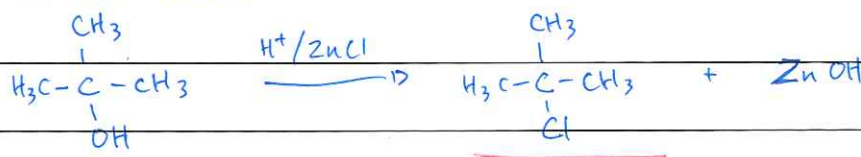
- the reagent used
- the expected result for any reactions that may or may not occur
- the structural formulae of the organic product(s) formed when the reaction(s) occur.

(i)



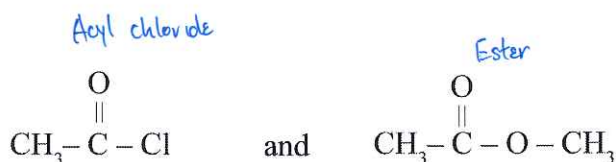
Does not clearly differentiate by the observation – missing (not).

- Reagent used: Lucas reagent \downarrow HCl/ZnCl
- $\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{OH}$ would react to the reagent
- Tertiary alcohol would immediately react with Lucas reagent forming cloudiness in the solution.



Although Lucas Reagent is not included in the new standard, a correctly crafted answer will be accepted.

(ii)



- Use damp blue litmus.
- Acyl chloride would turn damp blue litmus red.
- Ester wouldn't. //

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

Assessor's
use only

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

When **Compound W** is heated with excess acidified ^{$H^+ / Cr_2O_7^{2-}$} 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 .

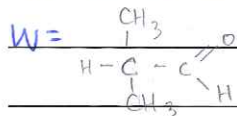
When **Compound Y** reacts with aminomethane, CH_3-NH_2 , a substitution reaction occurs and **Compound Z** forms.

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

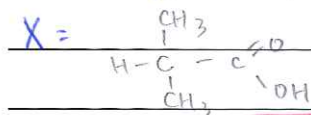
Justify your answer by explaining how you arrived at these structures from the information given above. In your answer, you should:

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

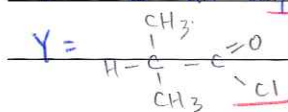
• W has to be a aldehyde, because ketones can't be oxidised. ~~alcohol~~



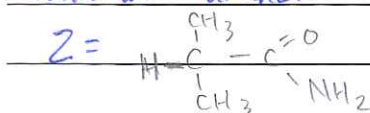
• When W is oxidised, it would form a carboxylic acid, which has acidic properties.



• Y is an acyl chloride, since the carboxylic acid (X) ~~is substituted~~ ^{undergoes substitution} with $SOCl_2$



• Compound Z must be an amide, as acyl chloride undergoes substitution with an amine.



Two correct structures.

