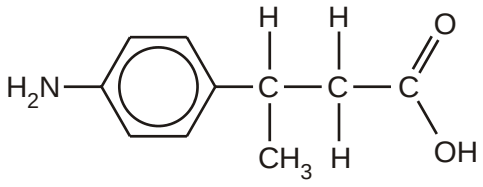
Nitrogen Compounds – Exam questions

1. Compound **A**, shown below, is an amino acid that is being used in the development of a new anti-inflammatory drug.



compound **A**

(a) (i) Explain why this molecule is described as an *amino acid*.

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[1]

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

Explain whether or not compound **A** fits this general formula.

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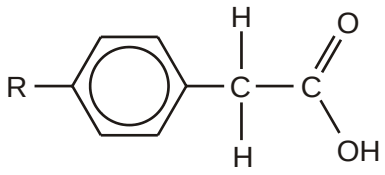
[2]

(c) The anti-inflammatory drug is made by combining compound **A** with compound **B**, shown below. R represents a side chain.



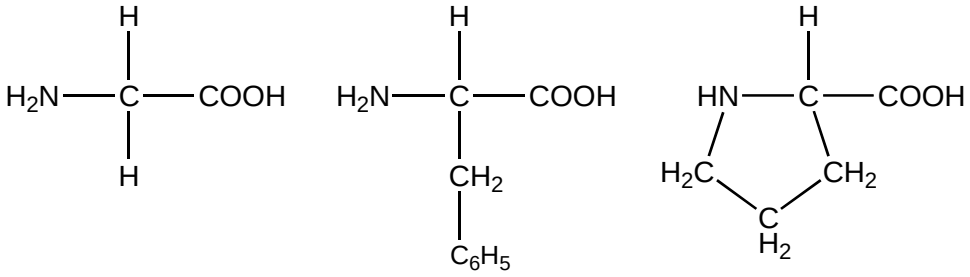
compound **B**

Show the structure of the anti-inflammatory drug formed from compound **A** and compound **B**.

[2]

[Total 7 marks]

2. Amino acids can act as monomers in the formation of polypeptides and proteins. The structures below show three amino acids, glycine, phenylalanine and proline.



glycine **phenylalanine** **proline**

Glycine, phenylalanine and proline can react together to form a mixture of tripeptides.

(i) Draw the structure of the **tri**peptide formed in the order glycine, phenylalanine and proline.

[3]

(ii) How many different **tri**petides could have been formed containing glycine, phenylalanine and proline?

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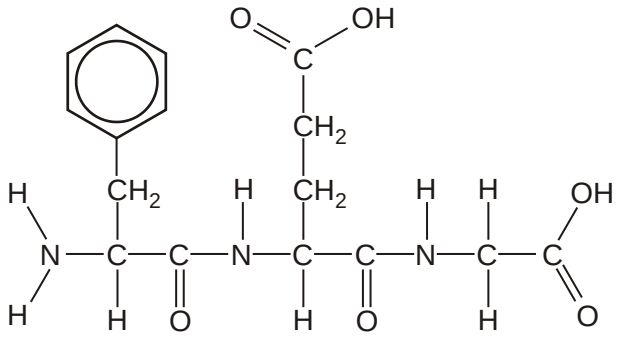
[1]

[Total 4 marks]

3. Compound **A** is currently being tested as a possible anti-allergic drug.



compound **A**

Compound **A** can be hydrolysed to form three organic products.

(i) Name a suitable reagent and conditions for the hydrolysis of compound **A**.

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[2]

(ii) The three organic products all belong to the same class of compound. State the general name for this class of organic compound.

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[1]

(iii) Draw the structure of **one** of the organic products from the hydrolysis of **A** using the reagent you have given in (a)(i) above.

[2]

(iv) Explain what is meant by the term *hydrolysis*. Use this reaction to illustrate your answer.

