LOW MERIT

3

SUPERVISOR'S USE ONLY

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Chemistry, 2013

91391 Demonstrate understanding of the properties of organic compounds

2.00 pm Tuesday 19 November 2013
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 is provided on the Resource Sheet L3–CHEMR.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL 14

ASSESSOR'S USE ONLY

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

ASSESSOR'S USE ONLY

QUESTION ONE

(a) Complete the table below by giving the IUPAC systematic name or the structural formula for each compound.

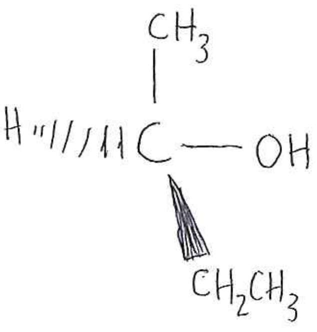
Structural formula	IUPAC systematic name
$HO-CH_2-CH_2-C(=O)H$	3-hydroxypropanal
$CH_3-CH_2-C(=O)NH_2$	propanamide
$CH_3-C(=O)-CH_2-CH(CH_3)-CH_3$	4-methylpent-2-one

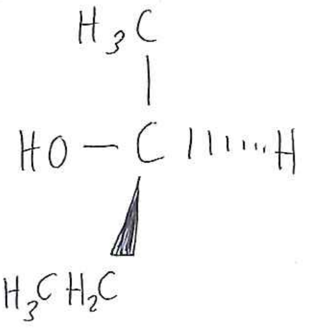
Missing 'an' above (4-methyl pentan-2-one).

(b) The alcohol below can exist as two enantiomers (optical isomers).

$CH_3CH(OH)CH_2CH_3$

(i) Draw three-dimensional structures for the two enantiomers.





(ii) Link the structure of enantiomers to a physical property that can be used to distinguish them from non-optically active molecules.

ASSESSOR'S USE ONLY

They have a chiral 'C' atom that has four different groups attached to it. They are superimposable and also rotate a plane of polarised light in different directions. A non-optically active molecule would not rotate a plane of polarised light.

Enantiomer structures link well to the physical property.

(c) Draw the structural formulae of three different isomers of $HO-CH_2-CH_2-C(=O)H$, which show the following properties:

- Isomer 1 turns moist blue litmus paper red.
- Isomer 2 is an ester.
- Isomer 3 is a ketone.

$C_3H_6O_2$

$CH_3-O-C(=O)-CH_2-CH$

$C-C-C(=O)OH$

Property	Structural formula
turns moist blue litmus paper red	$CH_3-CH_2-C(=O)OH$
is an ester	$CH_3-C(=O)-O-CH_3$
is a ketone	$H-CH_2-C(=O)-CH_2-OH$

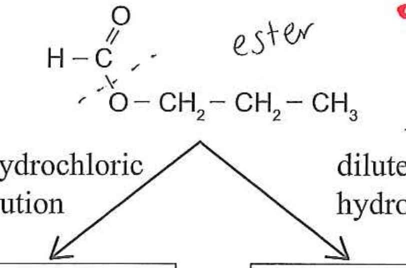
$HO-CH_2-C(=O)-CH_3$

(d) Give the structures and names of the products of the reactions below.

These reactions are carried out by heating in either:

- dilute hydrochloric acid solution, or
- dilute sodium hydroxide solution.

Most products are identified, however, hydrolysis reaction only partly explained.



alcohol acid | dilute hydrochloric acid solution

dilute sodium hydroxide solution | acid salt alcohol

H–C(=O)–OH ; H–C(=O)–Cl Name: ~~methanoic acid.~~ methanoyl chloride	HO–CH₂–CH₂–CH₃ Name: propan-1-ol	HO – CH₂–CH₂–CH₃ Name: ~~pent~~ propan-1-ol	H–C(=O)–O⁻Na⁺ Name: sodium methanoate

Compare and contrast the reactions above.

In your answer, you should include the type of reaction(s) taking place.

These reactions are ester hydrolysis in both basic and acidic conditions.

with NaOH an acid salt is produced as well as an alcohol when the C–O bond is broken

$H-C(=O)-O-CH_2-CH_2-CH_3 + NaOH \xrightarrow{warmth} H-C(=O)-O^-Na^+ + CH_3CH_2CH_2OH$.

With hydrochloric acid an ~~carboxylic acid~~ acid chloride and an alcohol ~~is~~ are produced when the C–O bond is broken.

$H-C(=O)-O-CH_2-CH_2-CH_3 + HCl \rightarrow H-C(=O)-OCl + CH_3CH_2CH_2OH$

M6

ASSESSOR'S USE ONLY

QUESTION TWO

(a) For the following conversions, identify the reagent required, and state the type of reaction occurring.

