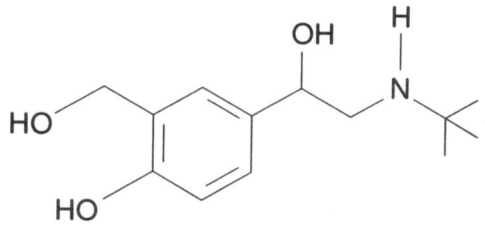
(4) June 2010

5 Hydroxyamines are organic compounds containing hydroxyl and amino functional groups.

(a) Salbutamol is a hydoxyamine used in the treatment of asthma and bronchitis. Salbutamol is an example of a chiral drug.

(i) Draw a circle around the chiral carbon in the structure of salbutamol shown below.



salbutamol

[1]

(ii) Suggest possible problems of making a chiral drug such as salbutamol and describe **two** ways that the pharmaceutical industry might overcome these problems.

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..... **[4]**

June 2020

2 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]

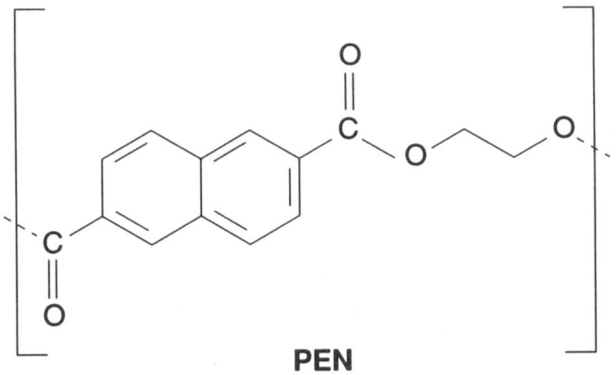
(ii) The industrial manufacture of PET involves two main stages. The first stage, known as 'pre-polymerisation', forms compound **F** with molecular formula $C_{12}H_{14}O_6$.

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?

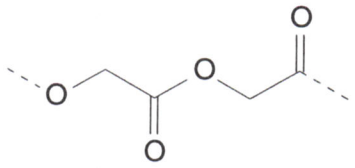
..... **[1]**

(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.

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..... [1]

[Total: 9]

4 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.

$$ClCH(R)COOH \xrightarrow[\text{concentrated ammonia solution}]{\textbf{step 1}} H_2NCH(R)COO^- \xrightarrow[\text{neutralisation}]{\textbf{step 2}} H_2NCH(R)COOH$$

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.

$$RCHO \xrightarrow{KCN(aq)/NH_4Cl(aq)} H_2NCH(R)CN \xrightarrow[\text{followed by neutralisation}]{\text{aqueous acid}} H_2NCH(R)COOH$$

(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.

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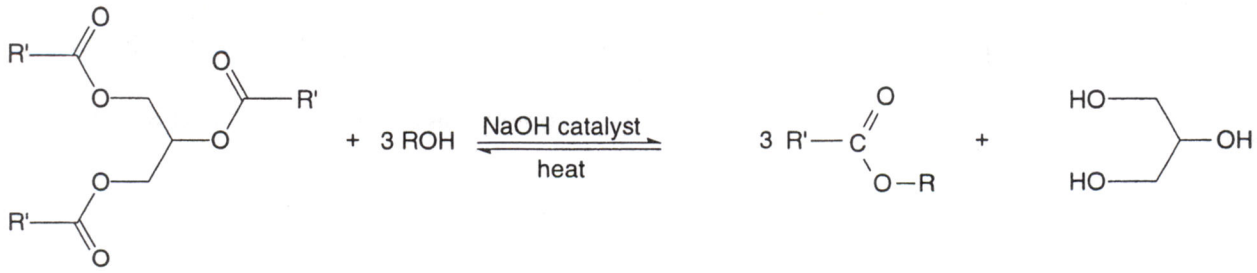
..... **[4]**

[Total: 9]

Jan 2011

2 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.

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.....[1]

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

Suggest why the alcohol has to be in excess.

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.....[1]

3 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.

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..... **[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.

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..... **[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	$(CH_2)_2COOH$

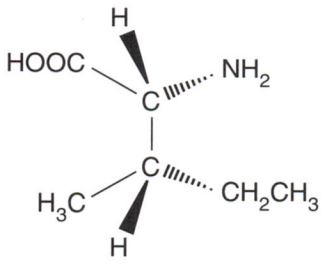
Table 1

(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]