

# 34. Nitrogen compounds

## 34.4 Amino acids

### **Paper 4**

#### Question Paper

**1 (e)** Phenylalanine,  $C_6H_5CH_2CH(NH_2)COOH$ , is an amino acid with an isoelectric point of 5.5.

**(i)** State what is meant by isoelectric point.

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

**(ii)** Draw the structure of  $C_6H_5CH_2CH(NH_2)COOH$  at pH 10.

[1]

**(f)**  $C_6H_5CH_2CH(NH_2)COOH$  and alanine,  $CH_3CH(NH_2)COOH$ , react to form a dipeptide containing both amino acid residues.

Draw the structure of this dipeptide.

The peptide functional group formed should be displayed.

[2]

- 2 The amino acid serine,  $\text{HOCH}_2\text{CH}(\text{NH}_2)\text{COOH}$ , exists in two optically active forms. These optical isomers, isomer **P** and isomer **Q**, are shown in Fig. 8.1.

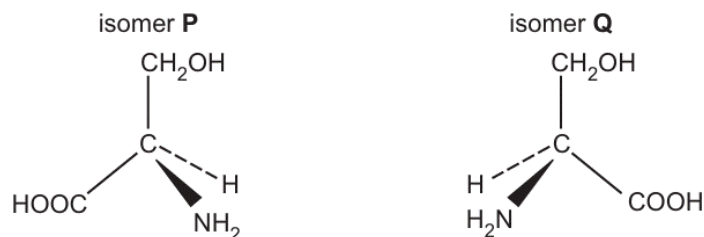
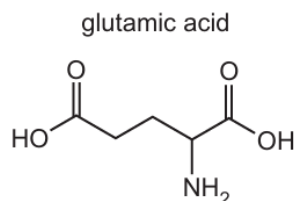


Fig. 8.1

- (h) Glutamic acid is a naturally occurring amino acid.

The skeletal formula of glutamic acid is shown.



The isoelectric point of glutamic acid is pH3.

A sample of glutamic acid is dissolved in a solution of pH 1. A strong alkali is then added until the pH of the mixture reaches pH 14. During this process **all** possible ionised forms of glutamic acid are present at different times, depending on the pH of the solution.

Complete the boxes below to show four **different** ionised forms of glutamic acid that are present at the stated pH values.



at pH 1



at pH 3

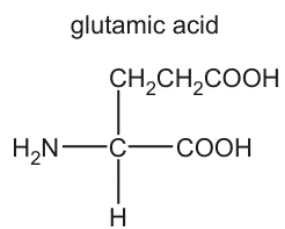


at pH 9



at pH 14

- 3 (c) Glutamic acid is another amino acid that acts as a buffer.



**Fig. 7.1**

- (i) Draw the **skeletal** formula for glutamic acid.

[1]

- (ii) Draw the structure for the dipeptide, ala-glu, formed from one molecule of alanine and one molecule of glutamic acid.

The peptide bond formed should be displayed.

[2]

- (d) The isoelectric point of alanine is 6.0 and of glutamic acid is 3.2.

A mixture of the dipeptide, ala-glu, and its two constituent amino acids, alanine and glutamic acid, is analysed by electrophoresis using a buffer at pH 6.0.

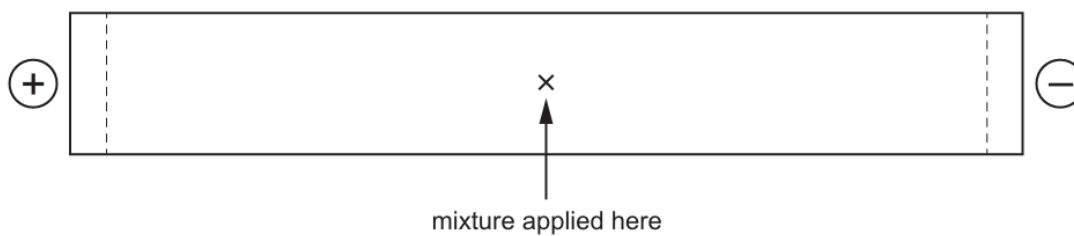


Fig. 7.2

Draw and label **three** spots on Fig. 7.2 to indicate the predicted position of each of these three species after electrophoresis.

Explain your answer.

.....

.....

.....

.....

..... [3]

4 (c) The isoelectric point of asparagine, asn, is at pH 5.4.

(i) Describe the meaning of the term isoelectric point.

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

(ii) Draw the structure of asparagine at pH 1.0.

[1]

(e) The isoelectric point of lysine, lys, is at pH 9.8.

