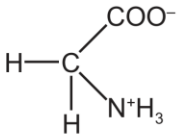
# 2. Biological Molecules

## 2.3 Proteins

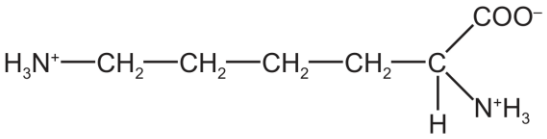
## Paper 1

Question Paper

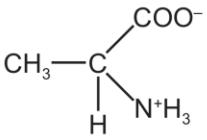
**1** The diagrams show the structure of four amino acids in aqueous solution.



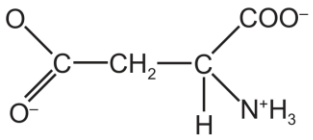

glycine




lysine




alanine




aspartate

Which two structures have an overall charge?

**A** alanine and aspartate

**B** alanine and glycine

**C** aspartate and lysine

**D** glycine and lysine

**2** Collagen molecules are made up of three polypeptide chains interacting together. The individual polypeptide chains consist of a regular pattern of amino acids. Almost every third amino acid is glycine.

Which protein structures of collagen are described?

**A** primary and secondary

**B** primary and quaternary

**C** secondary and tertiary

**D** tertiary and quaternary

**3** The masses of the parts of haemoglobin are shown in the table.

| component | mass / Da |
|---|---|
| α-globin chain | 15 126 |
| β-globin chain | 15 868 |
| haem group | 617 |

There are 1000 Da in 1 kDa.

What is the mass of a haemoglobin molecule in kDa?

**A** 31.6 **B** 33.5 **C** 62.6 **D** 64.5

**4** Which statements about peptide bond formation are correct?

1 The bond formation occurs between a carbon of one amino acid and a nitrogen of the next amino acid after the amino acids detach from tRNA.

2 The bond formation occurs at the ribosome while the amino acids are still attached to tRNA, and is a hydrolysis reaction.

3 The bond formation is important for growth of an organism and when the bond forms, a water molecule is removed.

**A** 1 and 3 **B** 2 and 3 **C** 2 only **D** 3 only

**5** Which row correctly identifies the weak and strong bonds in the tertiary and quaternary structure of a typical protein?

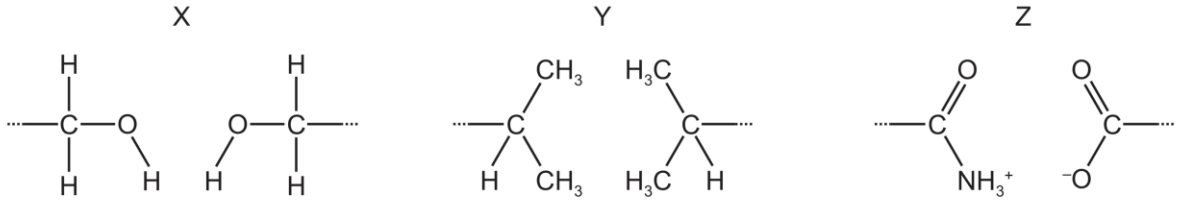
| | type of bond | | | |
|---|---|---|---|---|
| | disulfide | hydrogen | hydrophobic | ionic |
| **A** | strong | strong | weak | weak |
| **B** | strong | weak | weak | weak |
| **C** | weak | weak | strong | strong |
| **D** | weak | weak | weak | strong |

**6** Which row correctly describes haemoglobin?

| | | | | |
|---|---|---|---|---|
| **A** | four polypeptide chains, each containing a haem group | iron ions can associate with oxygen, forming oxyhaemoglobin | in each chain, hydrophobic R-groups of amino acids point towards the centre of the molecule | at 50% saturation, two oxygen molecules are transported by the molecule |
| **B** | polypeptide chains interact to produce a globular chain | each chain contains a haem group of amino acids surrounding an iron ion | consists of two identical alpha chains and two identical beta chains | each chain can transport an oxygen molecule |
| **C** | polypeptide chains interact to produce an almost spherical molecule | an iron ion is present within each haem group | quaternary structure has two alpha chains and two beta chains | each molecule can transport a total of four oxygen atoms |
| **D** | polypeptide chains produce a loose helical shape, which folds to form a spherical molecule | iron ions in the molecule can bind reversibly with oxygen | in each chain, hydrophobic R-groups of amino acids surround the iron ion | each molecule can transport a total of eight oxygen atoms |

