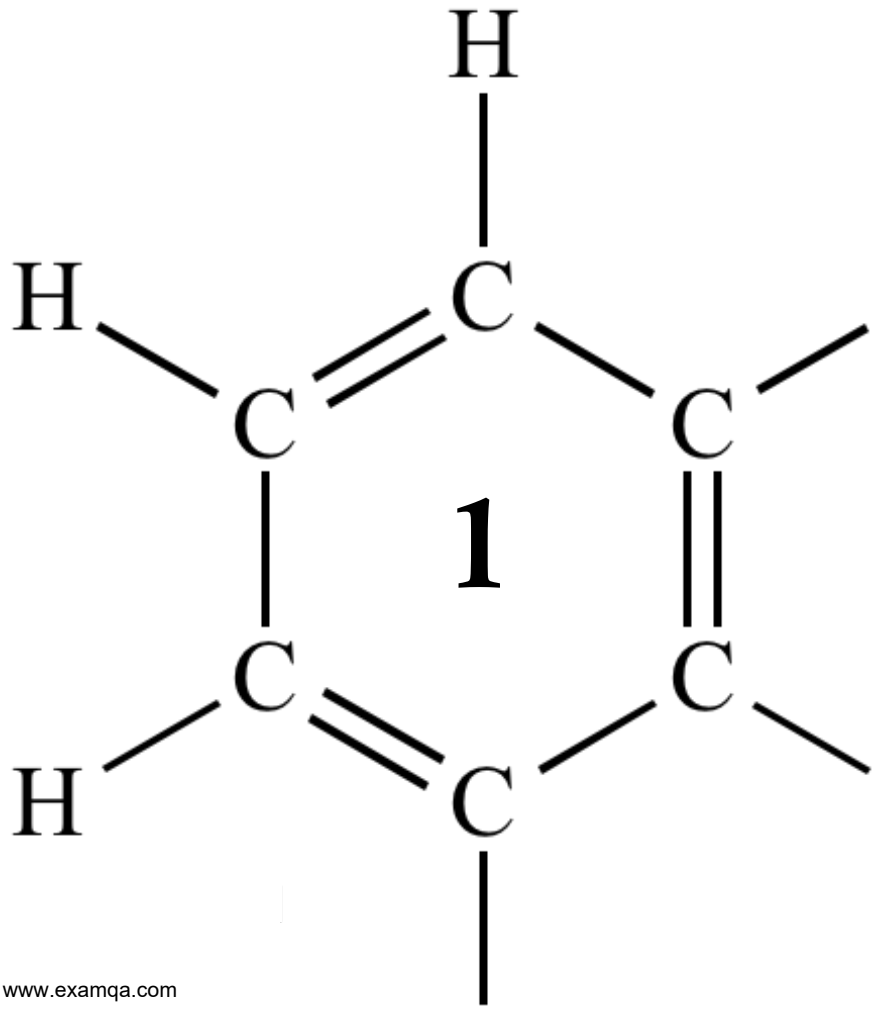
LONDON SCIENCE COLLEGE

AQA A2 CHEMISTRY

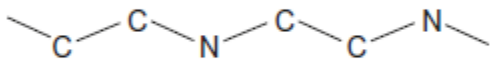
PROTEINS ~ DNA



1 Proteins contain sequences of amino acids joined by peptide links.
Amino acid chains (polypeptides) are attracted to each other by hydrogen bonding.

(a) (i) A section of a protein is formed from one molecule of each of the amino acids glycine (H_2NCH_2COOH) and alanine ($H_2NCH(CH_3)COOH$).

Add bonds and atoms to the diagram to complete a structural formula for this section of the protein.

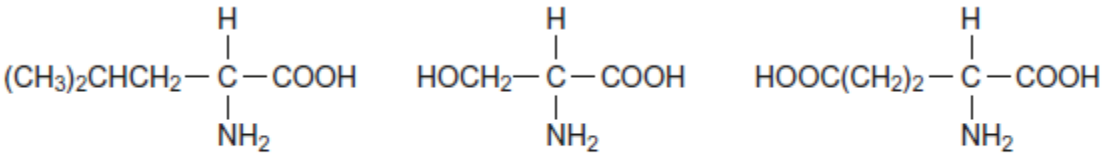


(2)

(ii) Draw a diagram to show how an amino acid chain can form a hydrogen bond with another amino acid chain.
Your diagram need only show the relevant atoms from one amino acid in each chain.

