ANSWERS

Level 3 Chemistry

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.

You should attempt ALL the questions in this booklet.

A periodic table is provided in the Resource Sheet.

If you need more room for any answer, use the extra space 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.

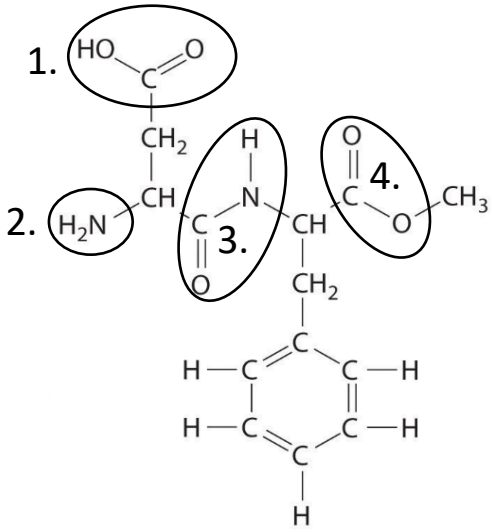
YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

TOTAL

ASSESSOR'S USE ONLY

QUESTION ONE

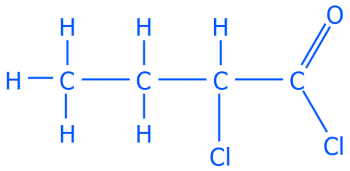
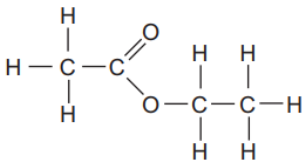
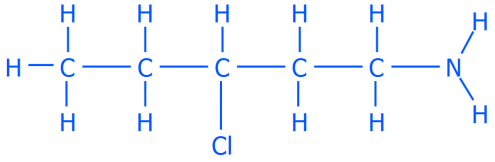
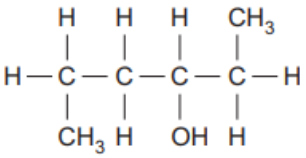
(a) Aspartame is one of the most popular artificial sweeteners available on the market. It has also faced controversy in recent years. Many opponents have claimed that aspartame is bad for your health.
The structure of aspartame is given opposite.



(i) Identify the different functional groups within the molecule that are circled and numbered above:

1 carboxylic acid	2 amino / amine
3 amide	4 ester

(ii) Complete the table below by drawing the structural formula for the named compounds or naming the drawn compound using its IUPAC systematic name.

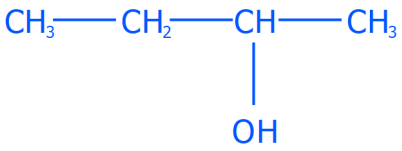
IUPAC systematic name.	Structural formula
2-chlorobutanoyl chloride	
Ethyl ethanoate	
3-chloropentan-1-amine	
Hexan-3-ol	

(b) There are a number of structural isomers of the alcohol with molecular formula C_4H_9OH. Only one of these structural isomers contains an asymmetric centre and can exist as optical isomers.

Explain, in terms of structure, the meaning of the expression 'optical isomers'. In your answer you should;

- Give the structural formula and name of the structural isomer which contains an asymmetric centre, explaining what is meant by the term asymmetric centre.
- Draw the 3D representations of the two optical isomers of the molecule identified.
- Explain how one optical isomer can be distinguished from the other.

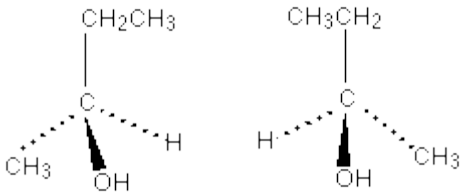
The only isomer of C_4H_9OH with an asymmetric centre is butan-2-ol.



The asymmetric centre is a carbon atom bonded to 4 different atoms / groups.

$CH_3CH_2\overset{*}{C}HOHCH_3$

This means that the molecule and its mirror image are non-superimposable. Butan-2-ol has a chiral centre / 4 different groups attached to one carbon atom.



The different isomers rotate the plane of polarised light in opposite directions

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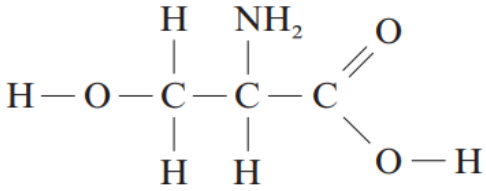
(c) Sericin is a protein created by *Bombyx mori* (silkworms) in the production of silk. Silk is a naturally occurring material composed of polymerised amino acids, mainly glycine, alanine, and serine.

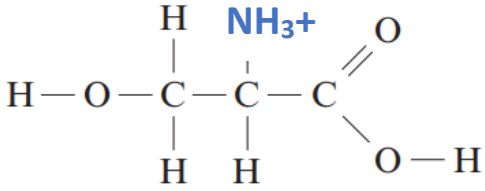


Serine

(i) Give the IUPAC systematic name of serine.