(i) Pentan-2-one is converted to pentan-2-ol.

Reagent required: $NaBH_4$

Type of reaction: reduction

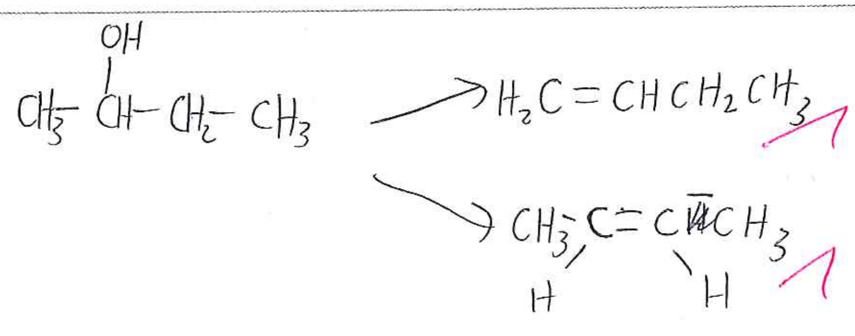
(ii) Butan-2-ol is converted to a mixture of but-1-ene and but-2-ene.

Reagent required: ~~dil~~ concentrated H_2SO_4 + heat

Type of reaction: elimination

(iii) Discuss the reaction occurring in (ii) above, with reference to the structures of the organic reactant and products.

In this elimination reaction H_2O is removed from butan-2-ol to form a double bond. Because this is a secondary alcohol there are two different possible 'C' atoms for the C=C to form between, making but-1-ene and but-2-ene. But-1-ene it forms a double bond with the first carbon in the chain, from which an 'H' is removed from. But-2-ene it forms a double bond with the second carbon in the chain, which an 'H' is removed from.



Needed to explain why two products are produced.
~ butan-2-ol is asymmetric
~ major and minor products needed to be identified.

(b) Discuss the laboratory procedures used to convert butan-1-ol into butanal, and butan-1-ol into butanoic acid.

In each discussion, you should:

- outline the process for each conversion
- state and justify the type of reaction occurring
- identify the reagents used, and explain any observations made.

ASSESSOR'S USE ONLY

Butan-1-ol to butanal:

Add cold Cr_2O_7 in order to oxidise butan-1-ol to butanal.

Laboratory procedures are poorly explained.

Butan-1-ol to butanoic acid:

Reflux is needed as you add $Cr_2O_7^{2-}/H^+$ to butan-1-ol under Oxidation to create ~~butanal~~ butanoic acid. It will first form butanal as ~~in~~ above, yet under further oxidation will produce a carboxylic acid. ~~The acid is formed~~ The ~~Cr~~ solution will go from brown/red to ~~green. colourless.~~ green.

1° alcohol, acid, acid chloride   C – C – C – C(=O)(Cl)

ASSESSOR'S USE ONLY

(c) Devise a method for distinguishing between the three liquid compounds, butan-1-ol, butanoic acid, and butanoyl chloride, using only blue litmus paper and water.

Explain each of the observations in your method, with reference to the structure of the organic compounds.

Add blue litmus paper to all. The acid chloride (butanoyl chloride) and the acid (butanoic acid) will turn it red. The alcohol (butan-1-ol) will have no effect on it. Add water to the ~~extremely reactive~~ acid chloride and acid. The acid chloride is extremely reactive and will react violently in a hydrolysis reaction to form an carboxylic acid. $CH_3CH_2CH_2COCl + H_2O \rightarrow CH_3CH_2CH_2COOH + HCl$
This is because of the presence of the Cl atom.

~ A correct method would involve dampening the blue litmus paper with water.

~ Chemical equation used as a reference to the structure of the organic compounds.

A4

ASSESSOR'S USE ONLY

QUESTION THREE

$CH_3-C(CH_3)(OH)-CH_3$ $CH_3CH_2CH_2COH$ / $CH_3-CH_2-CH_2-CH_2-OH$ $CH_3CH(OH)-CH_2-CH_3$

(a) (i) Three alcohol compounds are listed below.

methylpropan-2-ol butan-1-ol butan-2-ol

Compare and contrast the structures of the compounds above.

Methylpropan-2-ol is a tertiary alcohol as the OH functional group is bonded to a 'C' atom that is bonded to 3 other 'C' atoms. Butan-1-ol is a primary alcohol as the OH functional group is bonded to a 'C' atom that is bonded to one other 'C' atom. Butan-2-ol is a secondary alcohol as the OH functional group is bonded to two other 'C' atoms.

Alcohols contrasted, but not compared.

