Chemistry A H034/434 - GCE

Test Name: Y13 Term 2 Week 1

Test Duration (minutes): 0

Test Created By: Kate Critchley

Number of questions in test: 21

Candidate forename:		Candidate surname:	

INSTRUCTIONS TO CANDIDATES

- Answer **all** questions
- Read each question carefully. Make sure you know what you have to do before starting your answer.
- Write your answers to each question in the space provided. Additional paper may be used if necessary but you must clearly show your candidate number, centre number and question number(s).

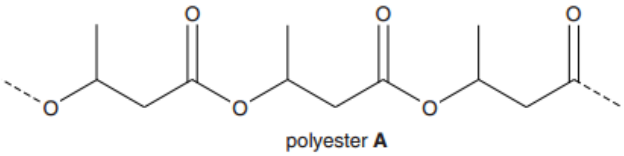
INFORMATION FOR CANDIDATES

- The number of marks is given in brackets **[ ]** at the end of each question or part question.

Question: 1

This question looks at different types of condensation polymers: polyesters, polyamides and
proteins.

(a) Polyester **A**, shown below, is a degradable polymer prepared by bacterial fermentation of
sugars.



polyester **A**

One reason that polyester **A** is degradable is that it can be hydrolysed.

(i) State another way that a polyester may be degraded.

_____

_____

_____

_____

_____

[1]

(ii) When polyester **A** is hydrolysed with aqueous acid, compound **B** is formed.

Draw the skeletal formula of **compound B**.

[1]

(b) Nylon-4,6 is a polyamide that can be prepared by reacting butane-1,4-diamine, $H_2N(CH_2)_4NH_2$,

with hexanedioic acid, $HOOC(CH_2)_4COOH$.

(i) $H_2N(CH_2)_4NH_2$ can be synthesised from 1,4-dichlorobutane, $Cl(CH_2)_4Cl$.

State the reagents and conditions required for this synthesis.

_____

_____

_____

_____

_____

[1]

(ii) $H_2N(CH_2)_4NH_2$ can act as a base and forms salts with dilute acids.

- Explain how an amine can act as a base.
- Write the formula of the salt formed when $H_2N(CH_2)_4NH_2$ reacts with an **excess** of dilute hydrochloric acid.

explanation ...

_____

_____

_____

_____

_____

formula of salt ...

_____

_____

_____

_____

_____

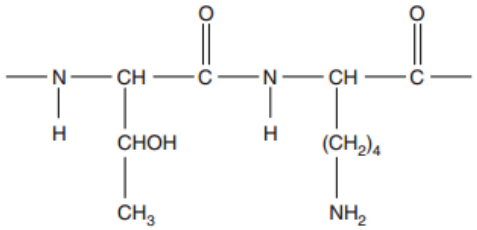
[2]

(iii) Draw the repeat unit of nylon-4,6.
Clearly display the bonding that links the two monomers.

[2]

(c) A sample of a protein is hydrolysed. The organic products are separated by chromatography.
Each organic product has its pH adjusted to its isoelectric point to form a zwitterion.

A section of the protein is shown below.



(i) In the boxes below, draw the structures of the zwitterions formed from this section of the
protein.

[2]

(ii) The isoelectric points of the zwitterions in **(i)** are at pH 5.60 and pH 9.60.

Explain why these isoelectric points are at different pH values

_____

_____

_____

_____

_____

[1]

[Total: 10]

Question: 2

This question is about different organic compounds containing C, H and O.

(a) A technician found an unlabelled bottle in a chemical store cupboard. The technician thinks that the bottle contains pentan-2-one, pentan-3-one or pentanal.

(i) Describe a series of chemical tests that the technician could use to confirm that the compound in the bottle is a ketone. Include appropriate reagents and any relevant observations.

_____

_____

_____

_____

_____

[2]

(ii) Describe how the technician could use the product of one of the tests in **(i)** to show whether the bottle contains pentan-2-one or pentan-3-one.

The method used should **not** involve spectroscopy.

_____

_____

_____

_____

_____

[2]

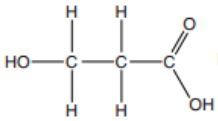
(b) 3-Hydroxypropanoic acid, $HOCH_2CH_2COOH$, can be produced microbiologically from sugars in corn. $HOCH_2CH_2COOH$ can be used as a 'green' starting material for the synthesis of many organic compounds including some important polymers.

Three synthetic routes are shown below for converting $HOCH_2CH_2COOH$, **A**, into different polymers.

The names of the processes for each synthetic step are given.

(i) In the boxes below, give the structures of the organic compounds formed.

Synthesis 1

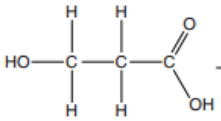


A

polymerisation →

one repeat unit

Synthesis 2

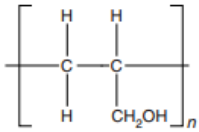


A

elimination of H_2O →

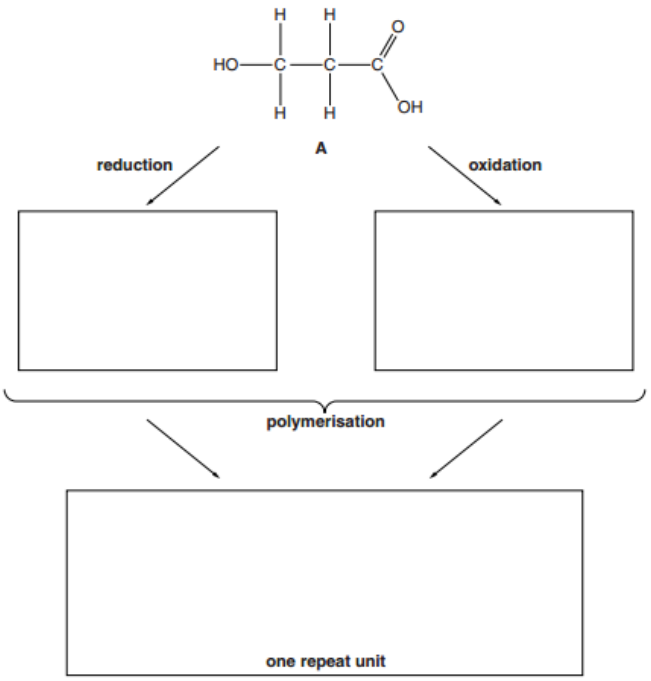
reduction ↓

← polymerisation



PVA, used in adhesives

Synthesis 3



[6]

(ii) State the type of polymerisation taking place in each synthetic route.

Synthesis 1: .....

_____

_____

_____

_____

_____

Synthesis 2: .....

_____

_____

_____

_____

_____

Synthesis 3: .....

_____

_____

_____

_____

_____

[1]

[Total: 11]

Question: 3

A chemist prepares and analyses some esters.

(a) The chemist prepares an ester of propan-2-ol, $CH_3CH(OH)CH_3$, by reacting $CH_3CH(OH)CH_3$ with ethanoic anhydride, $(CH_3CO)_2O$.

Using structural formulae, write an equation for the reaction of propan-2-ol and ethanoic anhydride.

[2]

(b) A sample contains a mixture of two esters contaminated with an alkane and an alcohol.

The chemist attempts to separate the four organic compounds in the mixture using gas chromatography, GC.

The column in the gas chromatograph contains a liquid alkane which acts as the stationary phase.

(i) How does a liquid stationary phase separate the organic compounds in a mixture?