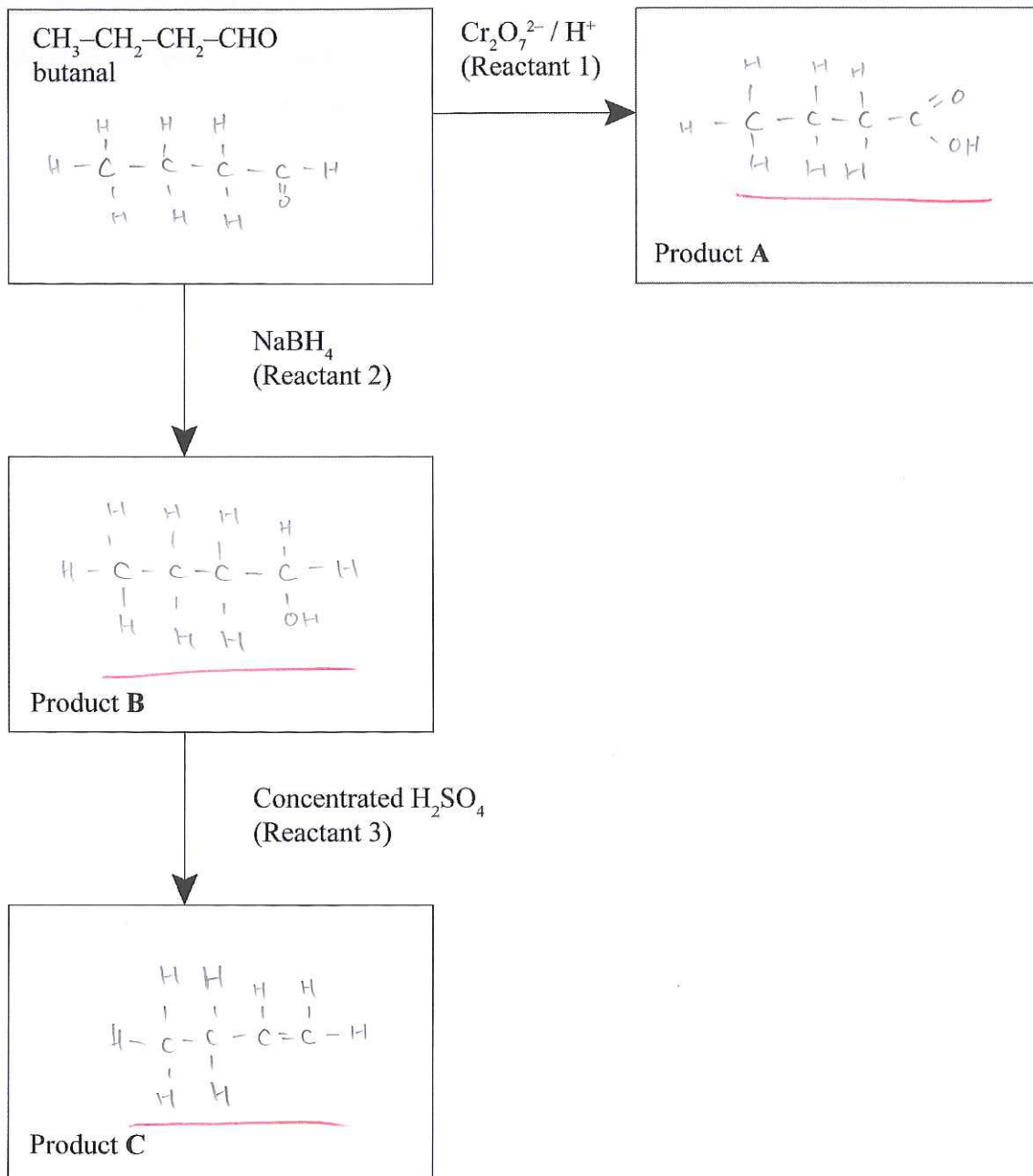
M5

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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.