(ii) Describe how you could distinguish between the alcohols in (i) above, using chemical tests on the alcohols and/or their oxidation products.

Add $Cr_2O_7^{2-}/H^+$ to all alcohols. The Methylpropan-2-ol will not react as it is a tertiary alcohol. The Butan-1-ol will form an aldehyde and butan-2-ol will form a ketone in oxidation reactions.

1° Alcohol Butan-1-ol to butanal:

×3 $CH_3CH_2CH_2CH_2OH \rightarrow CH_3CH_2CH_2CHO + 2H^+ + 2e^-$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$3CH_3CH_2CH_2CH_2OH + Cr_2O_7^{2-} + 12H^+ \rightarrow 3CH_3CH_2CH_2CHO + 2Cr^{3+} + 7H_2O$

Butan-2-ol to butan-2-one:

$CH_3CH(OH)CH_2CH_3 \rightarrow CH_3C(O)CH_2CH_3 + 2H^+ + 2e^-$

$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

$3CH_3CH(OH)CH_2CH_3 + Cr_2O_7^{2-} + 12H^+ \rightarrow 3CH_3COCH_2CH_3 + 2Cr^{3+} + 7H_2O$

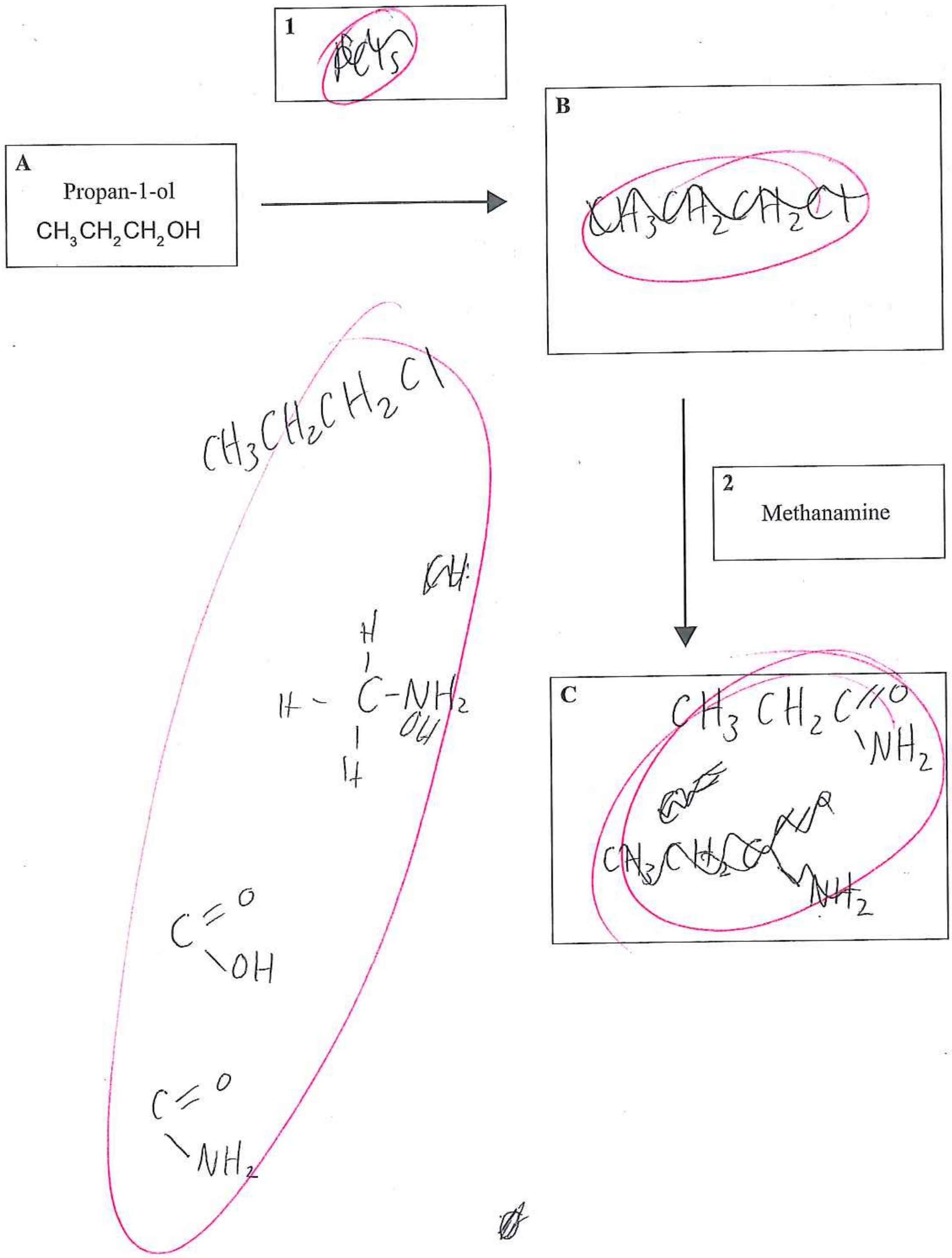
To the distinguish between the ketone and the aldehyde add Tollens reagent to both. This contains colourless silver diamine $[Ag(NH_3)_2]^+$ that will form a silver mirror/precipitate after heated for 10 minutes. It will only react with the aldehyde to form an acid. See extra paper.