(1)

(b) Leucine, serine and glutamic acid are naturally-occurring amino acids.



leucine serine glutamic acid

(i) Give the IUPAC name of leucine.

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(1)

(ii) Draw the structure of the zwitterion of serine.

(1)

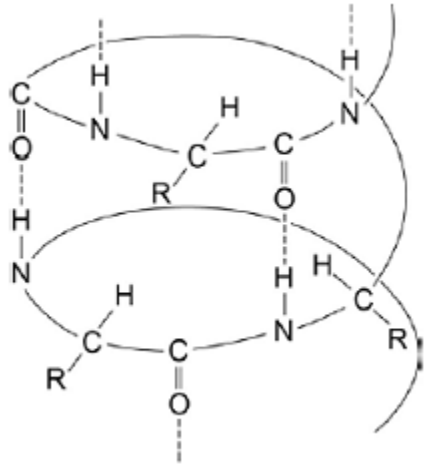
(iii) Draw the structure of the ester formed by two molecules of serine.

(1)

(iv) Draw the structure of the species formed by glutamic acid at low pH.

(1)
(Total 7 marks)

2 The following figure shows a simplified representation of the arrangement of some amino acids in a portion of a protein structure in the form of an α-helix.



(a) Name the type of protein structure in the figure.

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(1)

(b) Explain the origin of the interaction represented by the dotted lines in the figure above.

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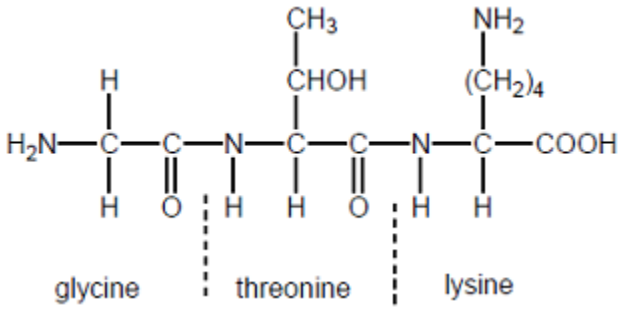
(4)
(Total 5 marks)

3 The tripeptide shown in the following figure is formed from the amino acids glycine, threonine and lysine.



(a) Draw a separate circle around **each** of the asymmetric carbon atoms in the tripeptide in the figure.

(1)

(b) Draw the zwitterion of glycine.

(1)

(c) Draw the structure of the species formed when glycine reacts with an excess of bromomethane.

(1)

(d) Deduce the IUPAC name of threonine.

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(1)

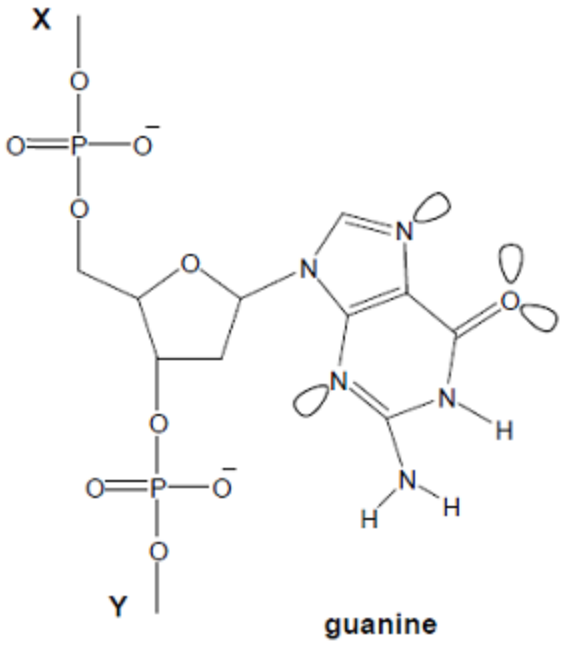
(e) Draw the structure of the species formed by lysine at low pH.

(1)
(Total 5 marks)

4 The anticancer drug cisplatin operates by reacting with the guanine in DNA.

Figure 1 shows a small part of a single strand of DNA. Some lone pairs are shown.

Figure 1



guanine

(a) The DNA chain continues with bonds at **X** and **Y**.

State the name of the sugar molecule that is attached to the bond at **X**.