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[2]

[Total 7 marks]

4. In this question, one mark is available for the quality of the use and organisation of scientific terms.

In all living organisms a large variety of polypeptides and proteins are formed naturally from α-amino acids.

State the general formula of an α-amino acid and use it to describe how amino acids can be combined to give a variety of polypeptides and proteins.

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[6]

Quality of Written Communication [1]

[Total 7 marks]

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

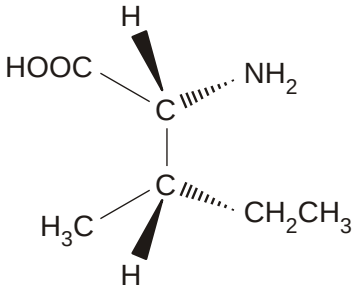
α-amino acid	**R group**
glycine	H
leucine	$CH_2CH(CH_3)_2$
isoleucine	$CH(CH_3)CH_2CH_3$
alanine	CH_3
valine	$CH(CH_3)_2$
lysine	$(CH_2)_4NH_2$
glutamic acid	$(CH_2)_2COOH$

(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.

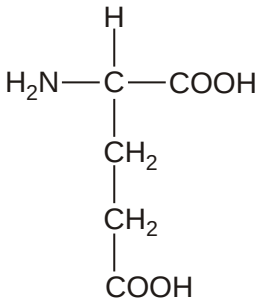


Draw 3D diagrams for the other **three** stereoisomers of isoleucine.

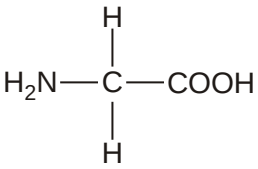
[3]

[Total 4 marks]

6. Glutamic acid and glycine are both α-amino acids that occur widely in living organisms. Their structures are shown below.



glutamic acid



glycine

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

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[1]

(ii) Explain how glutamic acid and glycine both fit the general formula given in part (i)

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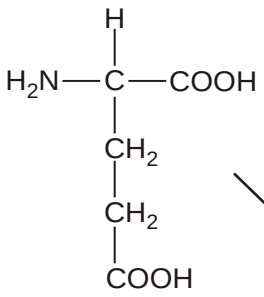
[2]

(b) Amino acids react with both acids and alkalis.

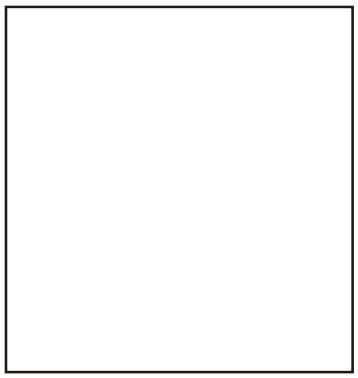
Draw structures below to show how the glutamic acid molecule is changed in the presence of excess acid and alkali.

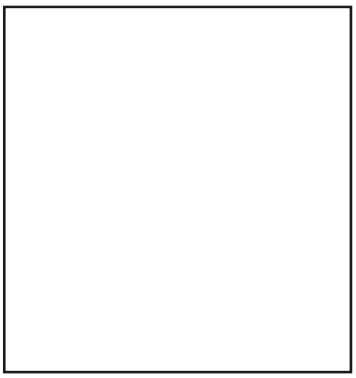


glutamic acid

excess HCl(aq)

excess NaOH(aq)





[5]

(c) In this question, one mark is available for the quality of use and organisation of scientific terms.

Glutamic acid exists as two optical isomers, but glycine does not.

Explain what structural feature causes optical isomerism in organic molecules. Include appropriate diagrams and use these two amino acids to illustrate your answer.