Methyl propan-2ol has not been identified with observations.

ASSESSOR'S USE ONLY

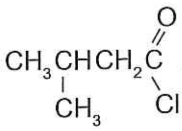
(b) Complete the following reaction scheme by drawing the structural formulae of the organic compounds **B** and **C**, and identifying reagent **1**.

Include any necessary conditions, needed to bring about the transformation from reactant **A** to the organic compound **C**, which is a **base**.



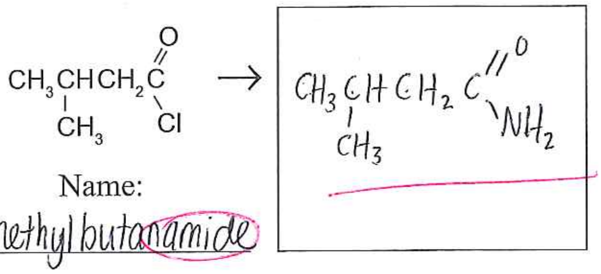
Question Three continues on the following page.

ASSESSOR'S USE ONLY

(c) When ammonia reacts with  , two products are formed.

Complete the equation below by naming compounds or drawing the structure.

Structural formula of organic product: | Name of inorganic product:

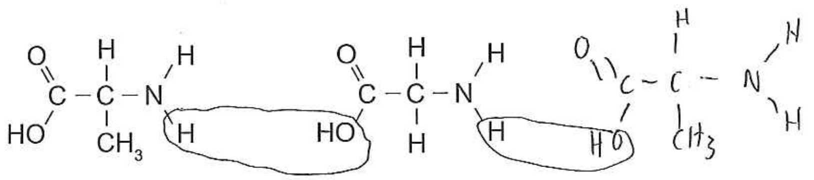
Ammonia +  + HCl (hydrochloric acid)

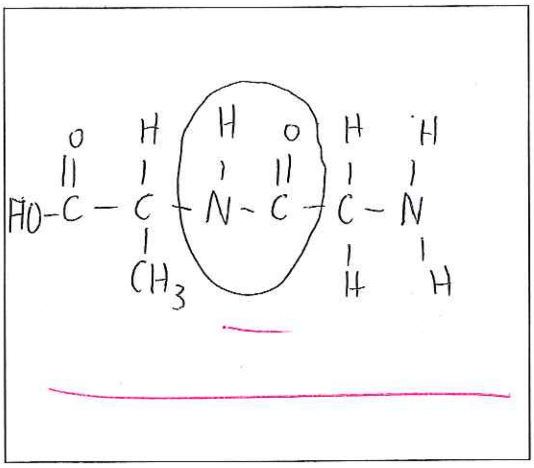
Name: 3-methylbutanamide

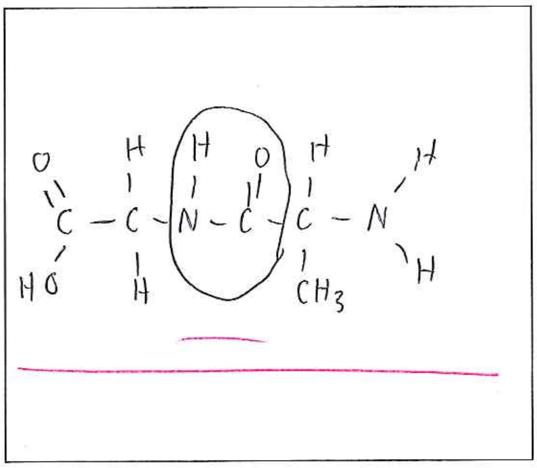
Reactant is an acyl chloride, not an amide.

(d) Peptides are formed when amino acids combine.

(i) In the boxes below, show two possible dipeptides that can be formed by combining the amino acids:







(ii) Circle the amide link in each dipeptide.

Dipeptides and amide links well drawn.