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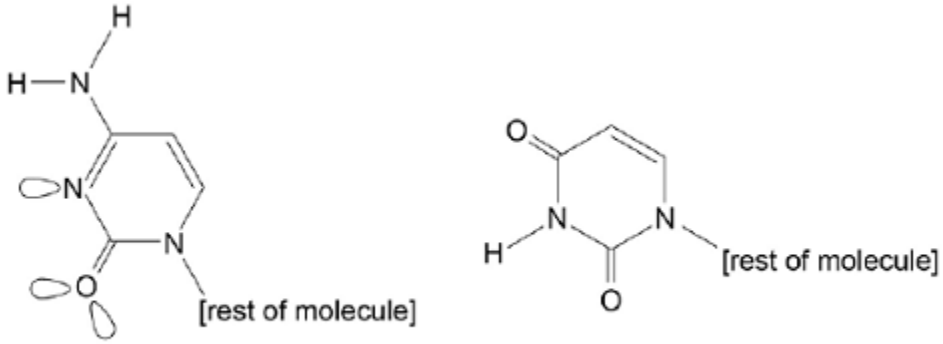
(1)

(b) Messenger RNA is synthesised in cells in order to transfer information from DNA. The bases in one strand of DNA pair up with the bases used to synthesise RNA.

Figure 2 shows two bases used in RNA.

Figure 2



Base A **Base B**

Suggest which of the bases **A** and **B** forms a pair with guanine in **Figure 1** when messenger RNA is synthesised.
Explain how the base that you have chosen forms a base pair with guanine.

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(4)

(c) Cisplatin works because one of the atoms on guanine can form a co-ordinate bond with platinum, replacing one of the ammonia or chloride ligands. Another atom on another guanine can also form a co-ordinate bond with the same platinum by replacing another ligand.

On **Figure 1**, draw a ring round an atom in guanine that is likely to bond to platinum.

(1)

(d) An adverse effect of cisplatin is that it also prevents normal healthy cells from replicating.

Suggest **one** way in which cisplatin can be administered so that this side effect is minimised.

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(1)
(Total 7 marks)

5 A peptide is hydrolysed to form a solution containing a mixture of amino acids. This mixture is then analysed by silica gel thin-layer chromatography (TLC) using a toxic solvent. The individual amino acids are identified from their R_f values.

Part of the practical procedure is given below.

1. **Wearing plastic gloves to hold a TLC plate**, draw a pencil line 1.5 cm from the bottom of the plate.
2. Use a capillary tube to apply a very small drop of the solution of amino acids to the mid-point of the pencil line.
3. Allow the spot to dry completely.
4. In the developing tank, add the developing solvent to **a depth of not more than 1 cm**.
5. Place your TLC plate in the developing tank.
6. Allow the developing solvent to rise up the plate **to the top**.
7. Remove the plate and quickly mark the position of the solvent front with a pencil.
8. Allow the plate to dry **in a fume cupboard**.

(a) Parts of the procedure are in bold text.

For each of these parts, consider whether it is essential and justify your answer.

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(4)

(b) Outline the steps needed to locate the positions of the amino acids on the TLC plate and to determine their R_f values.

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(4)

(c) Explain why different amino acids have different R_f values.

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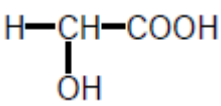
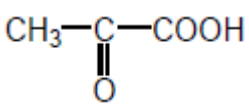
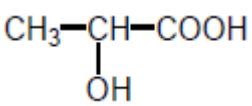
(2)
(Total 10 marks)

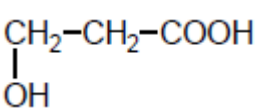
6 A drug is designed to simulate one of the following molecules that adsorbs onto the active site of an enzyme.

Which molecule requires the design of an optically active drug?

A  ⬭

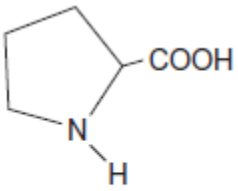
B  ⬭

C  ⬭

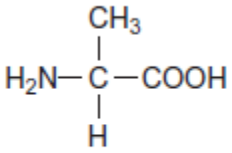
D  ⬭

(Total 1 mark)

7 (a) The structures and common names of two amino acids are shown.



proline



alanine

(i) Draw the structure of the zwitterion of proline.

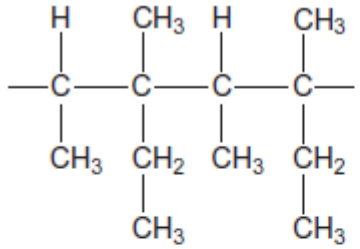
(1)

(ii) Draw the structure of the tripeptide formed when a proline molecule bonds to two alanine molecules, one on each side.