_____

_____

_____

_____

_____

[1]

(ii) Suggest how well these four compounds would be separated using the

alkane stationary
phase. In your answer, include some indication of the length of the retention times.
Explain your answer.

_____

_____

_____

_____

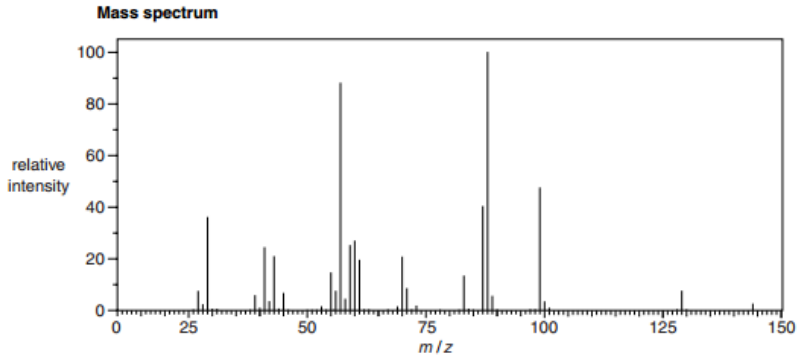
_____

[2]

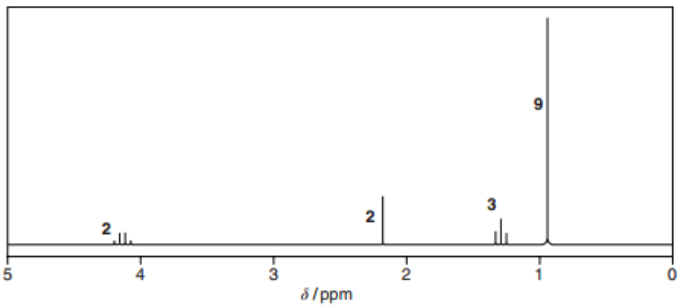
(c) GC is often used together with other techniques, such as mass spectrometry, MS, and NMR
spectroscopy, to provide a far more powerful analytical tool than GC alone.

One of the esters in a perfume is separated by GC and then analysed.
The results are shown below.

Elemental analysis by mass
C, 66.63%; H, 11.18%; O, 22.19%



Proton NMR spectrum
The numbers by each peak are the relative peak areas.



Use the results to identify the ester. Show **all** your reasoning.

In your answer, you should use appropriate technical terms, spelled correctly.

[10]

[Total: 15]

Question: 4

A chemist was investigating the reactions of benzene, phenol and cyclohexene with bromine.
She found that they all reacted with bromine but under different conditions.

(a) The chemist found that when benzene reacts with bromine, a halogen carrier is required as a
catalyst.

Write an equation for this reaction.
You do **not** need to show the halogen carrier in your equation.

_____

_____

_____

_____

_____

[1]

(b) The chemist also found that when phenol or cyclohexene reacts with bromine, a halogen
carrier is **not** required.

(i) The chemist observed that bromine decolourises when it reacts with phenol.

What other observation would she have made?

Draw the structure of the organic product formed.
Observation .....

_____

_____

_____

_____

_____

Organic product:

[2]

(ii) Cyclohexene also decolourises bromine.
Name the organic product formed.

_____

_____

_____

_____

_____

[1]

(iii) Explain the relative resistance to bromination of benzene compared to phenol and
compared to cyclohexene.

In your answer, you should use appropriate technical terms, spelt correctly.

_____

_____

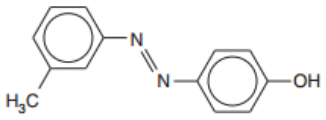
_____

_____

_____

[5]

(c) Compound **A**, shown below, is being considered as an azo dye by a chemical company. A
chemist planned a two-stage synthesis of compound **A** starting from an aromatic amine.



compound A

The aromatic amine is first converted into a diazonium ion.

- Draw the displayed formula of the aromatic amine **and** of the diazonium ion.

- State the reagents and conditions for each stage in the synthesis of

compound **A** from
an aromatic amine.

_____

_____

_____

_____

_____

[5]

[Total: 14]

Question: 5

Hydroxyethanal, $HOCH_2CHO$, is sometimes referred to as the 'first sugar' as it is the simplest possible molecule that contains both an aldehyde group and an alcohol group.

A biochemist investigated some redox reactions of hydroxyethanal and found that several different products were produced.

(a) The biochemist reacted hydroxyethanal with Tollens' reagent.

(i) State what the biochemist would see when hydroxyethanal reacts with Tollens' reagent.

_____

_____

_____

_____

_____

[1]

(ii) Write the structural formula of the organic product formed when hydroxyethanal reacts with Tollens' reagent.

_____

_____

_____

_____

_____

[1]

(b) The biochemist also reacted hydroxyethanal with acidified dichromate by heating under reflux.

Write an equation for this oxidation.

Use [**O**] to represent the oxidising agent.

_____

_____

_____

_____

_____

[2]

(c) The biochemist then reduced hydroxyethanal using aqueous $NaBH_4$.

(i) Write the structural formula of the organic product.

_____

_____

_____

_____

_____

[1]

(ii) Outline the mechanism for this reduction.

Use curly arrows and show any relevant dipoles.

[4]

[Total: 9]

Question: 6

α-Amino acids are found in human sweat. A student had read that chromatography could be used
to separate and identify the amino acids present in human sweat.

(a) The student used Thin-Layer Chromatography (TLC) to separate the α-amino acids in a
sample of human sweat and discovered that three different α-amino acids were present.

(i) Name the process by which TLC separates α-amino acids.

_____

_____

_____

_____

_____

[1]

(ii) The chromatogram was treated to show the positions of the separated α-amino acids.

Explain how the student could analyse the chromatogram to identify the three α-amino
acids that were present.

_____

_____

_____

_____

_____

[2]

(iii) Several α-amino acids have structures that are very similar.

Suggest why this could cause problems when using TLC to analyse mixtures of α-amino
acids.

[1]

(b) Some of the α-amino acids found in human sweat are shown in the table below.

α-amino acid	R group
glycine	H
leucine	$CH_2CH(CH_3)_2$
isoleucine	$CH(CH_3)CH_2CH_3$
alanine	CH_3
valine	$CH(CH_3)_2$
lysine	$(CH_2)_4NH_2$
glutamic acid	$(CH_2)_2COOH$

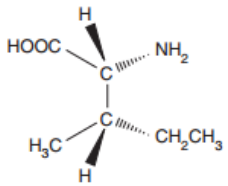
Table 1

(i) State the general formula of an α-amino acid.

[1]

(ii) There are four stereoisomers of isoleucine.

One of the stereoisomers is shown below.



Draw 3D diagrams for the other **three** stereoisomers of isoleucine.

[3]

α-amino acid	R group
glycine	H
leucine	$CH_2CH(CH_3)_2$
isoleucine	$CH(CH_3)CH_2CH_3$
alanine	CH_3
valine	$CH(CH_3)_2$
lysine	$(CH_2)_4NH_2$
glutamic acid	$(CH_2)_2COOH$

Table 1

(c) α-Amino acids form different ions at different pH values. Zwitterions are formed when the pH
is equal to the isoelectric point of the α-amino acid.