A4

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

QUESTION NUMBER

ASSESSOR'S USE ONLY

butanal to butanoic acid:

3(ii) $CH_3CH_2CH_2CHO + H_2O \rightarrow CH_3CH_2CH_2COOH + 2H^+ + 2e^-$

$Ag^+ + e^- \rightarrow Ag$

$CH_3CH_2CH_2CHO + 2Ag^+ + H_2O \rightarrow CH_3CH_2CH_2COOH + 2H^+ + 2Ag$

This is also an oxidation reaction

HIGH MERIT

3

4·00

SUPERVISOR'S USE ONLY

NZQA

NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

Level 3 Chemistry, 2013

91391 Demonstrate understanding of the properties of organic compounds

2.00 pm Tuesday 19 November 2013
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 is provided on the Resource Sheet L3–CHEMR.

If you need more space for any answer, use the page(s) provided at the back of this booklet and clearly number the question.

Check that this booklet has pages 2–11 in the correct order and that none of these pages is blank.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL 18

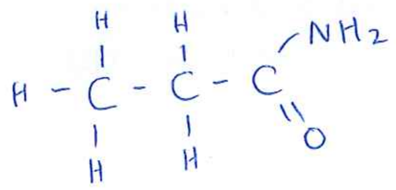
ASSESSOR'S USE ONLY

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

ASSESSOR'S USE ONLY

QUESTION ONE

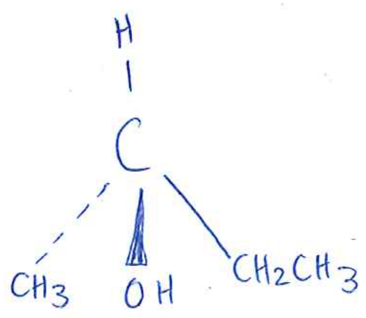
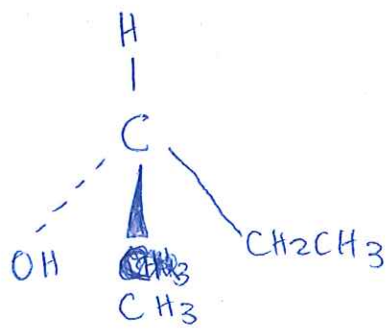
(a) Complete the table below by giving the IUPAC systematic name or the structural formula for each compound.

Structural formula	IUPAC systematic name
$HO-CH_2-CH_2-C(=O)H$	~~propan-1-ol-al~~ propan-1-ol propanal
	propanamide If an –OH group is added on to an aldehyde, the –OH group becomes a 'hydroxy' group.
$CH_3-C(=O)-CH_2-CH(CH_3)-CH_3$	4-methylpentan-2-one.

(b) The alcohol below can exist as two enantiomers (optical isomers).

$CH_3CH(OH)CH_2CH_3$

(i) Draw three-dimensional structures for the two enantiomers.

ASSESSOR'S USE ONLY

(ii) Link the structure of enantiomers to a physical property that can be used to distinguish them from non-optically active molecules.

The chiral carbon must have 4 different atoms or groups of atoms attached to it creating a non-superimposible image that can rotate plane polarised light.

Enantiomers rotate plane polarised light in opposite directions.

(c) Draw the structural formulae of three different isomers of HO – CH_2 – CH_2 – C(=O)H, which show the following properties: $C_3H_6O_2$

- Isomer 1 turns moist blue litmus paper red. acidic
- Isomer 2 is an ester.
- Isomer 3 is a ketone.

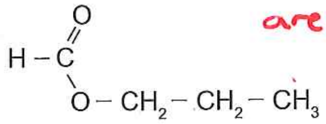
Property	Structural formula
turns moist blue litmus paper red	$CH_3 - CH_2 - C(=O) - OH$
is an ester	$CH_3 - C(=O) - O - CH_3$
is a ketone	$CH_3 - C(=O) - CH_2OH$

(d) Give the structures and names of the products of the reactions below.

These reactions are carried out by heating in either:

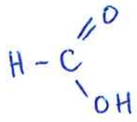
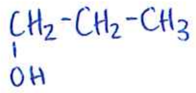
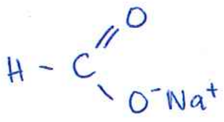
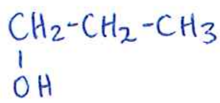
- dilute hydrochloric acid solution, or
- dilute sodium hydroxide solution.

All products are identified and acid/base hydrolysis are explained.



dilute hydrochloric acid solution — carbox acid alc.

dilute sodium hydroxide solution — carbox. ion. alc.

			
Name: methanoic acid	Name: propan-1-ol.	Name: sodium methanoate	Name: propan-1-ol

Compare and contrast the reactions above.

In your answer, you should include the type of reaction(s) taking place.