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[7]

Quality of Written Communication [1]

[Total 16 marks]

7. But-2-enal, $CH_3CH=CHCHO$, is a pale yellow, flammable liquid with an irritating odour.

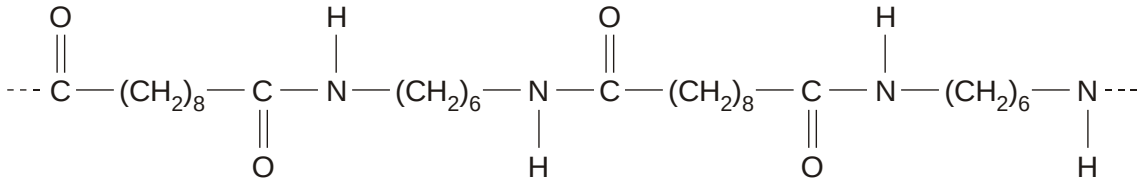
But-2-enal exists as two stereoisomers.

Draw skeletal formulae to show the structure of the two stereoisomers of but-2-enal.

[Total 2 marks]

9. 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.

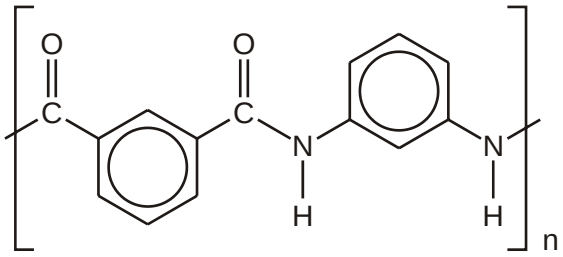


Draw the structures of **two** monomers that could be used to make this nylon.

[Total 2 marks]

10. Nylon is sometimes used for electrical insulation. However, if there is a risk of high temperatures then a polymer such as Nomex®, with a higher melting point, is used.

The repeat unit of Nomex® is shown below.



(i) Draw the structures of two monomers that could be used to form Nomex®.

[2]

(ii) Suggest a reason why the melting point of Nomex® is higher than that of nylon.

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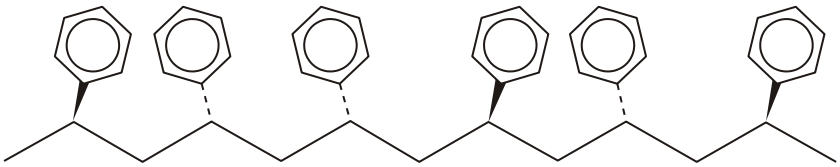
[1]

[Total 3 marks]

11. Poly(phenylethene) is one of the most versatile and successful polymers.

The 3-D skeletal formula of a section of atactic poly(phenylethene) is shown in the diagram below.



(i) State the type of polymerisation used to make poly(phenylethene).

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[1]

(ii) Draw a skeletal or displayed formula to show the monomer used to make poly(phenylethene).

[1]

(iii) Outline how the polymer is formed from the monomer molecules. (You do **not** need to give any details of the catalyst or conditions involved.)

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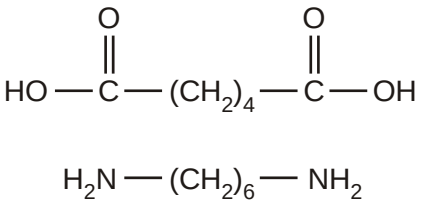
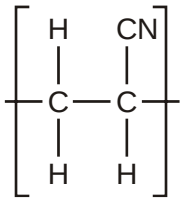
[2]

[Total 4 marks]