**7** The diagrams show parts of three pairs of amino acids within a protein.

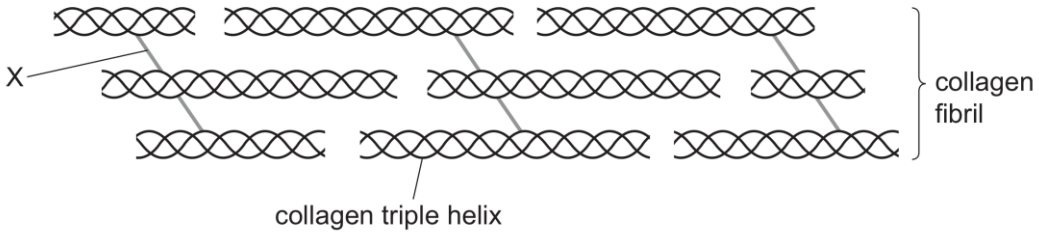
The pairs are labelled X, Y and Z.




Which row shows the correct type of interaction that would occur between the two amino acids in each pair?

| | X | Y | Z |
|---|---|---|---|
| **A** | hydrophobic interaction | hydrophobic interaction | hydrogen bond |
| **B** | hydrogen bond | hydrophobic interaction | ionic bond |
| **C** | hydrogen bond | hydrogen bond | hydrogen bond |
| **D** | hydrophobic interaction | hydrogen bond | ionic bond |

**8** The diagram shows part of a collagen fibril made of collagen triple helices. The collagen triple helices are linked to each other by one type of bond. This bond is labelled as X in the diagram.




What is bond X?

**A** covalent bond

**B** disulfide bond

**C** hydrogen bond

**D** peptide bond

**9** The table shows some information about the polypeptides that make up haemoglobin.

| | α-globin | β-globin |
|---|---|---|
| total number of amino acid residues in polypeptide chain | 141 | 146 |
| position of amino acid cysteine in polypeptide chain | 104 | 93 and 112 |

Scientists studied the region of the β-globin polypeptide chain containing the amino acid cysteine at position 93. They found that:

- this region faces outwards when **no** oxygen is attached to the haem group
- this region faces inwards when oxygen is attached to the haem group
- replacing cysteine with a different amino acid reduces the Bohr shift.

What can be concluded from the information about cysteine in haemoglobin?

**A** More than 1% of the amino acids in one haemoglobin protein are cysteine.

**B** In α-globin, there is a cysteine closer to the end of the polypeptide chain with an unreacted carboxyl group than in β-globin.

**C** The replacement of the cysteine at position 93 in β-globin decreases the affinity of haemoglobin for oxygen at low pH.

**D** The binding of oxygen to the haem group causes the region of β-globin containing cysteine at position 93 to become more hydrophilic.

**10** Which molecules are globular proteins?

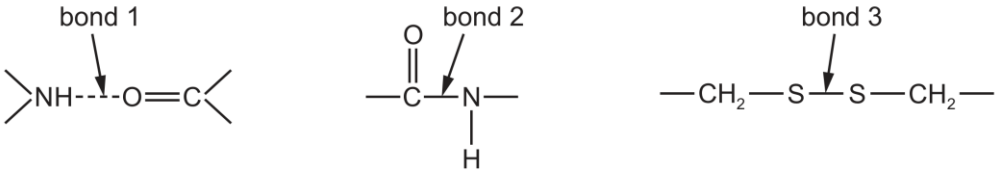
1 amylase

2 haemoglobin

3 DNA polymerase

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 only

**11** The diagrams show three examples of different bonds.




Which bonds hold the secondary structure of proteins together?

**A** 1, 2 and 3 **B** 1 and 3 only **C** 1 only **D** 2 and 3 only

**12** Insulin is a globular protein involved in cell signalling. It is transported in the blood plasma from the cells that synthesise it to its target cells. A molecule of insulin contains six sulfur-containing amino acids and has two polypeptide chains.

Which statements about insulin are correct?

1 An insulin molecule has a quaternary structure.

2 Insulin polypeptides are held together by six disulfide bonds.

3 Amino acids with hydrophobic R groups would be found in the centre of an insulin molecule.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**13** Which part of the structure of haemoglobin carries oxygen?

**A** four polypeptide chains

**B** haem groups

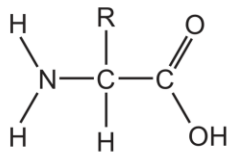
**C** hydrogen bonds

**D** hydrophilic R groups

**14** Which row about the bonding found in the primary, secondary, tertiary and quaternary structure of proteins is correct?

| | primary | secondary | tertiary | quaternary |
|---|---|---|---|---|
| **A** | covalent | covalent | ionic and disulfide only | hydrogen and hydrophobic interactions only |
| **B** | covalent | hydrogen | hydrogen, ionic, covalent and hydrophobic interactions | hydrogen, ionic, covalent and hydrophobic interactions |
| **C** | peptide | covalent | hydrogen, ionic, disulfide and hydrophobic interactions | hydrogen, ionic and disulfide |
| **D** | peptide | hydrogen | ionic and disulfide only | ionic and disulfide only |

**15** The diagram represents an amino acid.




R represents a variable side chain.