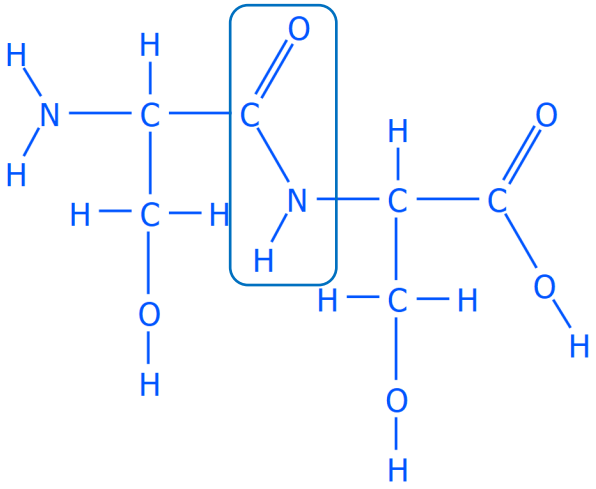
2-amino-3-hydroxypropanoic acid

(ii) Serine dissolves in acid. Draw the carbon-containing species that would be present in this solution.



The NH_2 group would be protonated, making it NH_3^+

(iii) When two molecules of serine react together, they make a dipeptide. Draw the structure of this dipeptide, circling the peptide link.



Question Two

(a) Butanone can be reduced using $NaBH_4$. The product can be dehydrated to give a mixture of but-1-ene and but-2-ene.

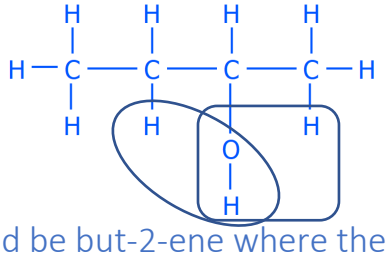
(i) Using [H] to represent $NaBH_4$, write the balanced equation for the reduction and name the product.

$CH_3CH_2COCH_3 + 2[H] \rightarrow CH_3CH_2CHOHCH_3$

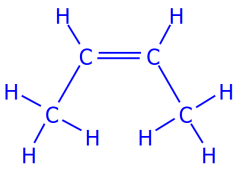
Product is butan-2-ol

(ii) Explain why a mixture of but-1-ene and but-2-ene would be formed. In your answer you should include named structural formula for the products formed.

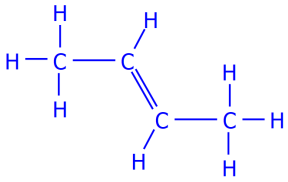
When butan-2-ol is dehydrated (in an elimination reaction) by reacting it with concentrated sulfuric acid, the -OH group and H atom are lost from adjacent carbon atoms.
The secondary alcohol produces major and minor products because the molecule is asymmetric OR it has two adjacent C atoms with different numbers of H atoms attached.
There are 2 possible products.



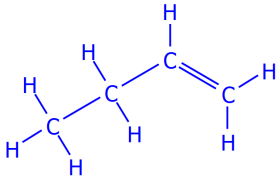
The major product would be but-2-ene where the H atom is lost from the C atom that already had least H atoms. A mixture of cis-but-2-ene and trans-but-2-ene would be formed.



and



The minor product would be but-1-ene. This is formed when a H atom is lost from the C atom on the end of the alcohol.



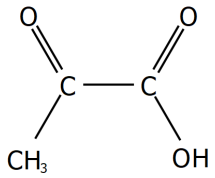
(b) Butanal is a structural isomer of butanone. Describe, giving practical details, and expected observations, how you would carry out a chemical test to distinguish between samples of butanal and butanone. Include any relevant equations.

Adding blue Benedict's solution to a warmed / heated sample of butanal will cause a (brick) red colour to form. This happens because the butanal has been oxidised to butanoic acid / carboxylic acid (red colour is copper(I) oxide). No change will occur when blue Benedict's solution is added to the ketone as it can't be further oxidised.