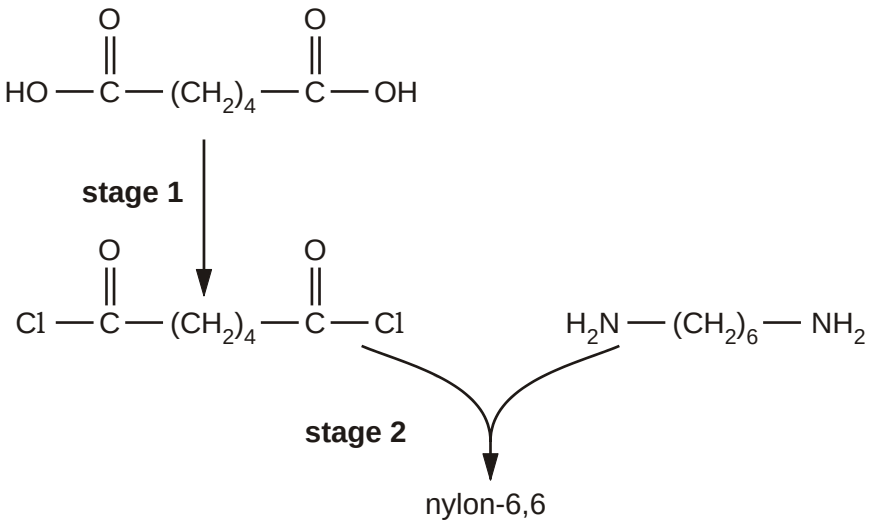
12. The fibres used in carpets are made from synthetic or natural polymers such as nylon-6,6, *Orlon*™ and wool.

(a) Complete the table below.

	nylo-6,6	**Orlon™**
monomer(s)		
repeat unit of the polymer		
type of polymerisation		

[4]

(b) Nylon-6,6 can be made from its monomers in the laboratory in two stages as shown below.



Deduce the inorganic product that is also formed in **stage 2**.

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[1]

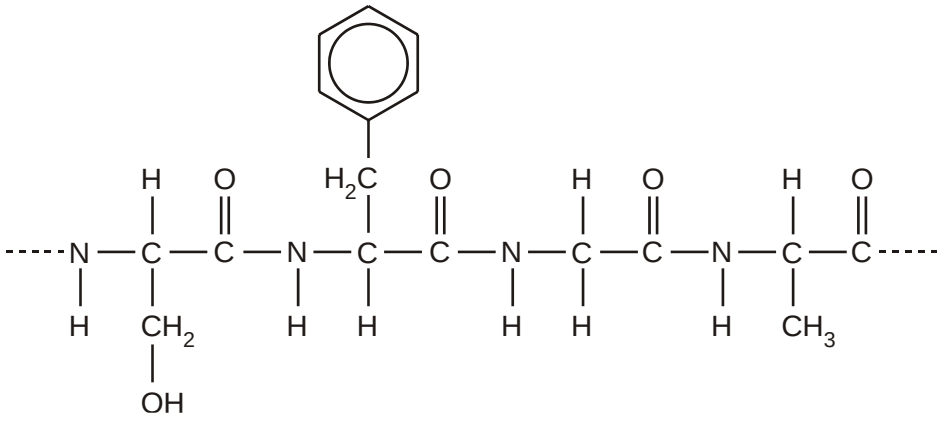
(c) Industrially, nylon-6,6 is **not** manufactured by the method in (b). Instead, the two monomers are mixed directly at room temperature to give a salt. This salt is then heated to convert it to nylon-6.6.

Suggest the structures of the two ions present in this salt.

[2]

(d) Wool is a protein. It is a natural polymer made by the same type of polymerisation as nylon-6,6.

A section of the polymer chain in a protein is shown below.



(i) How many monomer units does this section contain?

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[1]

(ii) Draw the structure of **one** of the monomer molecules that was used to form this section.

[1]

(iii) State **three** ways in which the monomer units of a protein differ from those of nylon-6,6.

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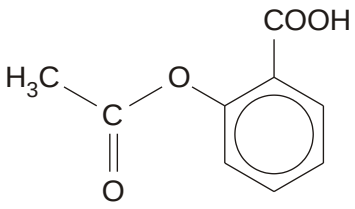
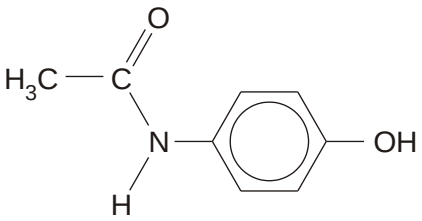
[3]

[Total 12 marks]

13. Aspirin and paracetamol are commonly available painkillers.



aspirin



paracetamol

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

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.