What is **not** a possible side chain?

**A** $CH_3$

**B** $CH_2CH_2SCH_3$

**C** $CH_2CONH_2$

**D** $HOCH_2CH(OH)CH_2OH$

**16** A polypeptide contains a specific number of amino acids, n.

How many peptide bonds are present in this polypeptide?

**A** n – 1 **B** n **C** n + 1 **D** n + 2

**17** The diagram shows two amino acids. Some of the hydrogen atoms are numbered 1 to 6.




Which two numbered hydrogen atoms could contribute to the production of a molecule of water when a peptide bond forms between these two amino acids?

**A** 1 and 4 **B** 1 and 6 **C** 3 and 5 **D** 2 and 4

**18** Typical enzymes are large globular proteins with a specific tertiary shape.

Which molecular interactions are directly involved in maintaining the tertiary shape?

1 hydrogen bonding

2 disulfide bridges

3 hydrophobic interactions

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**19** Bread contains a mixture of polypeptides known as gluten.

Two of the polypeptides found in gluten are glutenin and gliadin.

Which statement describes the tertiary structure of a protein?

**A** Disulfide bonds form between glutenin and gliadin.

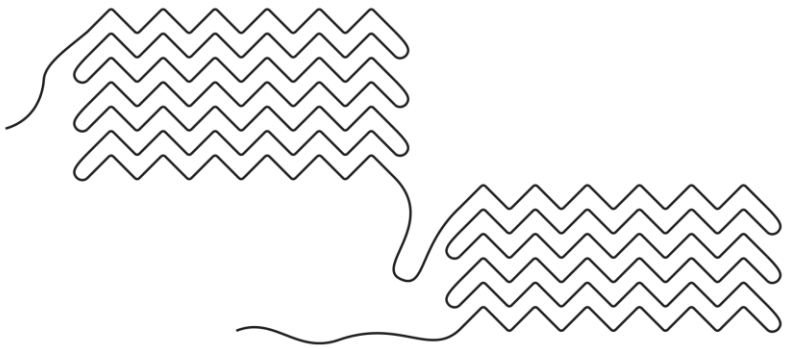
**B** A large proportion of the amino acids in gliadin are glutamine.

**C** $\alpha$-helical sections are found in glutenin and gliadin.

**D** Amino acids with hydrophobic R groups are found on the inside of glutenin.

**20** Silk moth caterpillars have been genetically modified to produce a mixture of their own silk and the much stronger spider silk of the golden orb web spider.

The spider silk polypeptide chain has many repeated sequences of two amino acids, glycine and alanine, arranged in a crystalline structure.



What correctly describes the structure of spider silk?

**A** primary protein structure with regions of $\alpha$-helices

**B** secondary protein structure with regions of $\beta$-pleated sheets

**C** tertiary protein structure with regions of $\alpha$-helices

**D** quaternary protein structure with regions of $\beta$-pleated sheets

**21** Which description of collagen is correct?

**A** A collagen molecule consists of three polypeptide chains, each in the shape of a helix. The three chains are wound together into a triple helix called a fibre.

**B** A collagen molecule consists of three polypeptide chains, each of which is an $\alpha$-helix. The three chains are wound tightly together into a triple helix. Many of these triple helices bind together as a fibre.

**C** A collagen molecule consists of three polypeptide chains wound tightly into a triple helix called a fibre.

**D** A collagen molecule consists of three polypeptide chains in which every third amino acid is glycine. The three polypeptides are wound tightly together into a triple helix. Many of these helices form a fibre.

**22** In a healthy human, the mean value for the number of haemoglobin molecules in one red blood cell is 260 million.

How many $\alpha$-globin chains does one red blood cell contain in a healthy human?