The isoelectric points of three α-amino acids are given below:

alanine, pH = 6.0 **glutamic acid, pH = 3.2** **lysine, pH = 9.7**

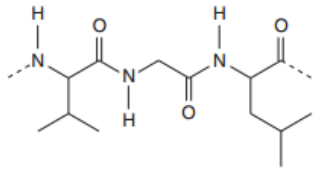
Draw the structures of the ions formed by these α-amino acids at the pH values below.
Refer to **Table 1** above.

alanine at pH = 6.0	glutamic acid at pH = 10	lysine at pH = 2.0

[3]

(d) α-Amino acids can react to form polypeptides.

A short section of a polypeptide is shown below.



Name the α-amino acid sequence in this section of the polypeptide. Refer to **Table 1**.

_____

_____

_____

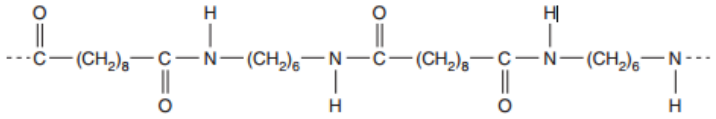
_____

_____

[1]

(e) Synthetic polyamides, such as nylon, contain the same link as polypeptides. Nylon is the general name for a family of polyamides.

A short section of a nylon polymer is shown below.



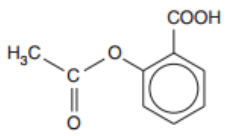
Draw the structures of **two** monomers that could be used to make this nylon.

[2]

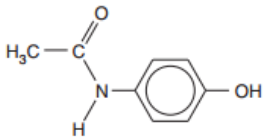
[Total: 14]

Question: 7

Aspirin and paracetamol are commonly available painkillers.



aspirin



paracetamol

Aspirin and paracetamol can be prepared using ethanoic anhydride, $(CH_3CO)_2O$.

Some examples of the reactions of ethanoic anhydride are shown below.

reaction 1 $(CH_3CO)_2O + CH_3OH \rightarrow CH_3COOCH_3 + CH_3COOH$

reaction 2 $(CH_3CO)_2O + CH_3NH_2 \rightarrow CH_3CONHCH_3 + CH_3COOH$

reaction 3 $(CH_3CO)_2O + C_6H_5NH_2 \rightarrow CH_3COOC_6H_5 + CH_3COOH$

(a) Draw the structure of a compound that could react with ethanoic anhydride to form aspirin.

[1]

(b) Ethanoic anhydride can react with 4-aminophenol to produce paracetamol.

(i) Write an equation, showing structural formulae, for this formation of paracetamol.

_____

_____

_____

_____

_____

[2]

(ii) An impurity with molecular formula $C_{10}H_{11}NO_3$ is also formed.

Draw the structure of this impurity.

[1]

(iii) Explain why it is necessary for pharmaceutical companies to ensure that drugs and
medicines are pure.

_____

_____

_____

_____

_____

[1]

(c) Name the functional groups in aspirin and in paracetamol.

aspirin .....

_____

_____

_____

_____

_____

paracetamol .....

_____

_____

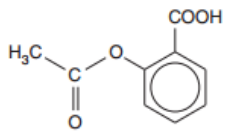
_____

_____

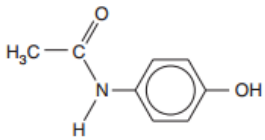
_____

[2]

(d) A student carried out some reactions with samples of aspirin and paracetamol in the laboratory.
Their structures are repeated below.



aspirin



paracetamol

The student tried to react each of the reagents **A**, **B** and **C** with aspirin and paracetamol.

- Reagent **A** reacted with aspirin andwith paracetamol.
- Reagent **B** reacted onlywith aspirin.
- Reagent **C** reacted onlywith paracetamol.

Suggest possible identities of reagents **A**, **B** and **C** and the organic products that would be
formed.

(i) Reagent **A**: .....

Organic product with aspirin:

Organic product with paracetamol:

[3]

(ii) Reagent **B**: .....

Organic prodcut with aspirin:

[2]

(iii) Reagent **C**: .....

_____

_____

_____

_____

_____

Organic product with paracetamol:

[2]

[Total: 14]

Question: 8

Methylbenzene, $C_6H_5CH_3$, is an aromatic hydrocarbon and is used widely as a solvent. It is readily
nitrated and it can form mono-, di-, or tri-nitromethylbenzenes.

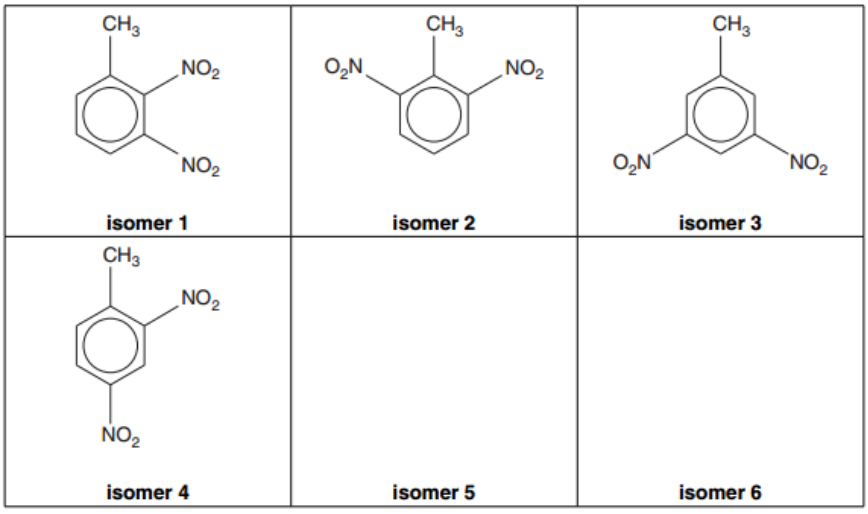
(a) 4-Nitromethylbenzene can be formed by the nitration of methylbenzene.

Outline the mechanism for the formation of 4-nitromethylbenzene from methylbenzene using
NO_2^+ as the electrophile.

[4]

(b) There are six possible structural isomers of $CH_3C_6H_3(NO_2)_2$ that are dinitromethylbenzenes.
Four of the isomers are shown below.

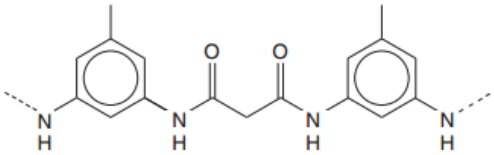
Draw the structures of the other two isomers in the boxes provided.



[2]

(c) A research chemist investigated whether dinitromethylbenzenes could be used in the

manufacture of fibres.
The chemist devised a **two**-stage synthesis of the condensation polymer below, starting from
one of the isomers in part **(b)**.



For the **first** stage of the synthesis,

- Which of the isomers **1**, **2**, **3** or **4** could be used?

- Identify the product formed and state suitable reagents.

- Write an equation.

For the **second** stage of the synthesis,

- Suggest an organic compound that could react with the organic product from the **first**
stage to form the polymer.

- State the type of condensation polymer formed.

_____

_____

_____

_____

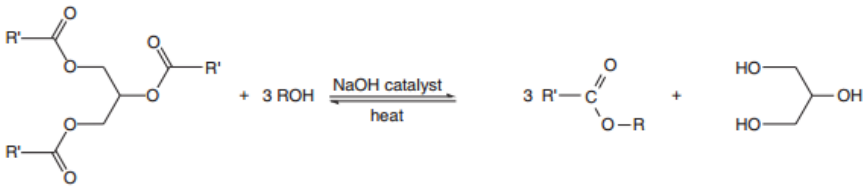
_____

[6]

[Total: 12]

Question: 9

Esters of fatty acids are used as biodiesels. These esters can be produced from triglycerides by
the transesterification process below.



triglyceride **biodiesel** **glycerol**

(a) Give the systematic name of glycerol.