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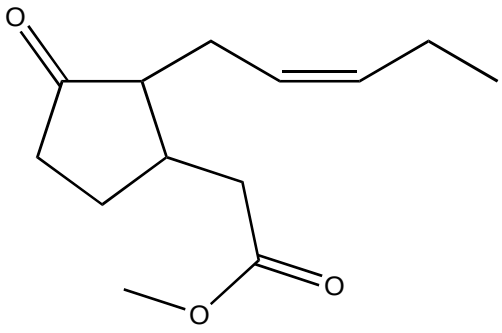
[1]

[Total 4 marks]

14. Compound **A**, shown below, contributes to the smell and taste of black tea and is a component in jasmine oil.



A

(i) Deduce the molecular formula of compound **A**.

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[1]

(ii) Compound **A** contains several functional groups.

Identify, by **name**, the functional groups in compound **A**.

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.....

[3]

(iii) Compound **A** is a stereoisomer.

On the structure above,

- mark each feature responsible for stereoisomerism with an asterisk, *,
- label each feature with the type of stereoisomerism.

[2]

(iv) Outline **two** important factors that pharmaceutical companies need to consider when manufacturing chiral compounds for use as medicines.

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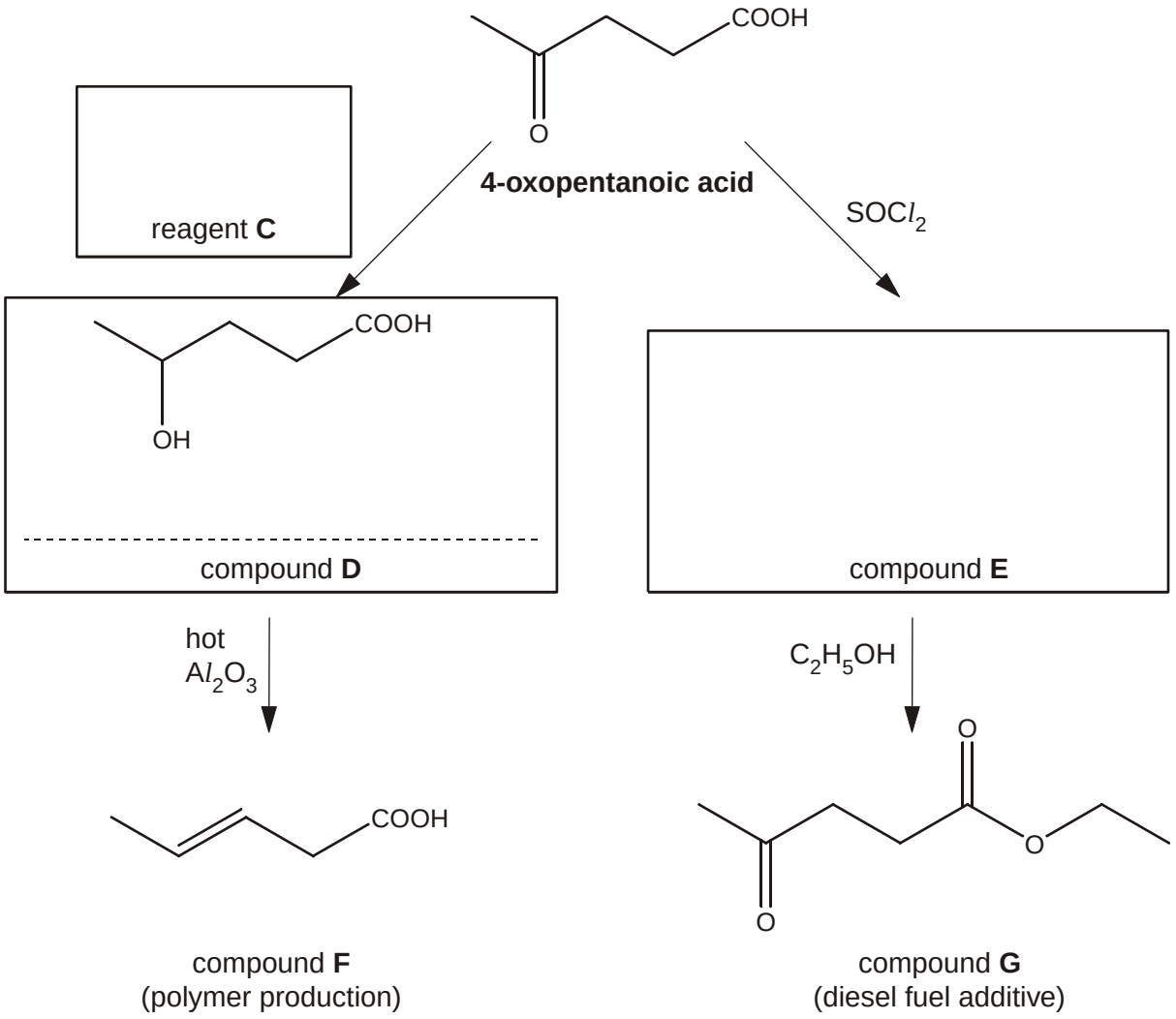
[2]