**A** $1.3 \times 10^8$ **B** $2.6 \times 10^8$ **C** $5.2 \times 10^8$ **D** $1.04 \times 10^9$

**23** Which statements about a peptide bond are correct?

1 It joins two monomers which are always identical to each other.

2 It contains four different atoms.

3 It can be broken by the addition of water at room temperature.

4 It is important in the primary structure of proteins.

**A** 1, 2 and 3 **B** 1 and 3 only **C** 2, 3 and 4 **D** 2 and 4 only

**24** Which molecule contains the smallest number of hydrogen atoms?

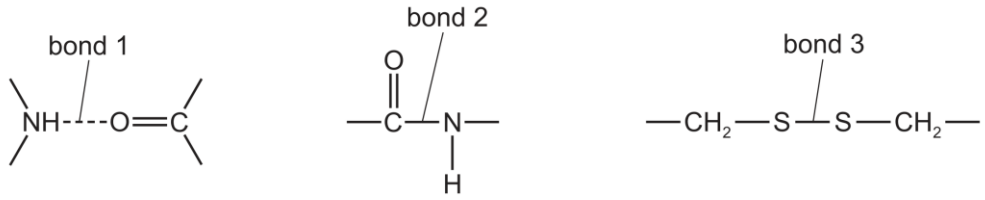
**A** α-glucose

**B** glycine, an amino acid in which the R group is H

**C** glycerol

**D** a saturated fatty acid containing eight carbon atoms

**25** The diagrams show three examples of different bonds.




Which bonds hold the tertiary structure of proteins together?

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**26** Which feature of collagen enables it to fulfil a structural role in skin and in tendons?

**A** Adjacent collagen molecules are linked by ester bonds.

**B** Collagen fibres form layers with the fibres in different directions.

**C** Collagen molecules are formed as a triple helix of polypeptide chains.

**D** Polypeptide chains of collagen are tightly folded into compact shapes.

**27** Which molecules contain at least two double bonds?

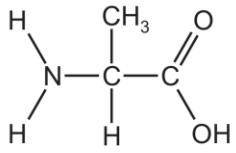
**A** saturated fatty acid, collagen and haemoglobin

**B** collagen and saturated fatty acid only

**C** haemoglobin and collagen only

**D** saturated fatty acid and haemoglobin only

**28** The diagram shows an amino acid.




Which group is changed to produce different amino acids?

**A** OH **B** C=O **C** $CH_3$ **D** $NH_2$

**29** Which row is correct about the structure of proteins?

| | primary | secondary | tertiary | quaternary |
|---|---|---|---|---|
| **A** | determined by the sequence of DNA nucleotides | occurs by hydrogen bonding between NH and C=O groups of amino acids | disulfide, ionic, hydrogen bonds and hydrophobic interactions are all involved | always formed by association of two or more polypeptides |
| **B** | the number of amino acids in each polypeptide chain | in a single polypeptide it is either an $\alpha$-helix or a $\beta$-pleated sheet | the bonds are formed at specific points determined by the primary structure | always formed by two or more polypeptides held together by bonds formed between the polypeptides |
| **C** | formed by twenty different amino acids linked in a specific order | an $\alpha$-helix is formed by hydrogen bonds between side chains of amino acids | only globular proteins have this level of structure | always formed by two or more different polypeptides to give the final shape |
| **D** | the sequence of amino acids in each polypeptide chain | a $\beta$-pleated sheet is the result of a folded polypeptide forming hydrogen bonds between adjacent strands | reactions between side chains of specific amino acids give a specific 3-D shape | always formed by two or more polypeptides and a metal ion |

**30** Which molecules contain at least two double bonds?

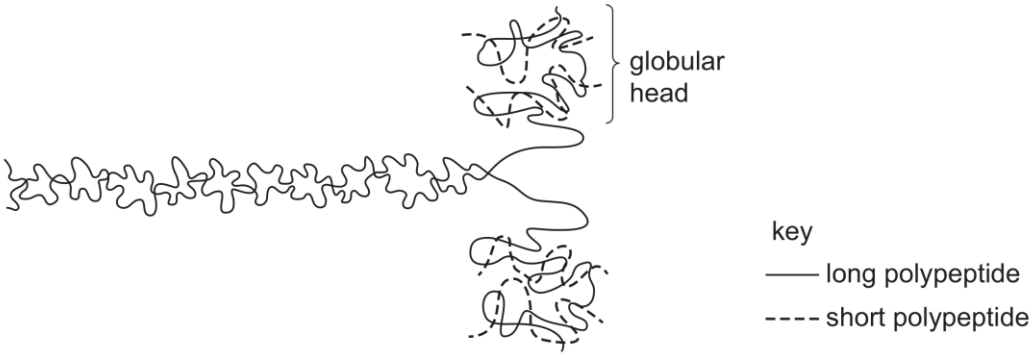
1 unsaturated fatty acid

2 collagen

3 haemoglobin

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**31** The diagram shows a protein molecule.




Two long polypeptides each form $\alpha$-helices for much of their length and these twist together into a fibre.

At one end, each of these polypeptides coils into a globular head.

Two short polypeptides bind to each globular head.

What describes the protein structure of this molecule?