_____

_____

_____

_____

_____

[1]

(b) (i) Suggest a suitable alcohol, ROH, that could be used industrially to make biodiesel.
Justify your answer.

_____

_____

_____

_____

_____

[1]

(ii) The alcohol, ROH, is added in excess.

Suggest why the alcohol has to be in excess.

_____

_____

_____

_____

_____

[1]

(c) Esters can also be made by reacting an alcohol with either a carboxylic acid or with an acid anhydride.

Write equations for the formation of ethyl propanoate, $CH_3CH_2COOCH_2CH_3$, starting from:

- a carboxylic acid and an alcohol,

_____

_____

_____

_____

_____

- an acid anhydride and an alcohol.

_____

_____

_____

_____

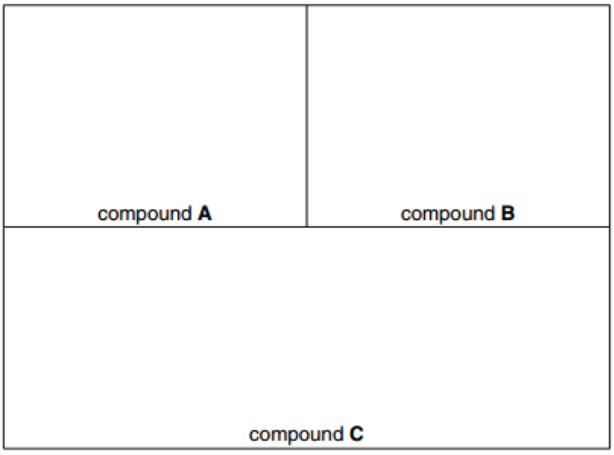
_____

[2]

(d) Compound **A**, $C_4H_8O_3$, can lose water to form either:

compound **B**, a cyclic ester
OR
compound **C**, a polyester.

Identify compounds **A**, **B** and **C**.



[3]

[Total: 8]

Question: 10

Benzaldehyde, C_6H_5CHO, is the simplest aromatic aldehyde and has a characteristic smell of almonds.

(a) Benzaldehyde can be nitrated with a mixture of concentrated nitric acid and concentrated sulfuric acid to form 3-nitrobenzaldehyde.

Explain, with the aid of curly arrows, the mechanism for the formation of 3-nitrobenzaldehyde.

Your answer should clearly show the role of sulfuric acid as a catalyst.

_____

_____

_____

_____

_____

[6]

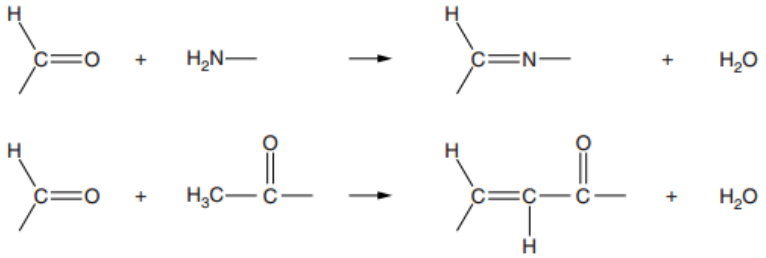
(b) Benzaldehyde reacts with a solution of potassium hydroxide. In this reaction, benzaldehyde is both oxidised and reduced to form two organic products.

Suggest an equation for this reaction, showing clearly the structures of the two organic
products.

[3]

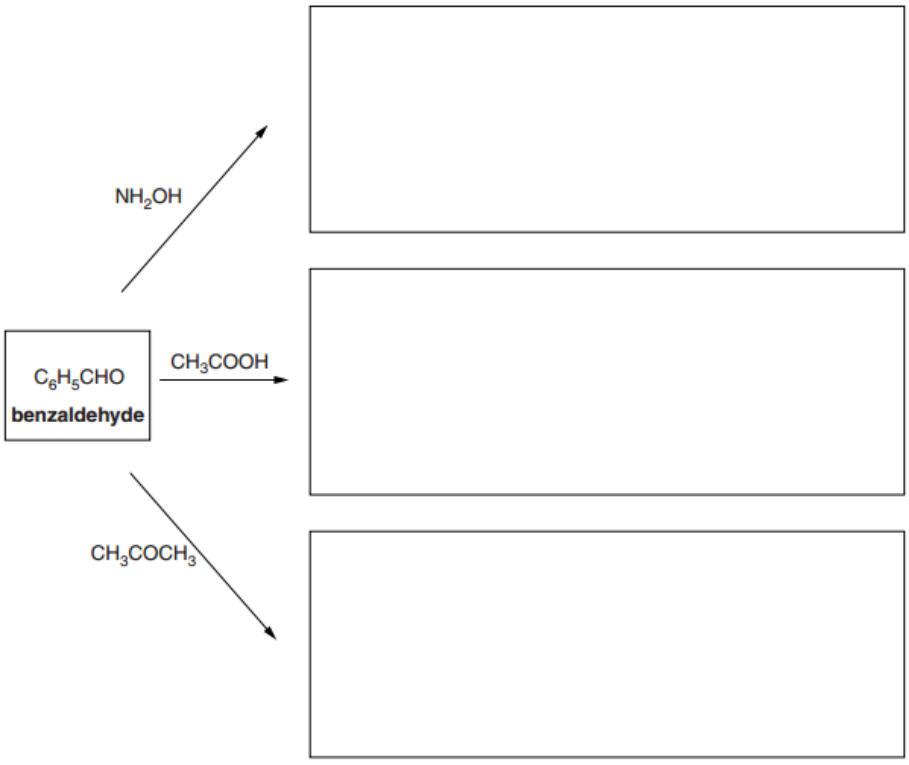
(c) The aldehyde group takes part in 'condensation' reactions with many compounds containing
an amine group or a methyl group adjacent to a C=O.

In these reactions, water is formed as a product. Two examples are shown below



Predict the organic products formed in the following condensation reactions of benzaldehyde.
In each reaction, an excess of benzaldehyde is used.

Draw the structure of each organic product in the boxes.



[3]

(d) Alkyllithium compounds, RLi, can be used to increase the number of carbon atoms in an organic compound. Different alkyl groups, R, add carbon chains with different chain lengths.

RLi provides a source of R^- ions, which act as a nucleophile.

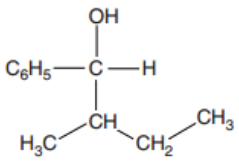
(i) The diagram below shows an incomplete mechanism for the reaction of RLi with benzaldehyde, followed by reaction with aqueous acid.

- Complete, using curly arrows and relevant dipoles, the mechanism for **stage 1**.

- Give the structure of the intermediate and the organic product.

[4]

(ii) A chemist needs to prepare the organic compound below from benzaldehyde.



Draw the structure of the alkyllithium compound needed for this synthesis.

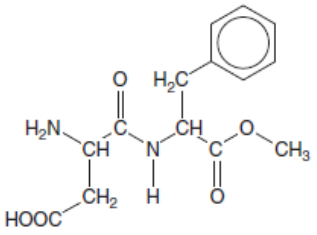
[1]

[Total: 17]

Question: 11

The addition of sucrose, table sugar, to food and drink has been linked to the increased risk of obesity and insulin resistance. Aspartame is used as an alternative to sugar.