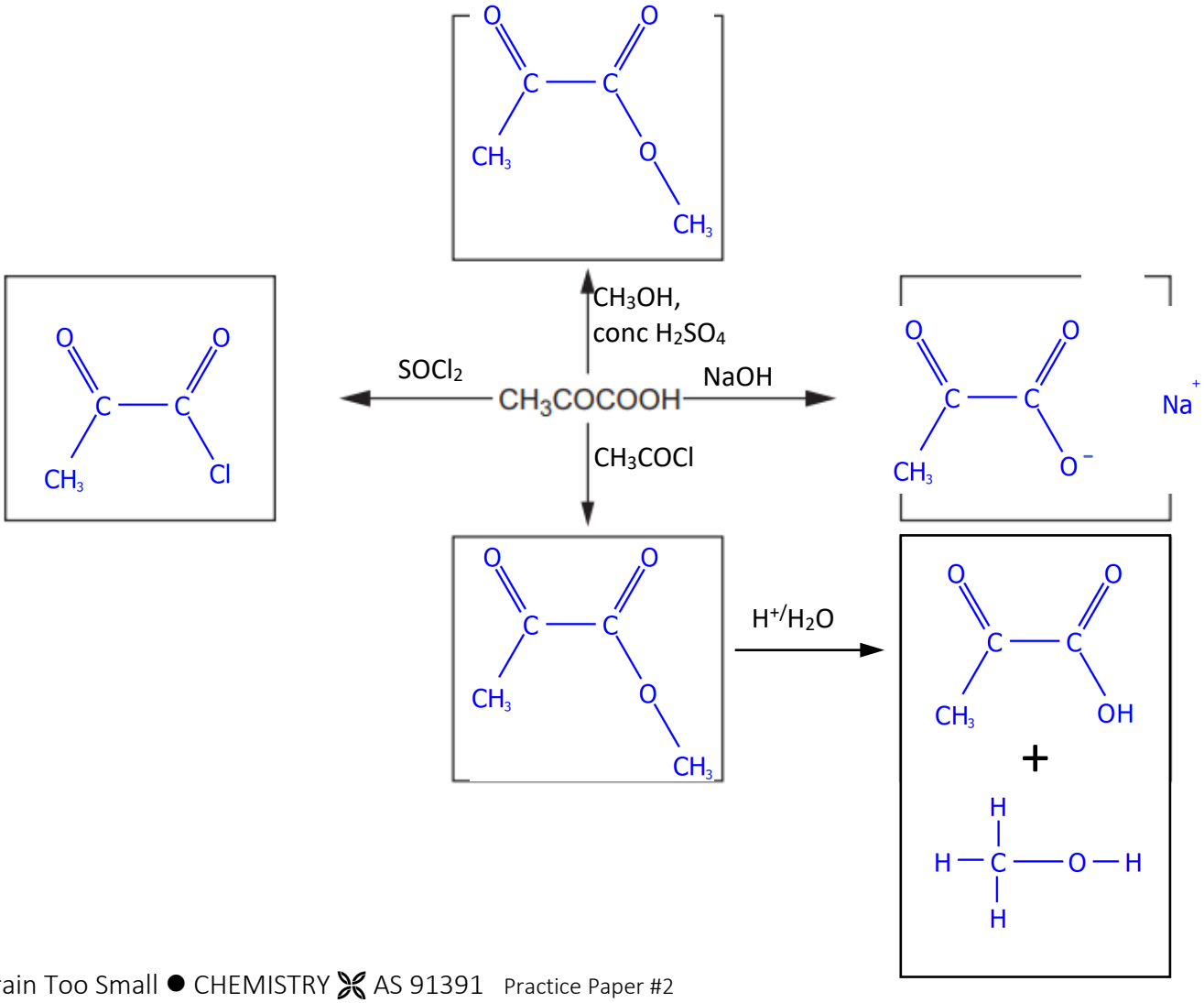
$$CH_3CH_2CH_2CHO \xrightarrow{[O]} CH_3CH_2CH_2COOH$$

Alternative answer: Tollens' reagent could be used giving a silver mirror with butanal but no positive test with the butanone.

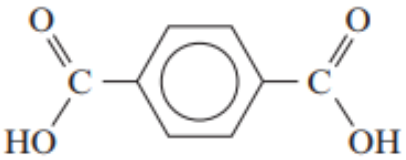
(c) Pyruvic acid is an intermediate compound in the metabolism of carbohydrates, proteins, and fats. It shows both the reactions of a ketone and a carboxylic acid. It has this structure.



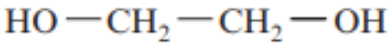
Complete the following flow sequences below showing the organic product in each case.



(d) Polyester is a condensation polymer made from the two monomers, benzene-1,4-dioic acid, and ethane-1,2-diol.



benzene-1,4-dioic acid

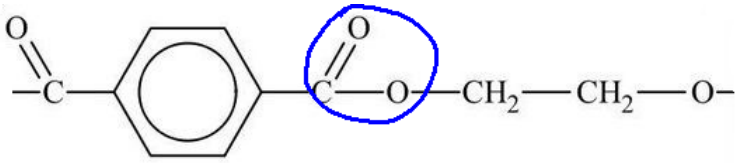


ethane-1,2-diol.

(i) Explain the term condensation polymer.

This is condensation or substitution (polymerisation), whereby the two monomers are joined together and a small molecule (H_2O in this example) is eliminated.

(ii) Draw the repeating unit in polyester, circling an ester link in the structure.