Reacting propylmethanoate (ester) with an acid is acid hydrolysis and produces an alcohol, propan-1-ol and a carboxylic acid, methanoic acid. Reacting propylmethanoate (ester) with a base is base hydrolysis and, like acid hydrolysis, will produce an alcohol propan-1-ol and, different to acid hydrolysis, a carboxylate ion, in this case sodium methanoate.

ASSESSOR'S USE ONLY

E7

QUESTION TWO

ASSESSOR'S USE ONLY

(a) For the following conversions, identify the reagent required, and state the type of reaction occurring.

(i) Pentan-2-one is converted to pentan-2-ol.

Reagent required: $NaBH_4$

Type of reaction: ~~elimination~~ reduction.

(ii) Butan-2-ol is converted to a mixture of but-1-ene and but-2-ene.

Reagent required: KOH (alc.) Conc. H_2SO_4 required here.

Type of reaction: elimination.

(iii) Discuss the reaction occurring in (ii) above, with reference to the structures of the organic reactant and products.

The reaction occuring between butan-2-ol and KOH (alc.) is an elimination reaction because the -OH functional group in butan-2-ol is eliminated ~~and~~ a C=C double bond forms ~~between~~ in its place. Two products are formed: $CH_3CH_2CH=CH_2$ but-1-ene (minor) $CH_3CH=CHCH_3$ but-2-ene (major) ~~These two products are formed due to the~~ ~~"rich get richer"~~ Both major and minor products are formed due to the "poor get poorer" rule.

Needed to elaborate on the elimination reaction.
~ water is removed
~ two products formed
~ butan-2-ol is asymmetric.

$Cr_2O_7^{2-}/H^+$, distilled

(b) Discuss the laboratory procedures used to convert butan-1-ol into butanal, and butan-1-ol into butanoic acid.

In each discussion, you should:

- outline the process for each conversion
- state and justify the type of reaction occurring
- identify the reagents used, and explain any observations made.

ASSESSOR'S USE ONLY

Butan-1-ol to butanal:

This reaction is an oxidation reaction, however to ensure the butanal is not further oxidised to butanoic acid it must be ~~refluxed~~ distilled off when forming.

$CH_3CH_2CH_2CH_2(OH) + Cr_2O_7^{2-}/H^+ \rightarrow CH_3CH_2CH_2C(=O)H$

during this reaction the oxidising agent, $Cr_2O_7^{2-}/H^+$, changes from orange to green as the butan-1-ol is oxidised to butanal reducing the $Cr_2O_7^{2-}/H^+$ to Cr^{3+} (green)

Oxidation reaction needs to be justified.

Butan-1-ol to butanoic acid:

This reaction is also an oxidation reaction and ~~does not need~~ can also ~~be~~ use $Cr_2O_7^{2-}/H^+$ or MnO_4^-/H^+. As MnO_4^-/H^+ is a strong oxidising agent it will oxidise the butan-1-ol to butanoic acid.

$CH_3CH_2CH_2CH_2(OH) + MnO_4^-/H^+ \rightarrow CH_3CH_2CH_2C(=O)OH$

The MnO_4^-/H^+ changes from purple to colourless as the butan-1-ol is oxidised to butanoic acid and MnO_4^- (purple) is reduced to MnO_2* (colourless)

ASSESSOR'S USE ONLY

(c) Devise a method for distinguishing between the three liquid compounds, butan-1-ol, butanoic acid, and butanoyl chloride, using only blue litmus paper and water.

neutral acidic vigourous.

Explain each of the observations in your method, with reference to the structure of the organic compounds.

add water

→ no reaction
- butan-1-ol
- butanoic acid

→ violent reaction, gas produced.
- butanoyl chloride

$CH_3CH_2CH_2C(=O)Cl + H_2O \rightarrow CH_3CH_2CH_2C(=O)OH + HCl(g)$

butan-1-ol, butanoic acid ↓ new samples of both ↓ test with moist blue litmus paper

→ turns moist blue litmus red
- butanoic acid

$CH_3CH_2CH_2C(=O)OH + H_2O(l) \rightarrow CH_3CH_2CH_2COO^- + H_3O^+$

→ no change
- butan-1-ol

Well presented method!

E7

ASSESSOR'S USE ONLY

QUESTION THREE

(a) (i) Three alcohol compounds are listed below.

no oxidation. aldehyde. ketone

methylpropan-2-ol butan-1-ol butan-2-ol

Compare and contrast the structures of the compounds above.