The structure of aspartame is shown below.



aspartame

(a) Aspartame contains five functional groups including the benzene ring, and has two chiral carbon atoms.

(i) Circle the **two** chiral carbon atoms on the structure above.

[1]

(ii) Name the **four** functional groups, other than the benzene ring, in aspartame.

_____

_____

_____

_____

_____

[2]

(b) Aspartame consumed in food or drink might be hydrolysed by the acid in the stomach. This acid consists mainly of hydrochloric acid.

Draw the structures of the **three** organic products formed by the **complete** acid hydrolysis of aspartame.

[4]

(c) Some artificial sweeteners commonly available many years ago have now been withdrawn from use.

Suggest why.

_____

_____

_____

_____

_____

[1]

[Total: 8]

Question: 12

Benzene is an important industrial chemical and is used in a wide range of manufacturing processes. Over time our understanding of the structure and bonding of benzene has changed and various models have been proposed.

(a) In 1865, Kekulé proposed a model for the structure and bonding of benzene, but there is considerable evidence to suggest that Kekulé's model may not be correct. Scientists have proposed alternative models for the structure and bonding of benzene.

Explain the evidence that led scientists to doubt the model proposed by Kekulé.

_____

_____

_____

_____

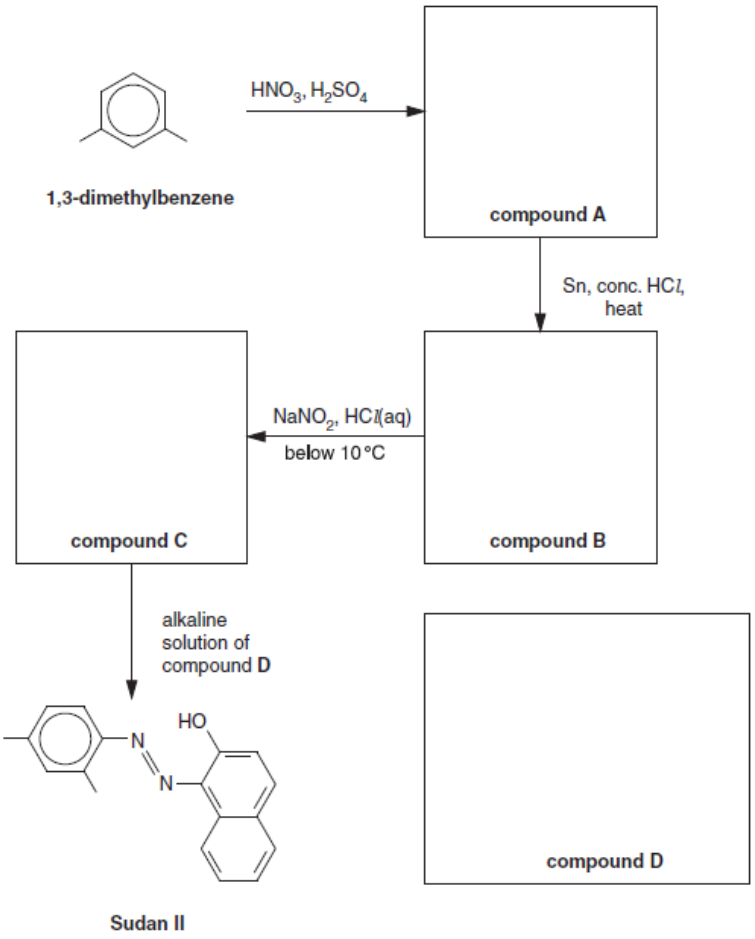
_____

[3]

(b) Sudan II is an azo dye which was used as a colourant in chilli powder. However, scientists advised the Food Standards Agency that Sudan II was linked to an increased risk of cancer and it is now no longer used as a food colourant.

The flowchart below shows how Sudan II could be prepared in the laboratory from 1,3-dimethylbenzene.

(i) Draw the structures of the organic compounds **A, B, C** and **D** in the boxes below.
Display the functional group in compound **C**.



[4]

(ii) Compound **A** is formed by reacting 1,3-dimethylbenzene with HNO_3 and H_2SO_4.

Explain, with the aid of curly arrows, the mechanism for the formation of compound **A**.

Your answer should clearly show the role of H_2SO_4 as a catalyst.

[5]

(iii) Deduce how many **other** structural isomers of compound **A** could have been formed from the mononitration of 1,3-dimethylbenzene.

_____

_____

_____

_____

_____

[1]

[Total: 13]

Question: 13

A student was researching the development of polymers and discovered three polyesters, PET, PEN and PGA, that are used in the manufacture of plastic bottles.

(a) The student discovered that the first polyester developed was Terylene which is also known as poly(ethylene terephthalate) or PET.
PET can be made by reacting benzene-1,4-dicarboxylic acid with ethane-1,2-diol.

(i) Draw the **displayed** formula of the repeat unit in PET.

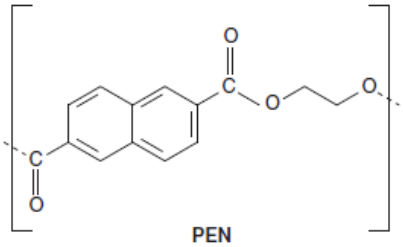
[2]

(ii) The industrial manufacture of PET involves two main stages. The first stage, known as 'pre-polymerisation', forms compound **F** with molecular formula $C_{12}H_{14}O_6$.

Draw the structure of compound **F**.

[1]

(b) PEN is a new kind of polyester. PEN is rigid at high temperature whereas PET readily softens.
The repeat unit of PEN is shown below.



PEN

(i) What is the empirical formula of the repeat unit in PEN?

_____

_____

_____

_____

_____

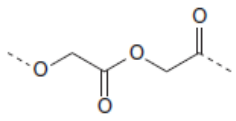
[1]

(ii) Draw the structures of two monomers that could be used to make PEN.

[2]

(c) Polyglycolic acid, PGA, is a polymer that is being developed as an inner coating for PET bottles.

A short section of PGA is shown below.



PGA

(i) Compared with other synthetic polymers, PGA can be easily hydrolysed.

Draw the skeletal formula of the organic product formed from the complete hydrolysis of PGA by NaOH(aq).

[2]

(ii) Explain why scientists now think that polymers such as PGA are better for the environment than hydrocarbon-based polymers.

In your answer, you should use appropriate technical terms, spelt correctly.

_____

_____

_____

_____

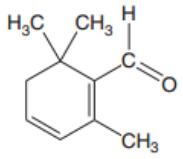
_____

[1]

[Total: 9]

Question: 14

Safranal, shown below, is an aldehyde which contributes to the aroma of saffron.



safranal

An undergraduate chemist investigated some reactions of safranal.

(a) She prepared a solution of Tollens' reagent and added a few drops of safranal. She then warmed the mixture for about 5 minutes in a water bath.

Describe what you would expect the chemist to see.

State the type of reaction that the safranal undergoes.

Draw the structure of the organic product formed in this reaction.

_____

_____

_____

_____

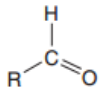
_____

[3]

(b) The chemist then reduced safranal using an aqueous solution of $NaBH_4$.

Outline the mechanism for this reaction.

Use curly arrows and show any relevant dipoles.



can be used to represent safranal.

(c) Suggest one reaction of safranal that does **not** involve the aldehyde group.