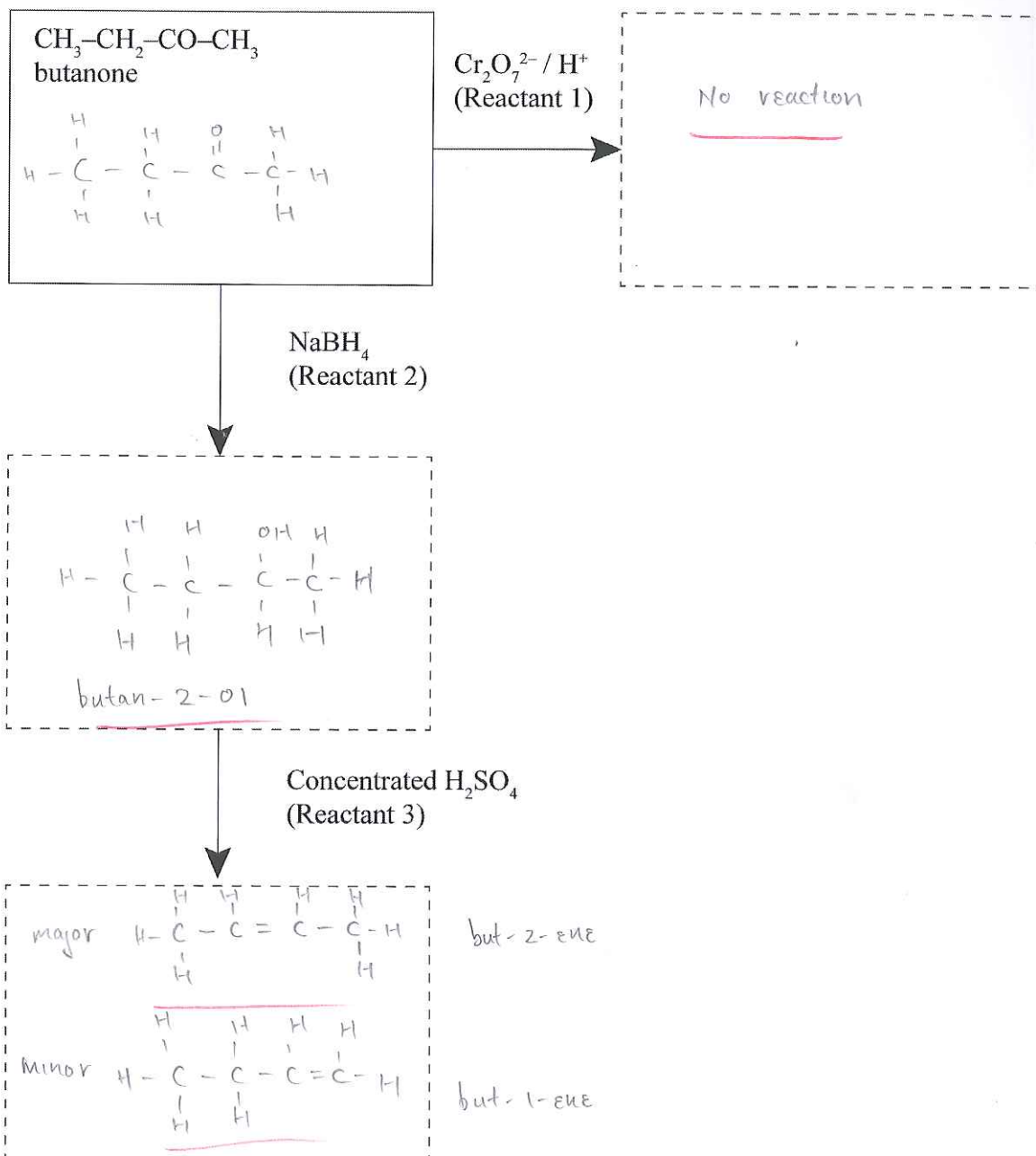
Scheme 1



(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).

Scheme 2



(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.

- Both reaction schemes produce an alcohol after reacting with NaBH₄ and alkane(s) after reacting with conc. H₂SO₄.
- But due to the fact that ketones can't be oxidised, ~~there's no product~~ when reacting butanone with H⁺/Cr₂O₇²⁻ whereas an carboxylic acid was formed when reacting with butanal.
- Due to the different place of C=O in the initial compound, the place of the hydroxyl group was different in the molecule in the 2 different schemes.
- So when elimination occurs (by using conc. H₂SO₄), there's only 1 product for scheme 1 as the hydroxyl group is on the end of the compound, so only 1 product is possible. 'Poor gets poorer' applies.
But in Scheme 2, the hydroxyl group is on the 2nd carbon atom, so 2 products were possible, a major and a minor product. The rule 'Poor gets poorer' applies here //

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EXEMPLAR FOR HIGH EXCELLENCE

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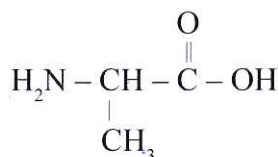
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QUESTION ONE

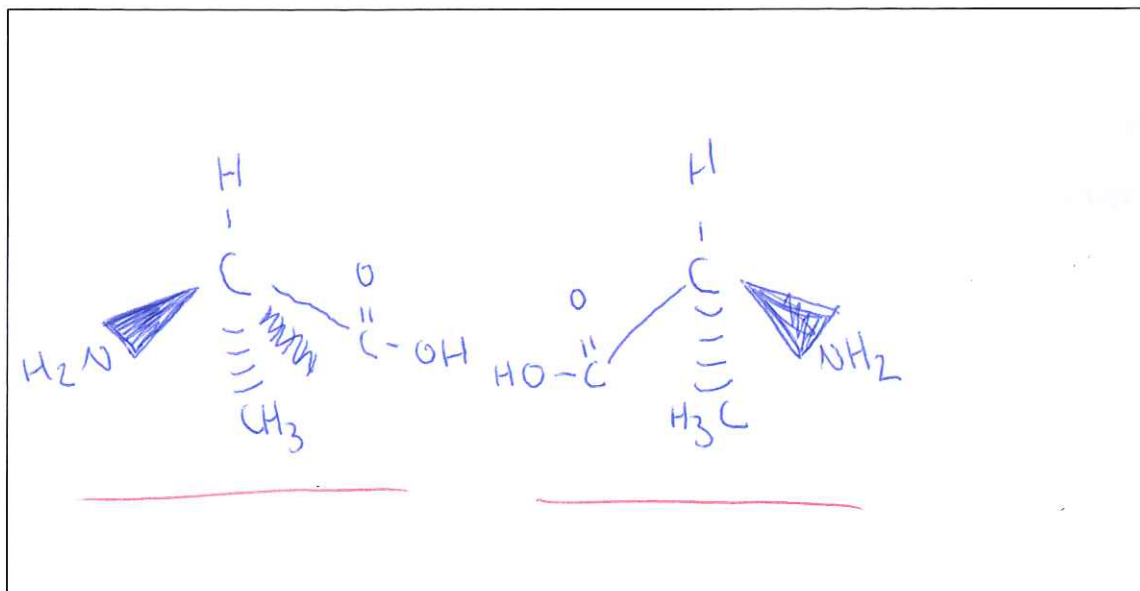
(a) Give the IUPAC systematic names for the following compounds.