**A** quaternary structure because each molecule consists of six polypeptides

**B** secondary structure because the long polypeptides form $\alpha$-helices

**C** tertiary structure because the $\alpha$-helices form a fibre

**D** tertiary structure because the heads form globular proteins

**32** Which types of bond will keep a folded protein in its precise shape for the longest time as the temperature rises?

**A** disulfide

**B** hydrogen

**C** hydrophobic interactions

**D** ionic

**33** What occurs during the formation of a peptide bond between two amino acids?

**A** OH is removed from COOH and H is removed from an R group.

**B** OH is removed from COOH and H is removed from $NH_2$.

**C** H is removed from COOH and OH is removed from an R group.

**D** O is removed from COOH and 2H is removed from $NH_2$.

**34** Which molecules are formed by condensation which involves a carboxyl group?

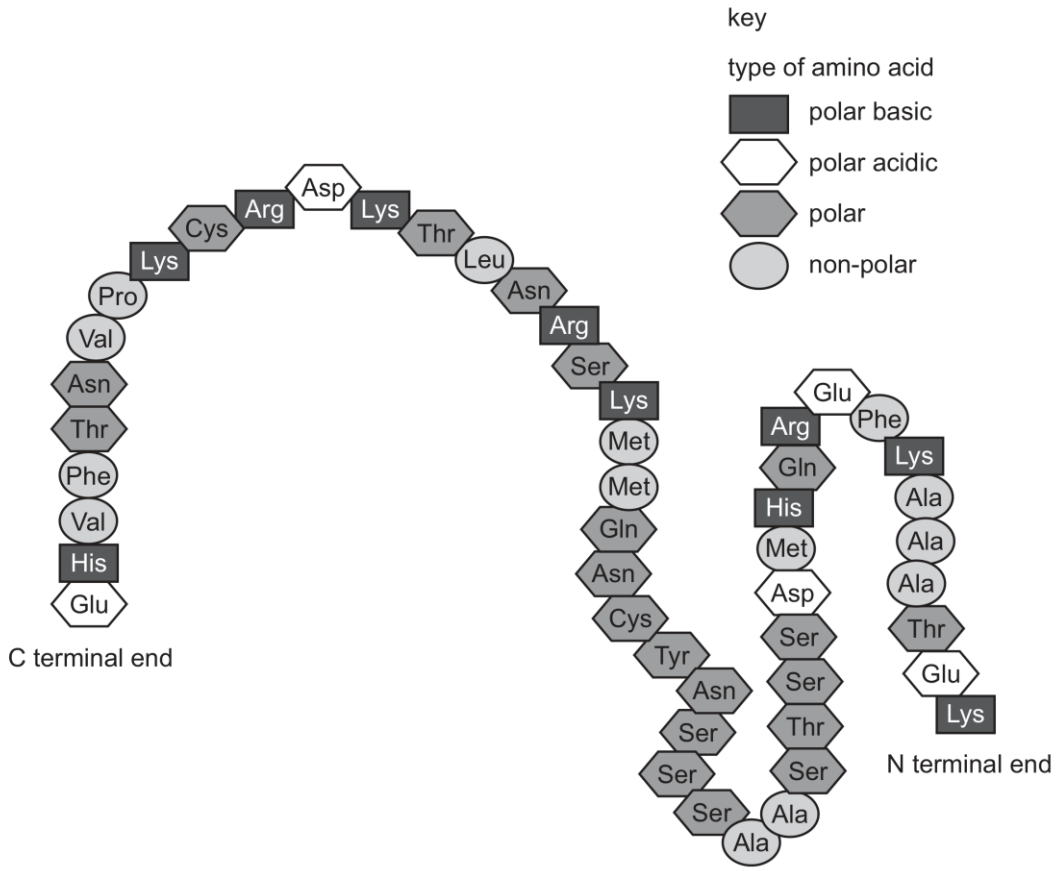
**A** amylopectin, collagen, triglyceride, sucrose

**B** amylopectin, collagen, triglyceride

**C** amylopectin, β-globin, sucrose

**D** collagen, β-globin, triglyceride

**35** The diagram shows the amino acids in a polypeptide.

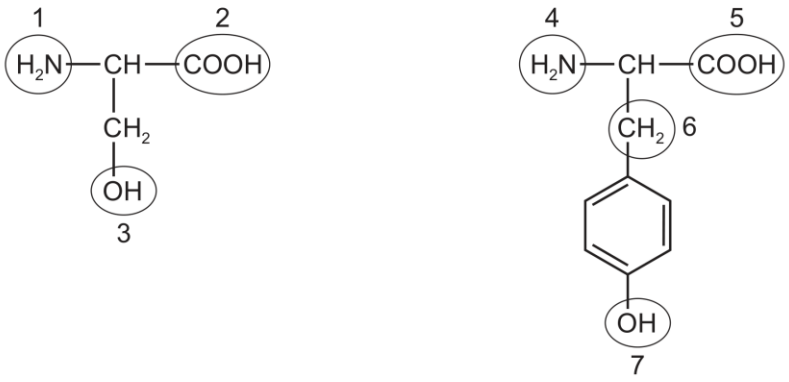



An enzyme catalyses the hydrolysis of **any** peptide bond between a non-polar amino acid **and** any polar amino acid.