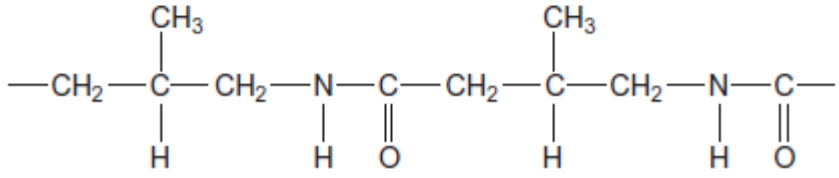
(2)

(b) Sections of two polymers, **L** and **M**, are shown.

L



M



(i) Give the IUPAC name of a monomer that forms polymer **L**.

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(1)

(ii) Give the IUPAC name of the monomer that forms polymer **M**.

.....

(1)

(iii) Draw the section of a polymer made from a dicarboxylic acid and a diamine that is isomeric with the section of polymer **M** shown.

(1)

(vi) Explain why polymer **L** is non-biodegradable.

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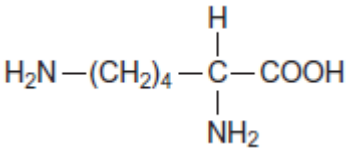
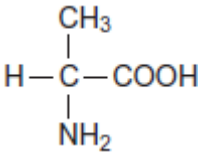
(1)
(Total 7 marks)

8 Lysine and alanine are two amino acids.



lysine



alanine

(a) Give the IUPAC name of lysine.

.....

(1)

(b) Draw structures to show the product formed in each case when lysine reacts with

(i) an excess of aqueous HCl

(1)

(ii) an excess of aqueous NaOH

(1)

(iii) methanol in the presence of a small amount of concentrated H_2SO_4

(1)

(c) The mass spectrum of alanine gives a major peak at $m / z = 44$

Write an equation for the fragmentation of the molecular ion of alanine to give an ion that produces this peak.
In your answer, draw the displayed formula for this fragment ion.

(2)

(d) Draw a dipeptide formed from one molecule of lysine and one molecule of alanine.

(1)

(e) The dipeptide in part (d) is hydrolysed in acid conditions and the mixture produced is analysed by column chromatography. The column is packed with a resin which acts as a polar stationary phase.

Suggest why lysine leaves the column after alanine.

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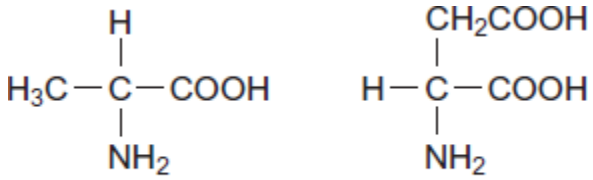
(2)
(Total 9 marks)

9 Alanine and aspartic acid are naturally occurring amino acids.



alanine

aspartic acid

(a) Draw the structure of the zwitterion formed by alanine.

(1)

(b) Draw the structure of the compound formed when alanine reacts with methanol in the presence of a small amount of concentrated sulfuric acid.

(1)

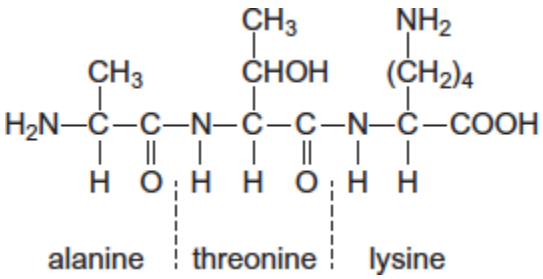
(c) Draw the structure of the species formed by aspartic acid at high pH.

(1)

(d) Draw the structure of a dipeptide formed by two aspartic acid molecules.

(1)
(Total 4 marks)

10 (a) The tripeptide shown is formed from the amino acids alanine, threonine and lysine.



(i) Draw a separate circle around **each** of the asymmetric carbon atoms in the tripeptide.

(1)

(ii) Draw the zwitterion of alanine.

(1)

(iii) Give the IUPAC name of threonine.

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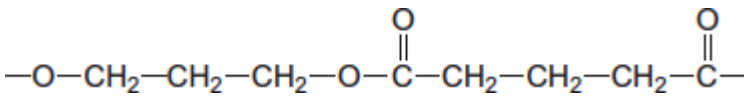
(1)

(iv) Draw the species formed by lysine at low pH.