Compound	IUPAC systematic name
$\text{CH}_3 - \overset{\text{O}}{\parallel} \text{C} - \text{Cl}$	<u>ethanoyl chloride</u>
$\text{CH}_3 - \text{CH}_2 - \underset{\text{Cl}}{\text{CH}} - \overset{\text{O}}{\parallel} \text{C} - \text{OH}$	<u>2-chloro butanoic acid</u>
$\text{CH}_3 - \underset{\text{CH}_3}{\text{CH}} - \text{CH}_2 - \text{NH}_2$	<u>1-amino 2-methyl propane</u>

(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.

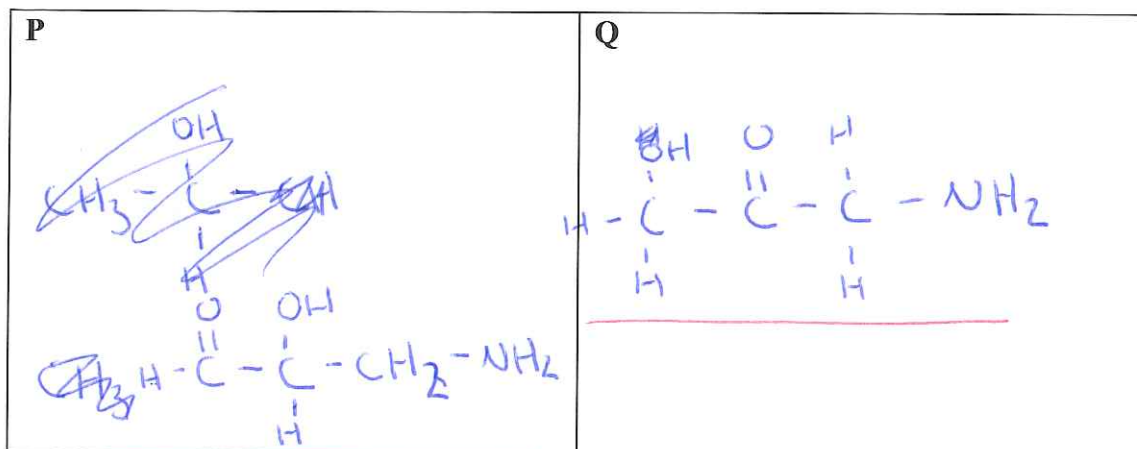


IN 7³H 20 3C

- (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.

Assessor's
use only

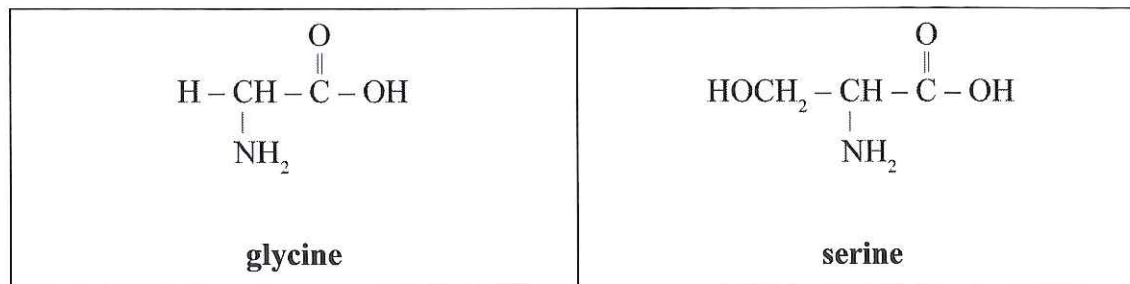
Draw **P** and **Q**.