(iii) This type of polymerisation differs from the type of polymerisation occurring when poly(propene) is made from propene. Explain why the disposal of polyesters in landfill sites is more environmentally acceptable than the similar disposal of poly(propene).

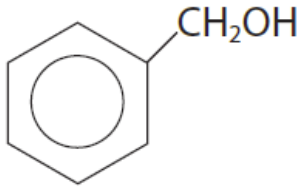
The production of poly(propene) is an example of addition polymerisation, when propene monomers react to produce poly(propene) and no other product. Because of the strong C-C bonds poly(propene) is very unreactive and doesn't biodegrade. It is non polar OR has no polar groups/bonds (for attack by water / acids / alkalis / nucleophiles or for hydrolysis).

Simple esters are easily hydrolysed by reaction with dilute acids or alkalis. Polyesters are attacked readily by alkalis, but much more slowly by dilute acids. Hydrolysis by water alone is very slow however. However they are more biodegradable than the addition polymer poly(propene).

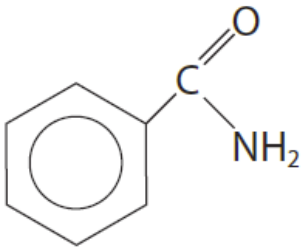
Question Three

(a) Explain how a chemist could use phenyl methanol to synthesise a sample of benzamide in three steps.

Note:  is a benzene ring and you can assume that it does not change during these reactions.



phenyl methanol

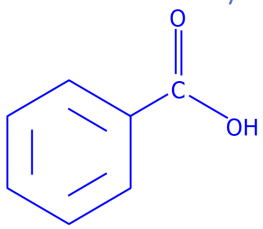


benzamide

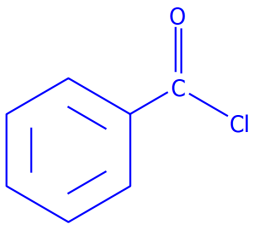
Include the reagents and conditions for the steps in the synthesis and draw the structures of **all** the intermediates.

 can also be drawn as  (which is what the program I used for these answers uses!)

1. Oxidation of the primary alcohol to carboxylic acid; heat with $Cr_2O_7^{2-}/H^+$



2. Conversion of carboxylic acid to acyl chloride; use $SOCl_2$



3. Conversion of acyl chloride to amide; Conc NH_3(alc)

(b) This is a brief method written by a student to enable others to prepare ethyl ethanoate by esterification.

- Mix together 0.45 mol of ethanoic acid with an equimolar quantity of ethanol. Add 5 mL of sulfuric acid.
- Heat under reflux for 15-20 minutes.
- Distil off everything boiling up to 82°C.
- Add the distillate to aqueous sodium hydrogen carbonate in a separating funnel, opening the funnel at regular intervals.
- Run off the ethyl ethanoate layer and dry it over anhydrous calcium chloride
- Distil off the dried ethyl ethanoate and collect the fraction boiling at 75-78°C.

(i) Give the equation for this reaction.

$CH_3COOH + C_2H_5OH \rightleftharpoons CH_3COOC_2H_5 + H_2O$

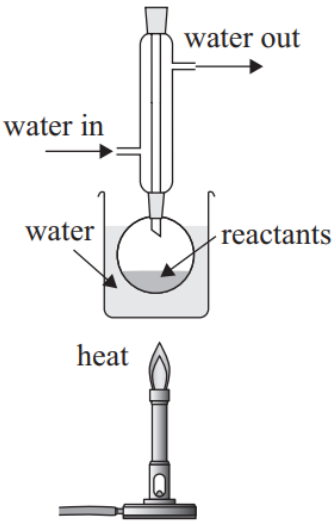
(ii) An important detail that is missing from the first bullet point. Explain what it is and why it is important.

The sulfuric acid needs to be concentrated sulfuric acid; the esterification reaction is both slow and reversible. The concentrated sulfuric acid acts both as a catalyst for the reaction as well as a dehydrating agent (removing H_2O), forcing the equilibrium to the right and producing a greater yield of ester.

(iii) Heating under reflux is a fairly common technique used in organic chemistry. Discuss the process. Include in your answer:

- the purpose of this process
- an explanation of how it works.

Refluxing allows the solution to be heated, which increases the rate of the chemical reaction. The reflux apparatus prevents the loss of volatile organic reactants or products. Condensing by the cold water jacket prevents volatile chemicals from being lost to the environment.



(iv) The distillate is added to sodium hydrogen carbonate solution. Explain:

- the purpose of using the sodium hydrogen carbonate.
- the reason for opening the tap of the separating funnel at regular intervals.

$NaHCO_3$ is used to remove any remaining acid mixed with the liquid product. Carbon dioxide / CO_2 is produced and so the tap must be opened to release the pressure caused by the buildup of CO_2 gas.