State the reagent, observation (if any) and draw the organic product.
reagent .....

observation .....

organic product

[3]

[Total: 10]

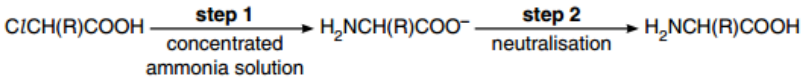
Question: 15

Read the passage below and answer the questions that follow.

α-Amino acids can be synthesised in the laboratory by the two synthetic routes below.

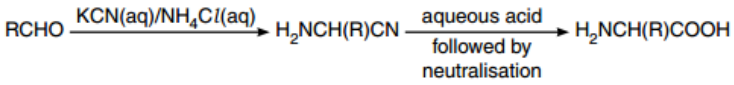
Synthesis 1

An α-chlorocarboxylic acid is reacted with an excess of concentrated ammonia solution. The resulting solution is neutralised to produce an α-amino acid.



Synthesis 2

An aldehyde is reacted with an aqueous solution of potassium cyanide and ammonium chloride. The resulting product is hydrolysed with aqueous acid and then neutralised to produce an α-amino acid.



(a) A chemist attempted the synthesis of the α-amino acid alanine (where R is CH_3) using **synthesis 1**.

(i) Write the equation for the reaction of $ClCH(CH_3)COOH$ with excess concentrated ammonia solution, $NH_3(aq)$, in **step 1** of **synthesis 1**.

_____

_____

_____

_____

_____

[1]

(ii) A disadvantage of **synthesis 1** is that the α-amino acid can react further. For example, in the synthesis of alanine, an impurity with molecular formula $C_6H_{11}NO_4$ is also formed.

Draw the structure of this impurity.

_____

_____

_____

_____

_____

[1]

(b) A chemist attempted the synthesis of the α-amino acid aspartic acid (where R is CH_2COOH)

using **synthesis 2**.

(i) Draw the **skeletal** formula of the organic compound that could be used to synthesise
aspartic acid using **synthesis 2**.

[1]

(ii) Draw **3D** diagrams of the optical isomers of aspartic acid.

[2]

(c) Many pharmaceuticals also have a chiral centre.

Discuss two possible **disadvantages** of producing a chiral drug as a mixture of

stereoisomers.

State **two** ways in which a single optical isomer might be synthesised.

_____

_____

_____

_____

_____

[4]

[Total: 9]

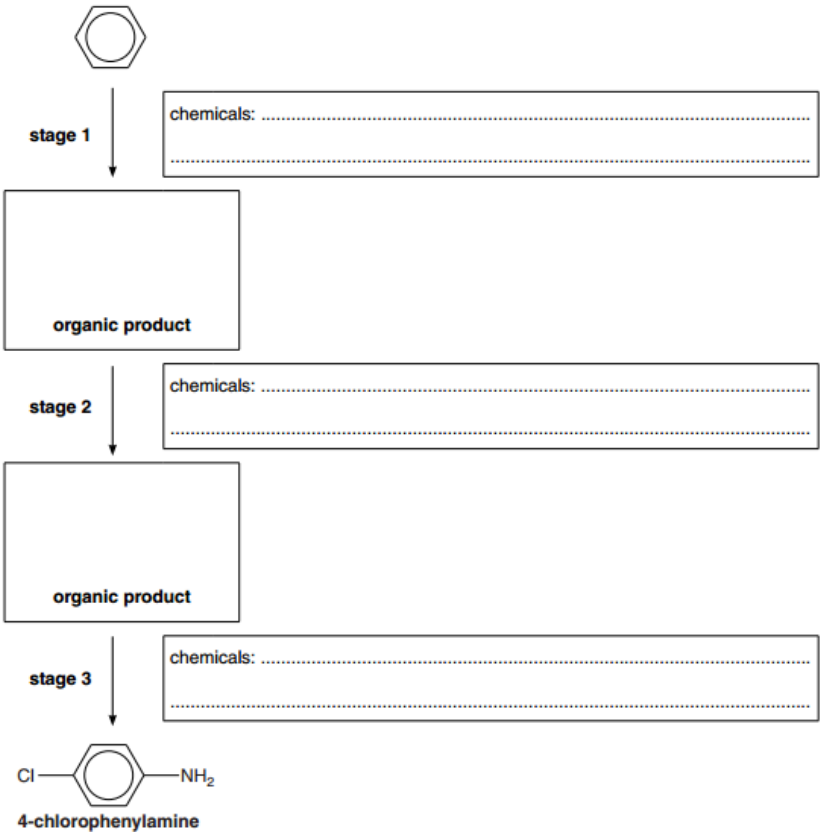
Question: 16

Benzene is an important starting material in the production of dyes, detergents and medicines.

(a) Aromatic amines, such as 4-chlorophenylamine, are intermediates in the manufacture of azo
dyes.

(i) Benzene can be converted into 4-chlorophenylamine in the three stages shown below.

In the boxes
- show the structures of the organic products
- state the chemicals used.



[5]

(ii) 4-Chlorophenylamine can be converted into a diazonium ion.
The diazonium ion can then be reacted with phenol in aqueous alkali to form an azo dye.

Draw the structures of the diazonium ion and the azo dye.

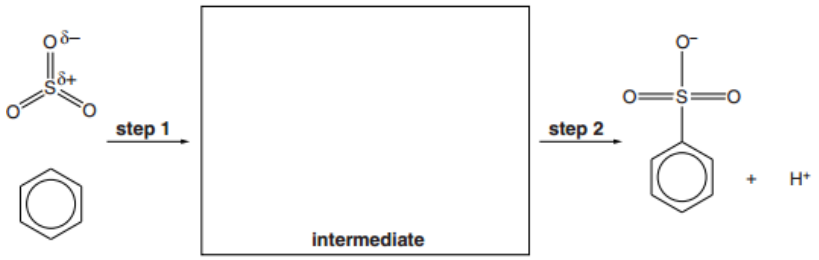
diazonium ion	azo dye

[2]

(b) Benzene can be converted into benzenesulfonic acid, $C_6H_5SO_3H$, which is used in the manufacture of many detergents.

The reaction between benzene and sulfuric acid is an electrophilic substitution reaction.
Sulfur trioxide, SO_3, is the electrophile.

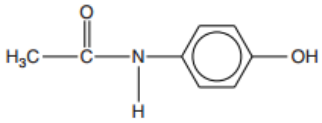
Part of the mechanism for this reaction is shown below.



Complete the mechanism by drawing the intermediate and by adding curly arrows to show
the movement of electron pairs in **steps 1** and **2**.

[4]

(c) The painkiller paracetamol has the structure shown below.



(i) Separate samples of paracetamol are reacted with bromine, Br_2, and with sodium, Na.
Draw the structures of possible organic products formed in each reaction.

reaction with Br_2	reaction with Na

[2]

(ii) Another sample of paracetamol is hydrolysed by heating under reflux with hot aqueous
sodium hydroxide, NaOH(aq).

Draw the structures of the two organic products formed in this hydrolysis.

[2]

[Total: 15]

Offline

Question: 17

Mandelic acid (2-phenyl-2-hydroxyethanoic acid), $C_6H_5CH(OH)COOH$, is used in some skin creams and can be converted into a condensation polymer.

The addition polymer of ethyl methacrylate (ethyl 2-methyl-2-propenoate), $CH_2C(CH_3)COOC_2H_5$, is used to make some artificial fingernails.

(a) Explain what is meant by the term *condensation polymerisation*.