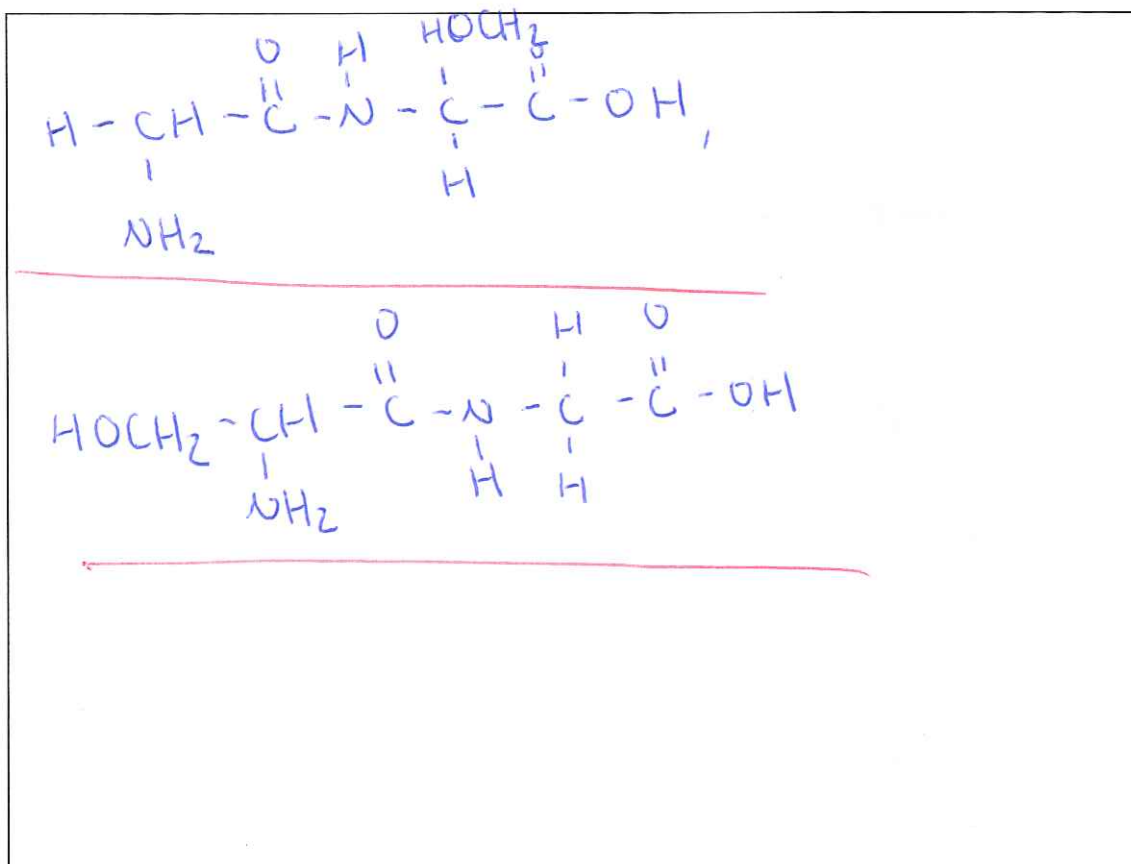
Explain why **P** exists as an enantiomer.

P exists as an enantiomer as there is a chiral carbon in it. This is a carbon that has four different groups bonded to it in this case the C is bonded to an OH group, H, CH₂NH₂ and CH₃. This means that if the molecule is flipped over it will not be able to be superimposed on its optical isomer so it can exist as an enantiomer. //

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



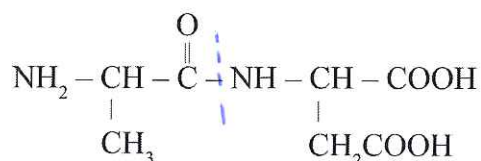
- (i) Draw the structure(s) of the possible dipeptide(s) formed from a combination of glycine and serine.



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

When amino acids join together, they form a peptide group which is $\text{C}-\text{N}$.
~~As there is~~ which is a carboxyl group and amino group joined together. As there is an amino group on each amino acid there is two possible combinations as the acid part of glycine can react with the amino group of serine or the other way round.

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



<p>Acidic conditions</p>	$\begin{array}{c} \text{O} \\ \parallel \\ \text{NH}_3^+ - \text{CH} - \text{C} - \text{OH} \\ \\ \text{CH}_3 \end{array} + \begin{array}{c} \text{O} \\ \parallel \\ \text{NH}_3^+ - \text{CH} - \text{COOH} \\ \\ \text{CH}_2\text{COOH} \end{array}$
<p>Basic conditions</p>	$\begin{array}{c} \text{O} \\ \parallel \\ \text{NH}_2 - \text{CH} - \text{C} - \text{O}^- \\ \\ \text{CH}_3 \end{array} + \begin{array}{c} \text{O} \\ \parallel \\ \text{NH}_2 - \text{CH} - \text{CH}_2\text{COO}^- \\ \\ \text{CH}_2\text{COO}^- \end{array}$

Justify your answer in terms of structure and reactivity.