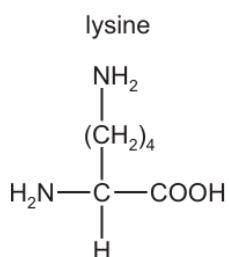


Fig. 6.2

A mixture of the dipeptide lys-asn and its two constituent amino acids, asparagine and lysine, is analysed by electrophoresis using a buffer at pH 5.0. The results obtained are shown in Fig. 6.3.

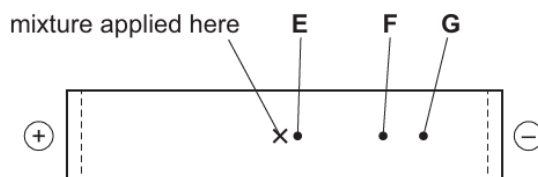


Fig. 6.3

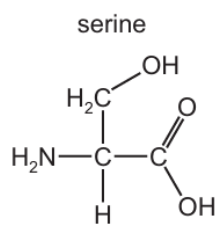
Suggest identities for the species responsible for spots **E**, **F** and **G**. Explain your answers.

spot	identity
<b>E</b>	
<b>F</b>	
<b>G</b>	

.....  
 .....  
 .....

[3]

- 5 (d) Serine can polymerise to form two different types of condensation polymer; a polyester and a polypeptide.



**Fig. 8.2**

Draw the structure of the polypeptide showing **two** repeat units. The peptide linkage should be shown displayed.

[2]



- 8** Valine (Val) and lysine (Lys) are amino acids. The structures of these amino acids can be found in the *Data Booklet*.

The isoelectric point of an amino acid is the pH at which it exists as a zwitterion. The isoelectric point of valine is 6.0. The isoelectric point of lysine is 9.7.

- (a) Draw the structure of valine at pH 6.0.

[1]

- (b) A solution of lysine is produced with pH 9.7. Dilute sulfuric acid is added slowly until the pH of the solution is 1.0. The sulfuric acid reacts with lysine to produce different organic ions that are not present in significant concentrations at pH 9.7.

Draw the structures of three of the organic ions that form during the addition of sulfuric acid in the boxes. Draw the organic ion present at pH 1.0 in box C.

A	B	C (pH 1.0)

[3]

- (c) Draw the structure of the dipeptide Val-Lys. The peptide bond should be shown fully displayed.

[2]

- 9** Alanine,  $\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2\text{H}$ , and glutamic acid,  $\text{H}_2\text{NCH}(\text{CH}_2\text{CH}_2\text{CO}_2\text{H})\text{CO}_2\text{H}$ , are two naturally occurring amino acids.

**(d)** At pH 11 alanine exists as  $\text{H}_2\text{NCH}(\text{CH}_3)\text{CO}_2^-$  ions and glutamic acid exists as  $\text{H}_2\text{NCH}(\text{CH}_2\text{CH}_2\text{CO}_2^-)\text{CO}_2^-$  ions. A mixture of alanine and glutamic acid at pH 11 is subjected to electrophoresis.

- (i)** State how the mixture can be maintained at pH 11 during electrophoresis.

..... [1]

- (ii)** Draw a fully labelled diagram for the apparatus that would be used to carry out this electrophoresis. Your diagram should include the position of the mixture of alanine and glutamic acid at the start of the electrophoresis experiment.

[2]

- (iii)** Identify the electrode that each amino acid travels towards during electrophoresis at pH 11.

alanine .....

glutamic acid .....

[1]

- (iv)** In a particular electrophoresis experiment at pH 11, the glutamic acid travels 3.4 cm. Alanine travels a shorter distance.

Explain the factors that account for the difference in the distances travelled.

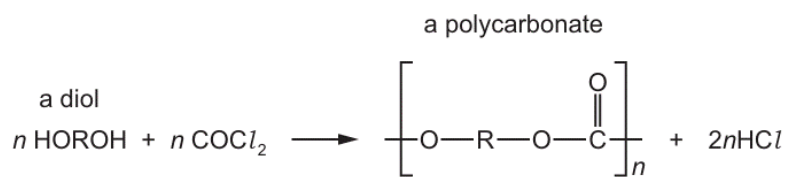
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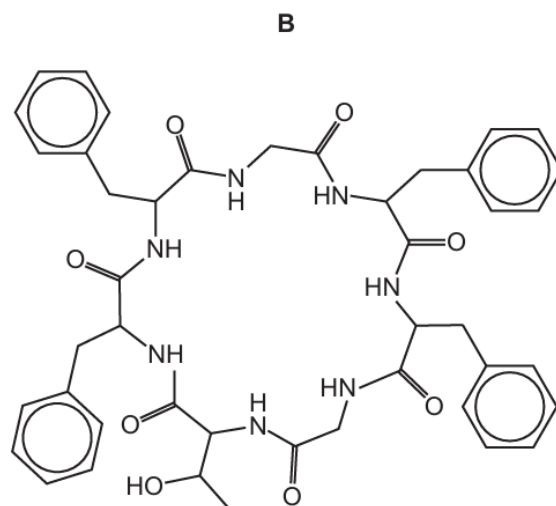
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..... [2]

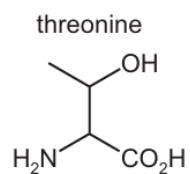
- 10** The class of polymers called polycarbonates are made by the reaction of carbonyl dichloride,  $\text{COCl}_2$ , with a diol.