Your answer should use appropriate technical terms, spelled correctly.

(b) Draw two repeat units of a polymer that is formed when,

(i) mandelic acid, $C_6H_5CH(OH)COOH$, polymerises

[2]

(ii) ethyl methacrylate, $CH_2C(CH_3)COOC_2H_5$, polymerises.

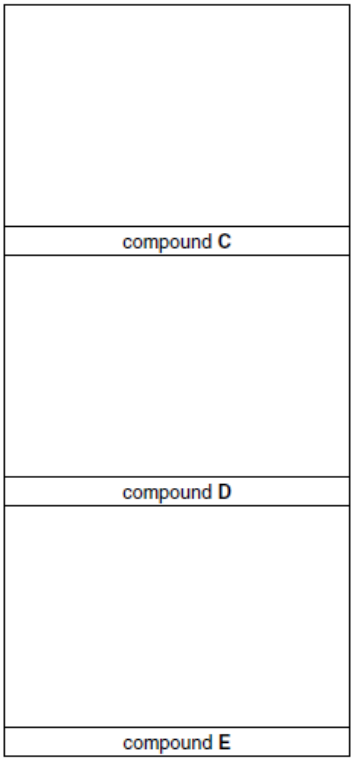
[1]

(c) When ethyl methacrylate, $CH_2C(CH_3)COOC_2H_5$, is heated under reflux with aqueous dilute acid, a hydrolysis reaction takes place forming compound **C** and ethanol.

When compound **C** is heated with steam in the presence of an acid catalyst, an addition reaction takes place forming two organic products **D** and **E**.

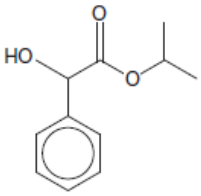
Compounds **D** and **E** are structural isomers with the molecular formula $C_4H_8O_3$.

Draw the structures of compounds **C, D** and **E.**

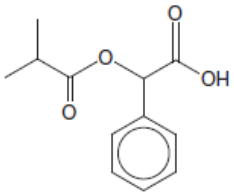


[3]

(d) Mandelic acid has anti-bacterial properties and is used in some skin creams. A cosmetic chemist used mandelic acid to prepare two different esters that might be suitable for new skin creams. The structures of the two esters are shown below.



ester 1



ester 2

(i) Draw the structure of an organic compound that could react with mandelic acid, $C_6H_5CH(OH)COOH$, to produce **ester 1**.

[1]

(ii) Identify an organic compound that could react with mandelic acid to produce **ester 2.**

[1]

(iii) Ester 1 is less soluble in water than mandelic acid, $C_6H_5CH(OH)COOH$.

Explain the difference in water solubility of mandelic acid and **ester 1.**
You may use a labelled diagram in your answer.

_____

_____

_____

_____

_____

[3]

(iv) Before any skin cream can be sold to the public, it must be tested to ensure it is safe to use.
Suggest why.

_____

_____

_____

_____

_____

[1]

[Total: 13]

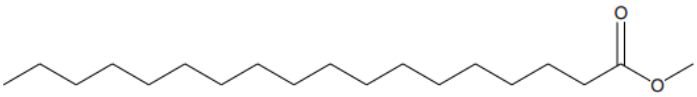
Question: 18

Fats and oils are mixtures of organic compounds. Some fats contain glycerides and steroids.

(a) Some processed foods contain *trans* oils which have been linked to health risks.

(i) The incomplete structure below shows an octadeca-12-enoate section of a *trans* oil.

- Add the double bond to the structure
- State how the *trans*-isomer is different from the *cis*-isomer.



_____

_____

_____

_____

_____

[2]

(ii) State **one** possible health risk of a diet that is high in *trans* oils.

_____

_____

_____

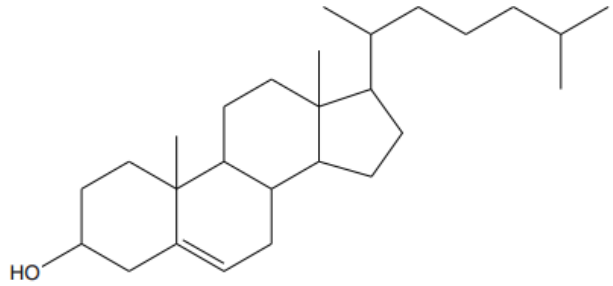
_____

_____

[1]

(b) Cholesterol is part of a family of compounds called steroids.

The structure of cholesterol is shown below.



(i) How many carbon atoms are there in a molecule of cholesterol?

_____

_____

_____

_____

_____

[1]

(ii) How many chiral centres are there in a molecule of cholesterol?

_____

_____

_____

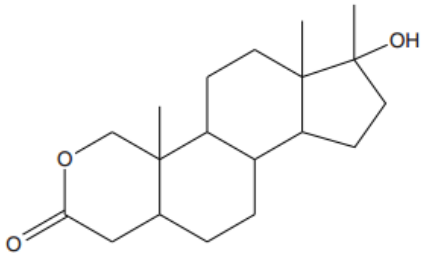
_____

_____

[1]

(c) Oxandrolone is a type of synthetic drug called an ‘anabolic steroid’, prescribed to promote
muscle growth.

The structure of oxandrolone is shown below.



(i) What are the functional groups in oxandrolone?

_____

_____

_____

_____

_____

[2]

(ii) Oxandrolone is synthesised from naturally occurring steroids.

Suggest an advantage of developing a synthetic route to oxandrolone starting from a
natural steroid.

_____

_____

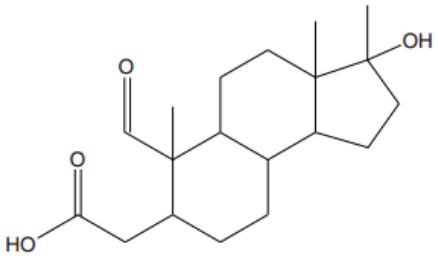
_____

_____

_____

[1]

(iii) Compound **C** below is an intermediate formed during the synthesis of oxandrolone.



compound C

Suggest a two-step synthesis of oxandrolone from compound **C**.

For each step of the synthesis,

- state the reagents and any conditions
- state the functional groups that would react and those that would form.

_____

_____

_____

_____

_____

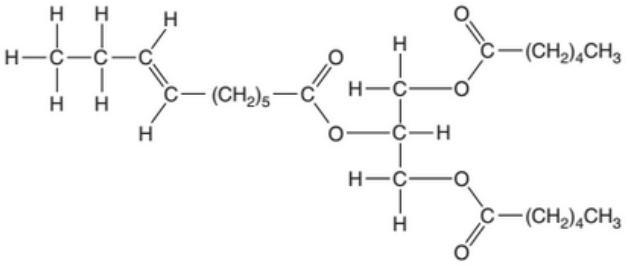
[4]

[Total: 12]

Question: 19

Triglycerides are triesters and are found in fats and oils.

The structure of a triglyceride found in some goats' milk is shown below.



(a) This triglyceride is hydrolysed with hot aqueous sodium hydroxide.

(i) Give the systematic name of the alcohol that is formed by this hydrolysis.

_____

_____

_____

_____

_____

[1]

(ii) Draw the structures of the other organic products of this hydrolysis.

[3]

(b) Suggest why people who consume a large quantity of this type of goats' milk might be more at risk of suffering from coronary heart disease.

In your answer, you should use appropriate technical terms, spelled correctly.