How many small peptides and single amino acids will be formed by the action of this enzyme?

| | small peptides | single amino acids |
|---|---|---|
| **A** | 6 | 1 |
| **B** | 8 | 1 |
| **C** | 12 | 3 |
| **D** | 13 | 4 |

**36** The diagram shows the structures of two amino acids.




These amino acids will form part of a protein that has a tertiary structure.

Which numbered groups could form hydrogen bonds to maintain the tertiary structure of the protein?

**A** 1 and 6 **B** 2 and 4 **C** 3 and 5 **D** 3 and 7

**37** Which row about the structure of proteins is correct?

| | primary structure | tertiary structure | quaternary structure |
|---|---|---|---|
| **A** | is the number of amino acids present in a protein | is the result of cross bonding between all the amino acids in the primary structure | is the polypeptides that link together to form a protein |
| **B** | is the order of amino acids present in a protein encoded by DNA | is the shape formed by folding of a polypeptide and held together by hydrogen bonds | contains two types of polypeptide that interact forming the shape of a protein |
| **C** | is the result of translation of an mRNA molecule by a ribosome into a chain of amino acids | is the result of ionic and hydrogen bonds, disulfide bridges and hydrophobic interactions between amino acids | is formed by four polypeptides and an additional reactive group attached to the protein |
| **D** | is the sequence of amino acids in a protein coded by an mRNA molecule | is formed as a result of interaction of the side chains of amino acids in the primary structure | is formed by the linking together of more than one polypeptide to form a protein |

**38** Which row correctly identifies structural features of a collagen molecule and a haemoglobin molecule?

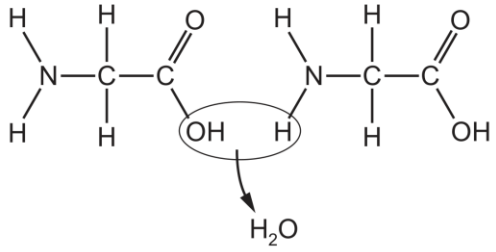
| | molecule consists of more than one polypeptide | globular protein |
|---|---|---|
| **A** | collagen and haemoglobin | collagen and haemoglobin |
| **B** | collagen and haemoglobin | haemoglobin only |
| **C** | haemoglobin only | collagen and haemoglobin |
| **D** | haemoglobin only | haemoglobin only |

**39** What is the minimum number of carbon atoms in an amino acid?

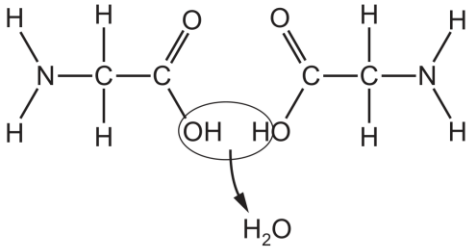
**A** 1 **B** 2 **C** 3 **D** 4

**40** Which diagram shows the formation of a peptide bond?

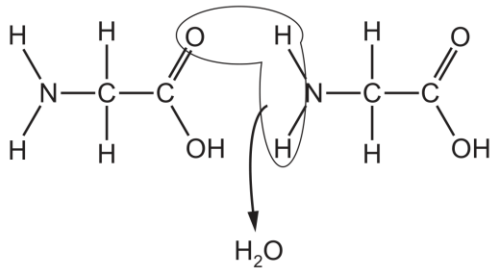
**A**



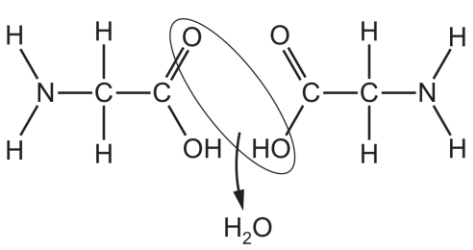

**B**




**C**




**D**



**41** In enzyme-catalysed reactions, the position of the amino acids found at the active site is important.

During the synthesis of enzymes, amino acids are brought together in the correct position to form the active site.