- (e) The cyclic peptide **B** is shown.



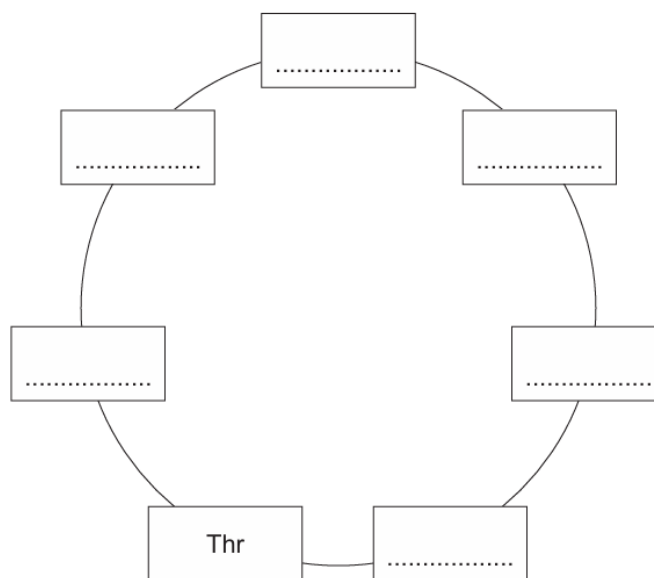
Cyclic peptide **B** is broken into its monomers by heating under reflux with dilute hydrochloric acid. The amino acid threonine, Thr, and two other organic products are formed.



- (i) Draw the structures of the two other organic products formed.

[2]

- (ii) Using the 3-letter abbreviations for the amino acids as given in the *Data Booklet*, complete the sequence for the cyclic peptide, **B**.



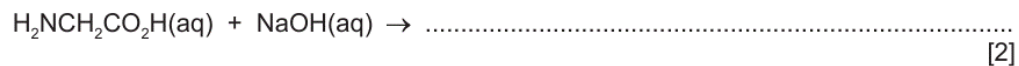
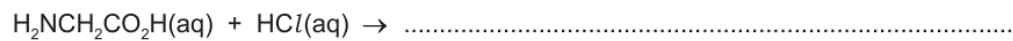
[1]

- (iii) Name **two** analytical techniques that could be used to separate these amino acids.

..... and ..... [1]

**11 (b)** Glycine,  $\text{H}_2\text{NCH}_2\text{CO}_2\text{H}$ , is the simplest amino acid.

(i) Complete the equations to show the acid-base properties of glycine.



[2]

(ii) In aqueous solution, amino acids exist as zwitterions.

Draw the zwitterionic structure of glycine. Explain how the zwitterion for glycine is formed.

.....  
.....  
.....

[2]

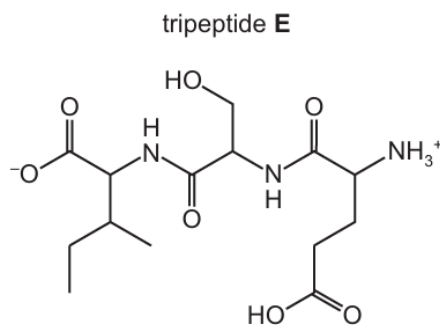
(c) Apart from glycine, all naturally occurring amino acids have a chiral centre and exhibit stereoisomerism.

Draw the two stereoisomers of alanine,  $\text{CH}_3\text{CH}(\text{NH}_2)\text{CO}_2\text{H}$ .



[1]

- 12** Proteins are natural polymers. When one particular protein is partially hydrolysed the product mixture includes tripeptide **E**.



- (a) (i)** Describe the conditions that could be used to hydrolyse **E** to produce a mixture of three amino acids.

..... [1]

- (ii)** Draw the structures of the three amino acids produced by this hydrolysis reaction.

The three amino acids should be shown in the correct form for the conditions you have chosen in **(a)(i)**.

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[2]

- (b)** If a pure sample of **E** is obtained in aqueous solution, several different types of intermolecular forces are possible between pairs of **E** molecules.

Name three different types of intermolecular force that exist between pairs of **E** molecules, stating the groups on the molecules where the forces are acting.

type of force/bond	pair of groups responsible

[3]