In the acidic conditions the amino group will react with the acid as it is a base and will therefore accept a proton and become NH_3^+ . While in basic conditions the carboxyl group which is acidic will react by losing its hydrogen and ~~the~~ would be ~~forming~~ a salt as acids and bases react ~~first~~ ~~was~~ to form salts. //

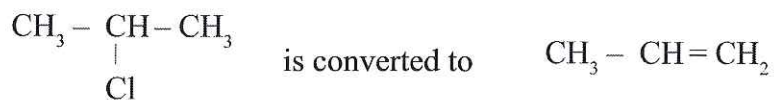
The candidate has answered all points correctly.

E8

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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: OH⁻ (alc)

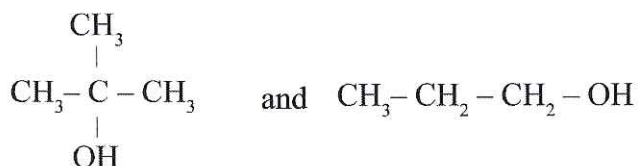
Type of reaction: elimination

Reason: because when a haloalkane reacts with OH⁻ (alc) it forms an alkene.

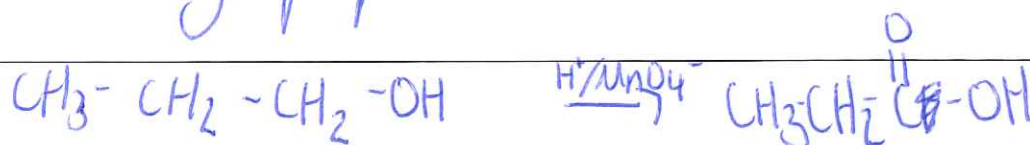
(b) Explain a laboratory procedure that would allow the following pairs of compounds to be distinguished. In your answers, you should include:

- 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.

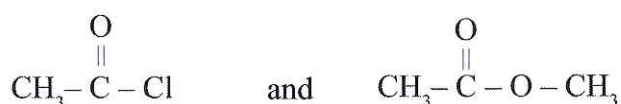
(i)



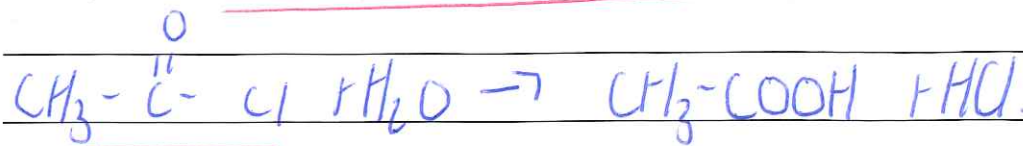
You would put some acidified MnO_4^- .
This would oxidise the ~~alcohol to~~
~~the~~ primary alcohol to a carboxylic acid
so the colour of the solution will change
from purple to colourless while the
tertiary alcohol will not react so the solution
will stay purple.

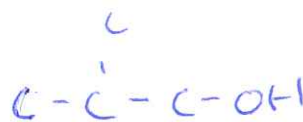


(ii)



You would put some water in each
of the compounds. One would react
violently ~~by~~ by smoking and fizzing ~~while~~
this is the acid chloride while the
ketone will not react.





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

Assessor's
use only

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 $\text{C}_4\text{H}_7\text{OCl}$.

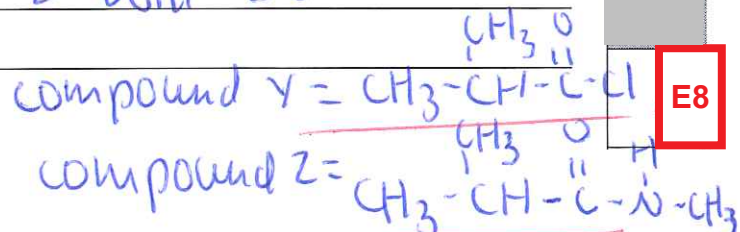
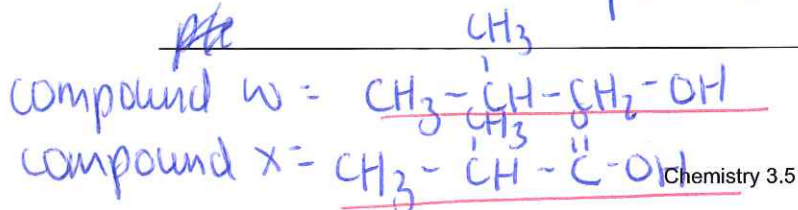
When **Compound Y** reacts with aminomethane, $\text{CH}_3\text{-NH}_2$, a substitution reaction occurs and **Compound Z** forms.

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.