_____

_____

_____

_____

_____

[2]

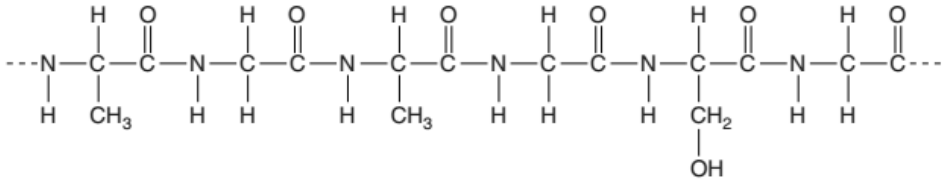
[Total: 6]

Question: 20

Many modern textiles are created using a mixture of natural and synthetic polymers.

(a) Silk is a natural fibre. It is made up of two main proteins, fibroin and sericin.

A section of a **fibroin** strand is shown below.



(i) Proteins are natural condensation polymers.

State what is meant by a *condensation polymer*.

_____

_____

_____

_____

_____

[1]

(ii) A student hydrolysed a sample of fibroin protein. She analysed the amino acids that A student hydrolysed a sample of fibroin protein. She analysed the amino acids that were formed from the hydrolysis. She found that fibroin contained the amino acid glycine, H_2NCH_2COOH.

Draw the structures of the **two** other amino acids that make up the section of fibroin shown in the diagram above.

[2]

(iii) The isoelectric point of glycine is 5.8.

Define the term isoelectric point and draw the structure of glycine at its isoelectric point.

isoelectric point

[2]

(b) The student then hydrolysed a section of sericin protein. She analysed the amino acids formed using Thin-Layer Chromatography (TLC).

(i) Name the process by which TLC separates amino acids.

_____

_____

_____

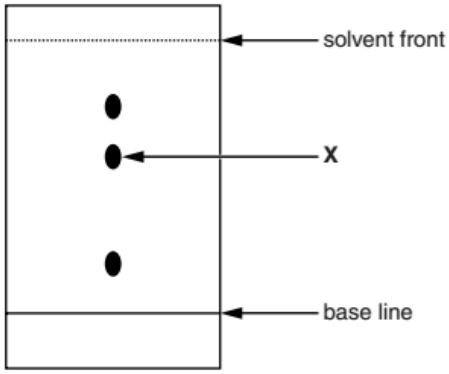
_____

_____

[1]

(ii) The chromatogram the student obtained, and a table of R_f values for amino acids, are shown below.

Estimate the R_f value for the amino acid found at **X**. Hence identify the amino acid found at **X.**



Amino acid	R_f value
alanine	0.38
aspartic acid	0.15
glycine	0.26
leucine	0.75
methionine	0.58
threonine	0.35

_____

_____

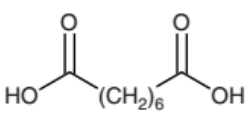
_____

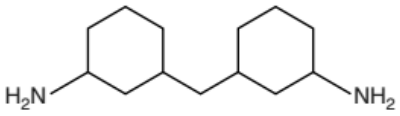
_____

_____

[2]

(c) *Quiana* is a synthetic polymer that can be spun into a soft, silky fabric.
The monomers used to make *Quiana* are shown below.

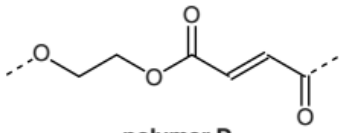




Draw the repeat unit of the polymer formed from these two monomers.

[2]

(d) Polymer **D** has been developed by the textile industry. The repeat unit of polymer **D** is shown below.

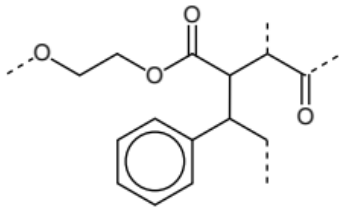


polymer D

(i) Polymer **D** is a condensation polymer.
Draw the structure of each of the monomers that make up polymer **D**.

[2]

(ii) Polymer **D** reacts with a third monomer to form an addition polymer. The repeat unit of this polymer is shown below.



addition polymer

Draw the structure of the third monomer.

[1]

[Total: 13]

Question: 21

'Methylglyoxal', CH_3COCHO, is formed in the body during metabolism.

Describe **one** reduction reaction and **one** oxidation reaction of methylglyoxal that could be carried out in the laboratory..

Your answer should include reagents, equations and observations, if any.

_____

_____

_____

_____

_____

[5]

[Total: 5]

Resource assets
Question(s): 1 2 4 5 6 9 10 11 16 20

General Information

- 1 mol of gas molecules occupies 24.0 dm^3 at room temperature and pressure, RTP.
- Avogadro constant, $N_A = 6.02 \times 10^{23}\ mol^{-1}$.
- Ionic product of water, $K_w = 1.00 \times 10^{-14}\ mol^2\ dm^{-6}$.

Characteristic infrared absorptions in organic molecules

bond	location	wavenumber/cm^{-1}
C—O	alcohols, esters, carboxylic acids	1000–1300
C=O	aldehydes, ketones, carboxylic acids, esters, amides	1640–1750
C—H	organic compound with a C—H bond	2850–3100
O—H	carboxylic acids	2500–3300 (very broad)
N—H	amines, amides	3200–3500
O—H	alcohols, phenols	3200–3550 (broad)

Resource assets
Question(s): 1 2 4 5 6 9 10 11 16 20

Data Sheet for Chemistry A

(version 2.0)

GCE Advanced Level and Advanced Subsidiary

Chemistry A (H034, H434)

Chemistry A units F321–F326

The information in this sheet is for the use of candidates following Chemistry A (H034 and H434).

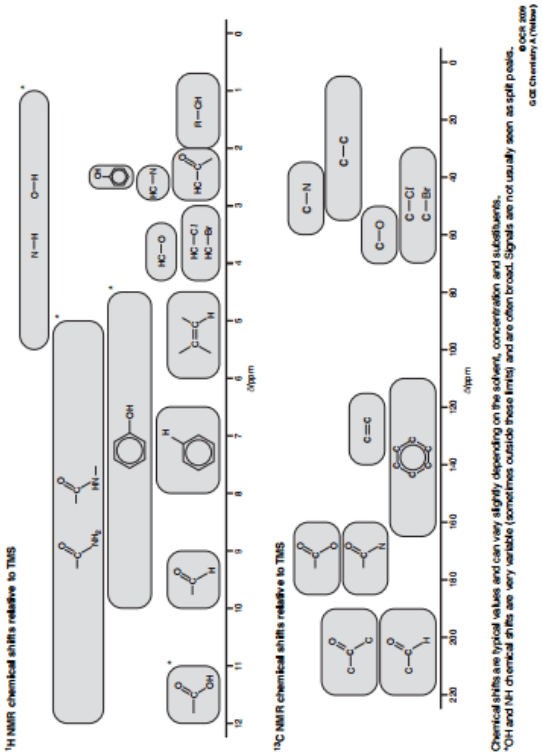
Clean copies of this sheet must be issued to candidates in the examination room, and must be given up to the invigilator at the end of the examination.

Copies of this sheet may be used for teaching.

DC (SLM/SW) 15341/2

Resource assets

Question(s): 1 2 4 5 6 9 10 11 16 20



Resource assets

Question(s): 1 2 4 5 6 9 10 11 16 20

Resource assets
Question(s): 7 8 12 13 15 17 18 19 21
resource asset

Resource assets
Question(s): 7 8 12 13 15 17 18 19
resource asset

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