[Total 8 marks]

15. Chemists are currently developing renewable sources of organic chemicals to replace diminishing crude oil reserves.

One process involves the conversion of plant material to 4-oxopentanoic acid. This can then be converted to other useful organic compounds, including those shown below.



(a) Complete the scheme by filling in the boxes to:

(i) identify reagent **C**

[1]

(ii) state the name of compound **D**

[1]

(b) Compound **F** can be used to form a polymer.

(i) Draw a short section of this polymer showing at least three repeat units.

[1]

(ii) Draw a circle round one repeat unit on your structure.

[1]

(c) Compound **G** can be added to diesel fuel to reduce the amount of soot formed when the fuel burns.

(i) Deduce the molecular formula of compound **G**.

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[1]

(ii) Write a balanced equation for the complete combustion of compound **G**.

[2]

(iii) Suggest how compound **G** reduces the amount of soot when the fuel burns.

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[1]

(d) If compound **G** is accidentally spilt, it is broken down rapidly in the environment by reactions such as alkaline hydrolysis.

(i) State the reagents and conditions that would normally be used for alkaline hydrolysis in the laboratory.

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[2]

(ii) Explain why compound **G** is able to be hydrolysed.

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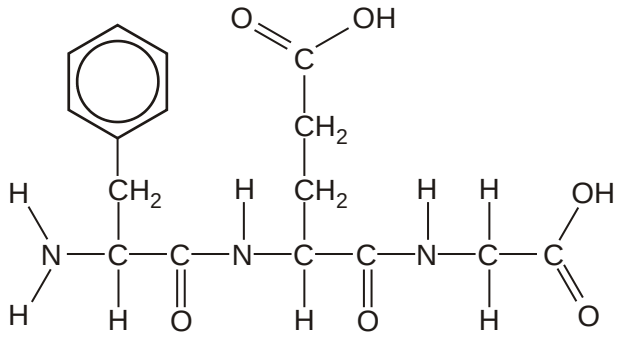
[1]

[Total 11 marks]

16. Compound **A** is currently being tested as a possible anti-allergic drug.



compound **A**

Compound **A** can exist as a number of stereoisomers, but only one of them is pharmacologically active as the anti-allergic drug.

(i) Explain what causes stereoisomerism in compounds such as **A**.

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[3]

(ii) Explain why there are **four** different stereoisomers of compound **A**.

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[2]

(iv) Sometimes it is difficult to manufacture a drug containing only the one pharmacologically active stereoisomer.

Describe **two** possible disadvantages of producing a drug containing a mixture of several stereoisomers.

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[2]

[Total 8 marks]