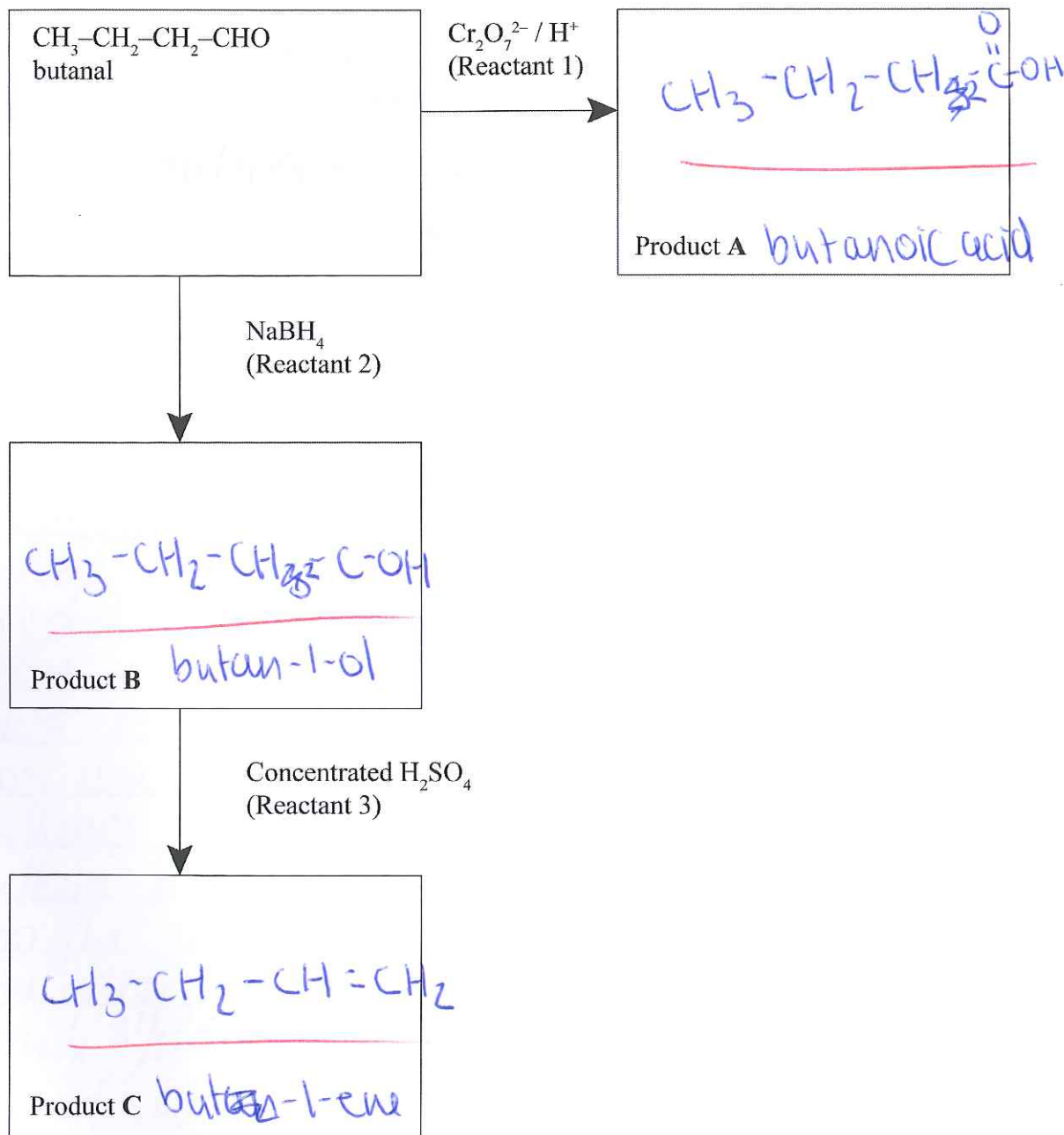
Compound W must be a primary alcohol as it has been oxidised to a carboxylic acid. So it must be 2-methyl propan-1-ol which would be oxidised to carboxylic acid as that is the only acidic product possible by oxidation of a primary alcohol. So compound X will be 2-methyl propanoic acid. Primary alcohols can also be oxidised to aldehydes but they do not have acidic properties so cannot be compound X. When a carboxylic acid undergoes substitution reaction with SOCl_2 an acid chloride is formed so 2-methyl propanoic acid will be formed. So that must be what compound Y is. When acid chlorides react with amines a secondary amide is formed which is what compound Z will be.