(1)

(b) The repeating unit shown represents a polyester.



(i) Name this type of polymer.

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(1)

(ii) Give the IUPAC name for the alcohol used to prepare this polyester.

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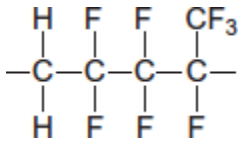
(1)

(c) The repeating unit shown represents a polyalkene co-polymer. This co-polymer is made from two different alkene monomers.



(i) Name the type of polymerisation occurring in the formation of this co-polymer.

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(1)

(ii) Draw the structure of each alkene monomer.

Alkene monomer 1 Alkene monomer 2

(2)

(d) One of the three compounds shown in parts (a), (b) and (c) cannot be broken down by hydrolysis.

Write the letter **(a)**, **(b)** or **(c)** to identify this compound and explain why hydrolysis of this compound does **not** occur.

Compound .....

Explanation .....

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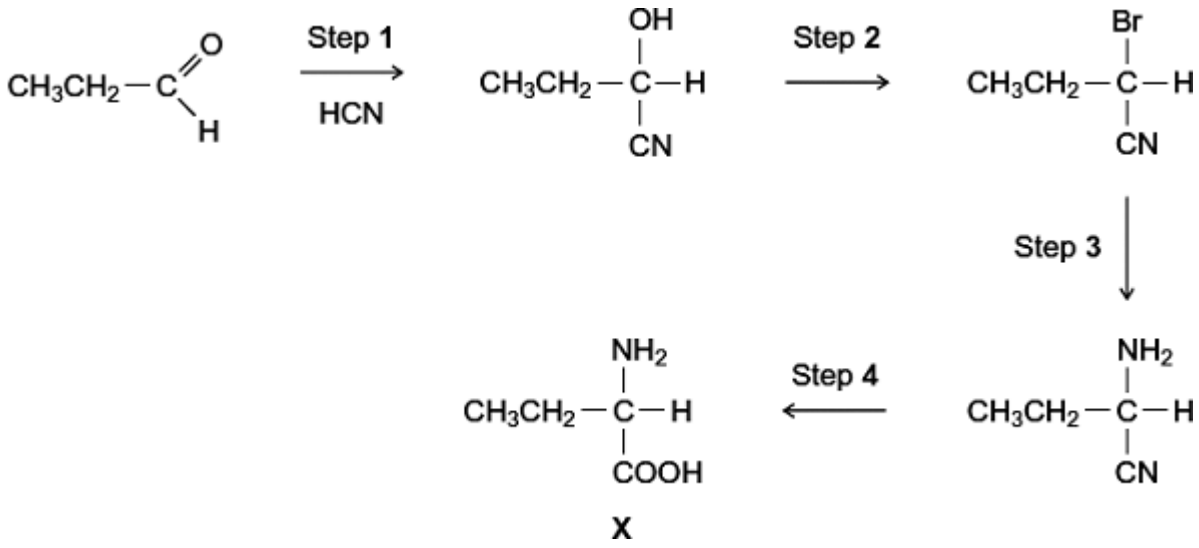
(2)
(Total 11 marks)

11 A possible synthesis of the amino acid **X** is shown below.



X

(a) Name and outline a mechanism for Step **1**.

Name of mechanism .....

Mechanism

(5)

(b) Give the IUPAC name of the product of Step **2**.

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(1)

(c) For Step **3**, give the reagent, give a necessary condition and name the mechanism.

Reagent .....

Condition .....

Name of mechanism .....

(3)

(d) At room temperature, the amino acid **X** exists as a solid.

(i) Draw the structure of the species present in the solid amino acid.

(1)

(ii) With reference to your answer to part (d)(i), explain why the melting point of the amino acid **X** is higher than the melting point of $CH_3CH_2CH(OH)COOH$.

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(Extra space) .....

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(2)

(e) There are many structural isomers of **X**, $CH_3CH_2CH(NH_2)COOH$.

(i) Draw a structural isomer of **X** that is an ethyl ester.

(1)

(ii) Draw a structural isomer of **X** that is an amide and also a tertiary alcohol.

(1)

(iii) Draw a structural isomer of **X** that has an unbranched carbon chain and can be polymerised to form a polyamide.

(1)

(f) Draw the structure of the tertiary amine formed when **X** reacts with bromomethane.

(1)
(Total 16 marks)