Which levels of protein structure **must** be involved in forming the active site?

| | level of protein structure | | | |
|---|---|---|---|---|
| | primary | secondary | tertiary | quaternary |
| **A** | ✓ | ✓ | ✓ | ✓ |
| **B** | ✓ | ✓ | ✓ | ✗ |
| **C** | ✗ | ✓ | ✓ | ✓ |
| **D** | ✗ | ✓ | ✗ | ✓ |

key

✓ = involved

✗ = not involved

**42** Which features affect the tensile strength of collagen?

1 the helical structure of collagen chains

2 the small R group of the amino acids in collagen

3 the insoluble nature of collagen

4 the bonds between collagen molecules

**A** 1, 2, 3 and 4

**B** 1, 2 and 4 only

**C** 1 and 3 only

**D** 2, 3 and 4 only

**43** Which statements could be used to describe enzyme molecules **and** antibody molecules?

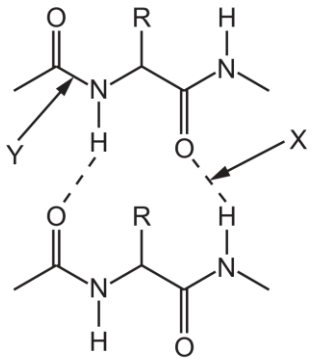
1 Hydrogen bonds stabilise the structure of the protein and are important for it to function efficiently.

2 Hydrophilic R-groups point in to the centre of the molecule and cause it to curl into a spherical shape.

3 The tertiary structure of the protein molecule plays an important role in the functioning of the protein.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**44** Fibrous proteins are composed of chains of amino acids held together by bonds. An example of part of a fibrous protein is shown.



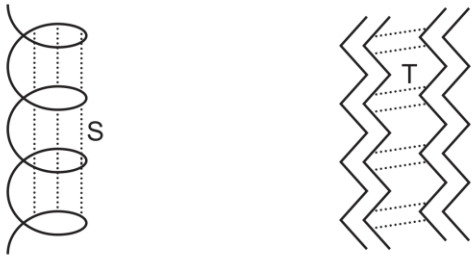

Which type of bond is at X and Y?

| | X | Y |
|---|---|---|
| **A** | disulfide | hydrophobic interaction |
| **B** | hydrogen | peptide |
| **C** | hydrophobic interaction | ionic |
| **D** | ionic | peptide |

**45** Which row about the structure of proteins is correct?

| | primary structure | secondary structure | quaternary structure |
|---|---|---|---|
| **A** | is the number of amino acids present in a protein | is the left-handed spiral formed by the primary structure | is the sub-unit polypeptides that link together to form a protein |
| **B** | is the order of amino acids present in a protein encoded by DNA | is the coiling of a chain of amino acids to form a β-pleated sheet or α-helix | contains two types of polypeptide that interact forming the shape of a protein |
| **C** | is the result of translation of an mRNA molecule by a ribosome into a chain of amino acids | occurs because of attraction between hydrogen and oxygen atoms in the peptide bonds | is formed by four polypeptides and an additional reactive group attached to the protein |
| **D** | is the sequence of amino acids in a protein coded by an mRNA molecule | is formed by hydrogen bonding between amino acids forming the primary structure | is formed by the linking together of more than one polypeptide to form a protein |

**46** The diagrams show two arrangements of amino acids in a protein.



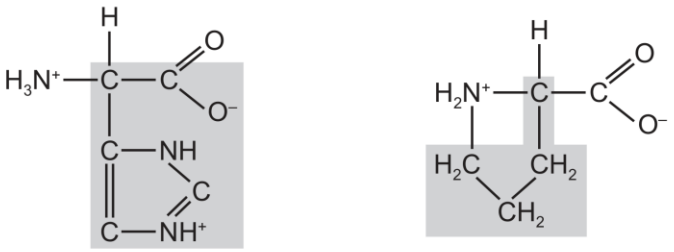

Which row correctly names the bonds at S or T?

| | ionic bond | hydrogen bond |
|---|---|---|
| **A** | absent | S and T |
| **B** | S only | T only |
| **C** | S and T | absent |
| **D** | T only | S and T |

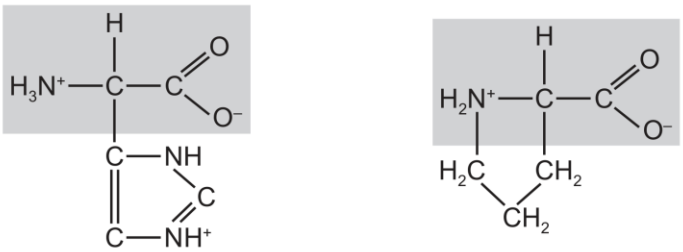
**47** Students were asked to highlight only the R groups of two ring-shaped amino acids.

Which pair of diagrams are correct for both amino acids?