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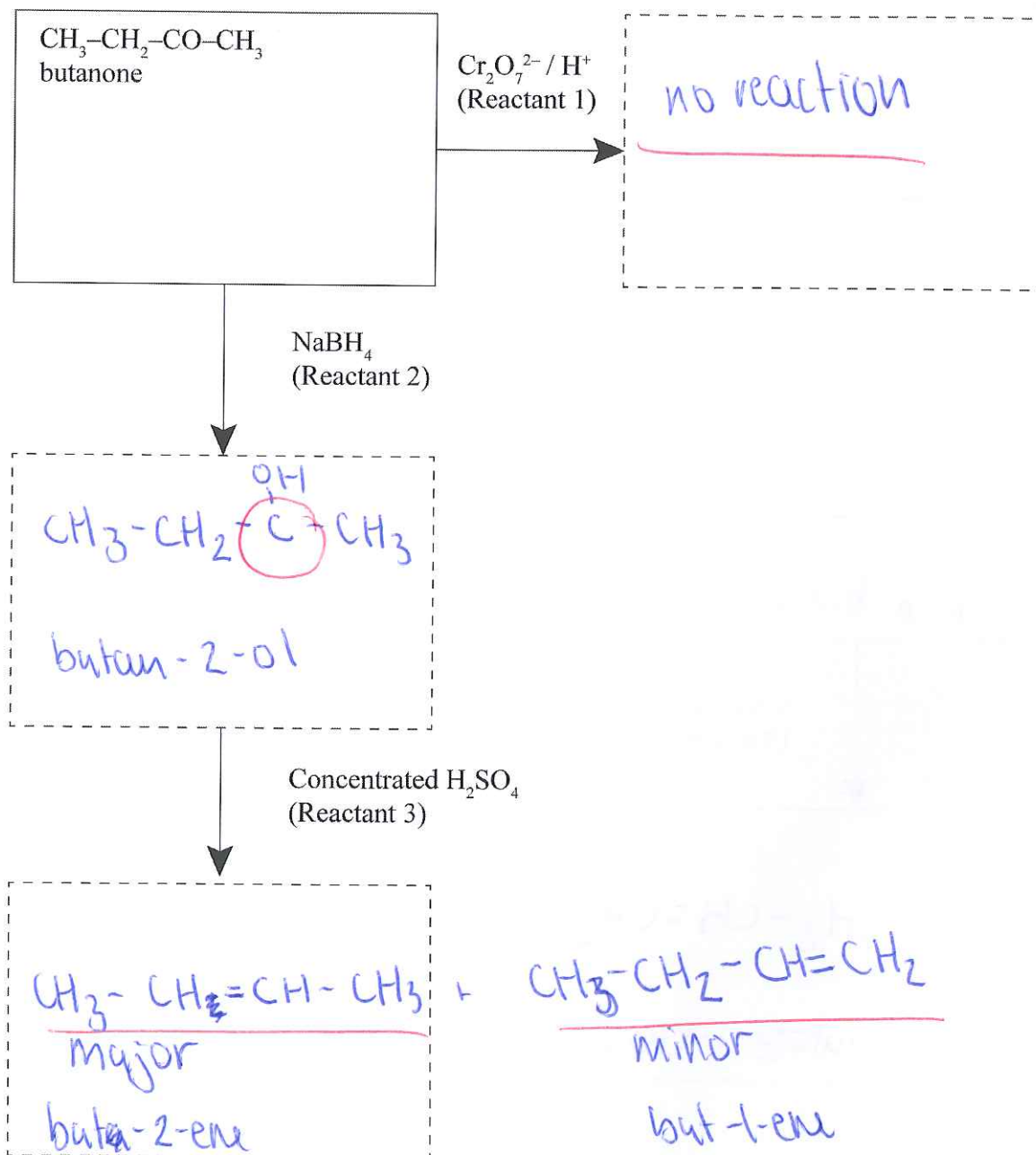
QUESTION THREE

- (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.

The two reaction schemes start with different compounds. The first reaction starts with an aldehyde which can be oxidised further to a carboxylic acid (butanoic acid). While the ketone can not as the carbon with the double bond oxygen has no more hydrogens, so will not be oxidised. In the second reaction both the schemes form an alcohol. But the first scheme produces a primary alcohol as that is what an aldehyde is derived from i.e. a primary alcohol is oxidised to form an aldehyde. (butan-1-ol). While in the second scheme a secondary alcohol is produced as the ketone is derived from a secondary. (butan-2-ol) In the last reaction both the schemes form alkenes as conc H_2SO_4 reacts with alcohols to form alkenes. The first scheme forms 1-ene as the last carbon loses the OH so the double bond can only form with the next carbon so but-1-ene is formed. While in the second scheme because the OH was on the second carbon there are two possible products the major product but-2-ene and the minor product but-1-ene. The major product will form ~~more as~~

Lacks detail of major / minor product formation.

E7