~~methylpropan2~~ methylpropan-2-ol, $CH_3C(OH)(CH_3)CH_3$, is a tertiary alcohol. In comparison to butan-1-ol which is a primary alcohol, $CH_2(OH)CH_2CH_2CH_3$, and butan-2-ol which is a secondary alcohol, $CH_3CH(OH)CH_2CH_3$.

The alcohols have been contrasted but not compared.

(ii) Describe how you could distinguish between the alcohols in (i) above, using chemical tests on the alcohols and/or their oxidation products.

add MnO_4^-/H^+

no colour change
• methylpropan-2-ol
(3° alcohols don't oxidise)

colour change, purple → colourless
• butan-1-ol and butan-2-ol

add Tollen's reagent

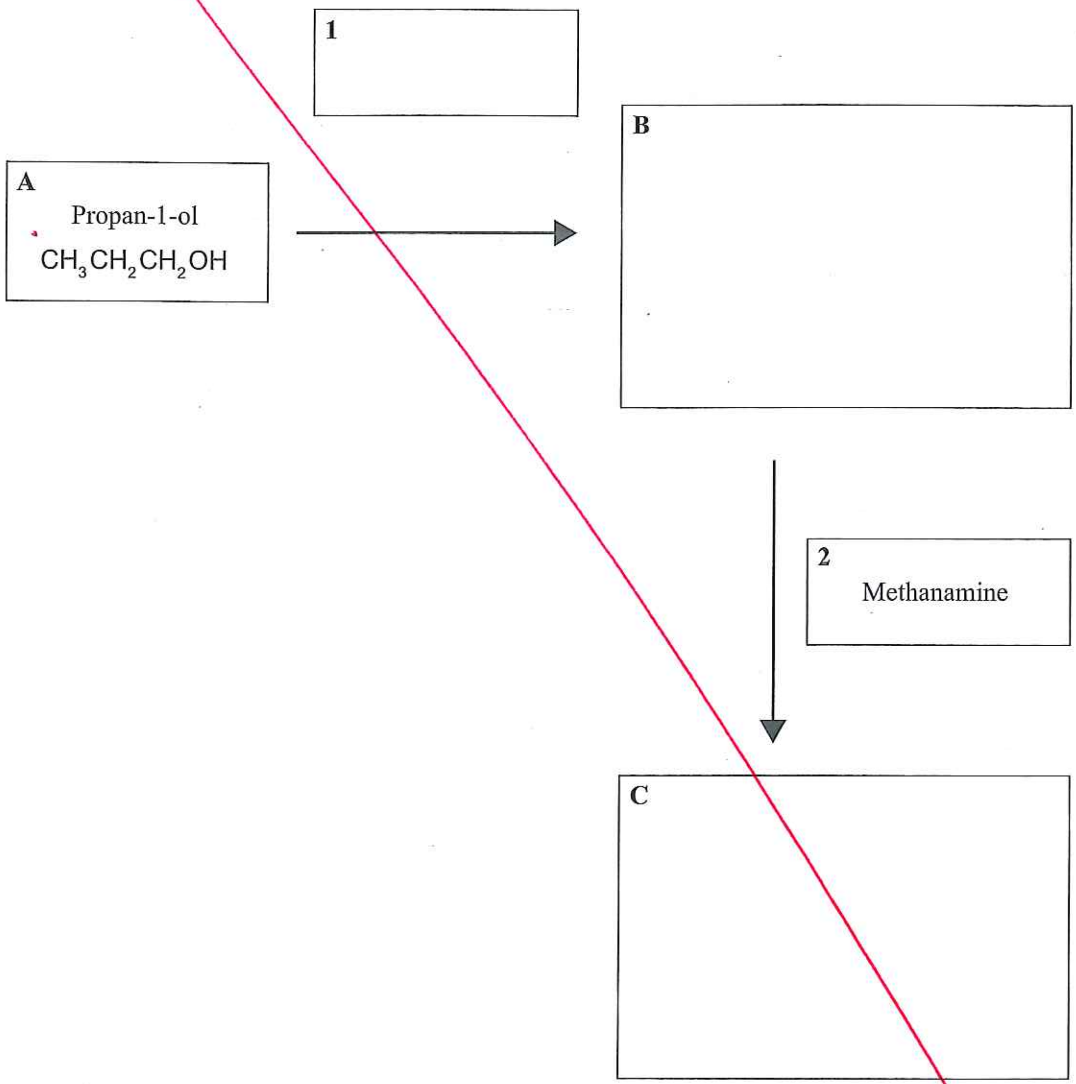
no change
• butan-2-ol

See extra paper, page 11.

~ A well presented method on page 11.

(b) Complete the following reaction scheme by drawing the structural formulae of the organic compounds **B** and **C**, and identifying reagent **1**.