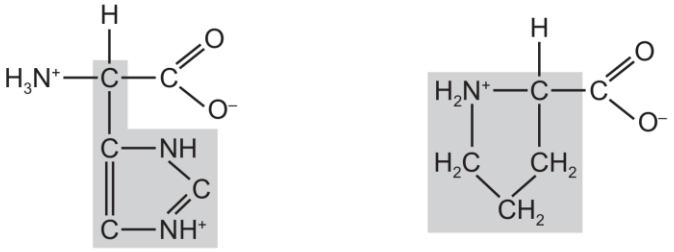
**A**



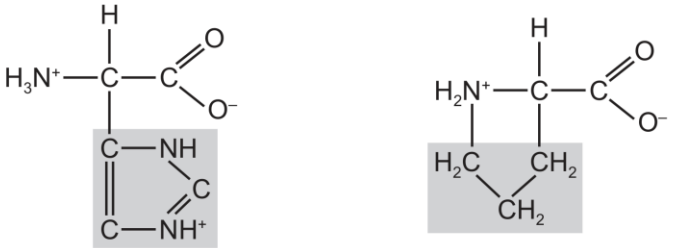
**B**



**C**



**D**



**48** Which row describes a collagen molecule?

| | bonds stabilising the molecule | properties | primary structure | helix |
|---|---|---|---|---|
| **A** | disulfide | high temperatures increase flexibility | high proportion of glycine | double |
| **B** | disulfide | resistant to stretching | repeat sequences of three amino acids | single |
| **C** | hydrogen | high tensile strength | repeat sequences of three amino acids | triple |
| **D** | hydrogen | insoluble in water | high proportion of glycine and proline | alpha |

**49** Which statements about the primary structure of a protein are correct?

1 It may be branched.

2 It is determined by the sequence of DNA bases.

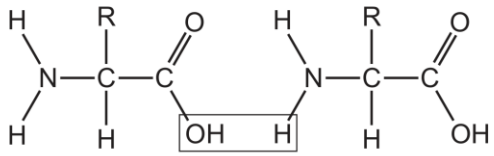
3 It is unique to that protein.

4 It determines the tertiary structure of the protein.

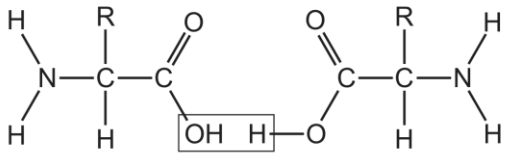
**A** 1, 2 and 3 **B** 1, 2 and 4 **C** 1, 3 and 4 **D** 2, 3 and 4

**50** Which diagram shows where a peptide bond would be formed?

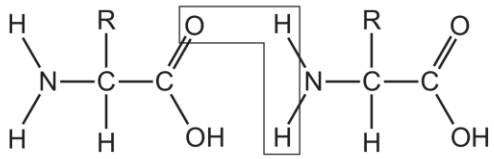
**A**



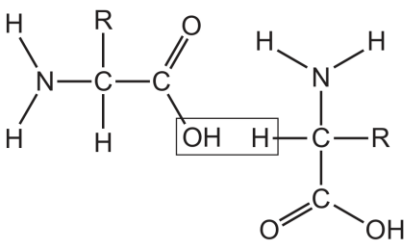
**B**



**C**



**D**



**51** Which statements about collagen molecules are correct?

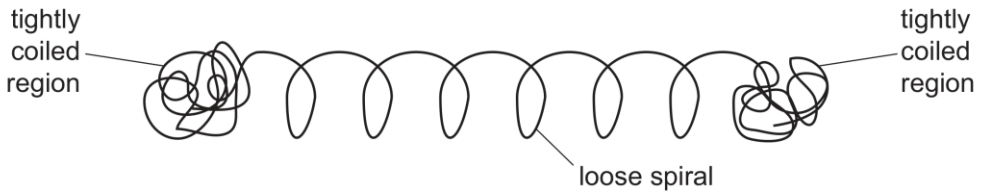
1 Both types of secondary structure occur within the molecules.

2 Large numbers of hydrogen bonds stabilise the molecules.

3 Repeated amino acid sequences determine the tertiary structure.

**A** 1, 2 and 3 **B** 1 and 2 only **C** 1 and 3 only **D** 2 and 3 only

**52** The protein glutenin gives bread dough its elasticity. The diagram represents a polypeptide of glutenin.




What describes the structure of glutenin?

**A** quaternary structure because there are both globular and fibrous regions

**B** quaternary structure because there are both spiral and tightly coiled regions

**C** secondary structure because the loose spiral is an $\alpha$-helix

**D** tertiary structure because the different regions form a 3D shape