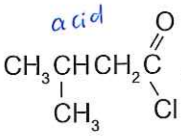
Include any necessary conditions, needed to bring about the transformation from reactant **A** to the organic compound **C**, which is a **base**.



ASSESSOR USE ONLY

Question Three continues on the following page.

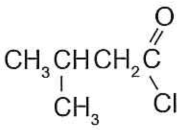
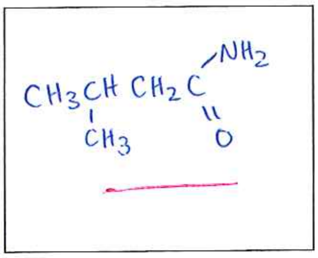
ASSESSOR'S USE ONLY

(c) When ammonia reacts with  , two products are formed.

Complete the equation below by naming compounds or drawing the structure.

Structural formula of organic product:

Name of inorganic product:

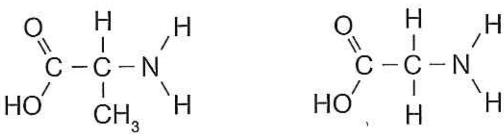
Ammonia +  →  + Ammonium chloride.

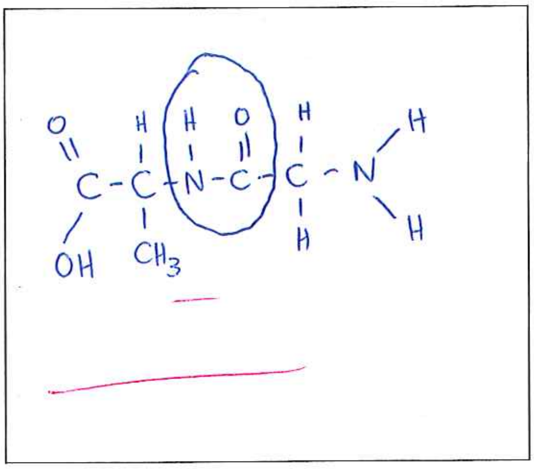
Name:

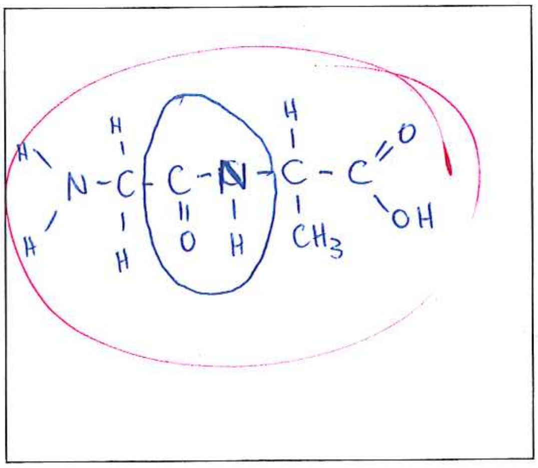
3-methylbutanoyl chloride

(d) Peptides are formed when amino acids combine.

(i) In the boxes below, show two possible dipeptides that can be formed by combining the amino acids:







(ii) Circle the amide link in each dipeptide.

Both products are identical - just mirror reflections of the same molecule.

A4

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

QUESTION NUMBER

ASSESSOR'S USE ONLY

~~CH_3-CH_2~~

~~$CH_3-C(=O)-CH_3$~~

~~CH_3-C-CH_2 OH~~

~~$CH_3CH_2CH=CH_2$ ← minor $CH_3CH_2CH(OH)CH_3$~~
~~$CH_3CH=CHCH_3$ ← major~~

~~$CH_3CH_2CH_2C(=O)-Cl$~~

~~$CH_3CH_2CH_2COOH + H_2O \rightarrow$~~

3.(ii) Add MnO_4^-/H^+

→ colour change purple → colourless

- butan-1-ol

$CH_3CH_2CH_2CH_2(OH) + MnO_4^-/H^+ \rightarrow CH_3CH_2CH_2C(=O)H$ butanal

~~• butan-2-ol~~

- butan-2-ol

$CH_3CH_2CH(OH)CH_3 + MnO_4^-/H^+ \rightarrow CH_3CH_2C(=O)CH_3$ butanone.

→ no colour change
- methylpropan-2-ol
(3° alcohols cannot be oxidised)

↓

add Tollen's reagent to both samples. → silver precipitate forms
- butan-1-ol as butanal ~~is oxidised further to~~ butanoic acid,

$CH_3CH_2CH_2C(=O)H + Ag(NH_3)$ (Tollens) $\rightarrow CH_3CH_2CH_2C(=O)OH$

↓

no colour change
- butan-2-ol as butanone cannot be oxidised further.