

2.3 Proteins

Name: _____ Class: _____ Date: _____

Total: 31 marks

KEY WORDS amino acid • collagen • primary
 • primary structure • fibrous

Objective

Build the skills to answer exam questions on **proteins** – the structure of **amino acids** and the **peptide bond**, the four levels of protein structure, and how the structures of **haemoglobin** and **collagen** fit their functions.

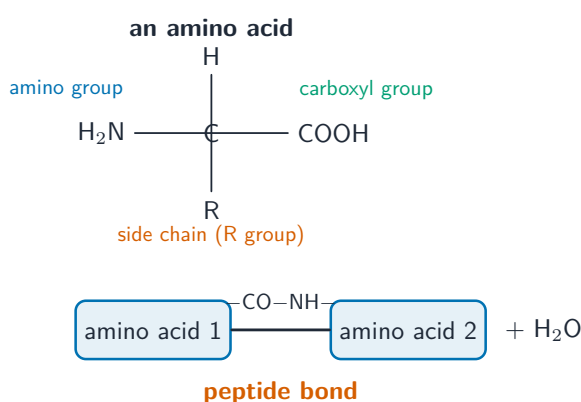
You must be able to:

- draw the general structure of an amino acid and the formation of a peptide bond
- explain primary, secondary, tertiary and quaternary structure and the bonds that hold them
- relate the structure of haemoglobin (globular) and collagen (fibrous) to their functions

1 Key knowledge and worked examples

■ Amino acids and the peptide bond

Every amino acid has a central carbon bonded to an **amino group** ($-\text{NH}_2$), a **carboxyl group** ($-\text{COOH}$), a hydrogen, and a variable **R group**. Two amino acids join by **condensation**: a peptide bond forms and **one water molecule is removed**. Many joined this way make a **polypeptide**.



condensation removes one water for each peptide bond

Two amino acids join by a peptide bond, releasing water

■ The four levels of structure

level	meaning
primary	the order of amino acids
secondary	local shapes (α -helix, β -pleated sheet) held by hydrogen bonds
tertiary	the whole chain folded into a precise 3-D shape
quaternary	two or more chains joined into one protein



primary (1°)

order of
amino acids



secondary (2°)

α -helix & β -sheet
(hydrogen bonds)



tertiary (3°)

folded into a
precise 3-D shape



quaternary (4°)

two or more
chains together

Primary → secondary → tertiary → quaternary structure

The folded shape is held by interactions between R groups: **hydrophobic interactions**, hydrogen bonds, **ionic bonds**, and strong **disulfide bonds**.

■ Globular vs fibrous

Globular proteins fold into rounded, usually **soluble** shapes with jobs in the body – e.g. **haemoglobin**, four chains (two α , two β), each with a **haem group** holding an iron atom that binds one O_2 (so one molecule carries four O_2).

Fibrous proteins form long, insoluble strands for support – e.g. **collagen**, three chains wound into a triple helix, cross-linked into strong fibres.

2 Practice

2.1 Name the bond that forms between two amino acids, and state what small molecule is removed. [2]

2.2 State the level of protein structure described by each: [3]

(a) two or more polypeptide chains joined together

(b) the sequence of amino acids

(c) folding into a precise 3-D shape

3 Exam-style questions

3.1 Which bond is **not** involved in holding the tertiary structure of a protein? [1]

- ☐ **A** disulfide bond
B glycosidic bond
C hydrogen bond
D ionic bond

3.2 A polypeptide is made from 120 amino acids. How many water molecules were released in forming it? [1]

- ☐ **A** 60
B 119
C 120
D 240

3.3 Haemoglobin has a quaternary structure.

(a) Describe what is meant by quaternary structure, using haemoglobin as an example. [3]

(b) Explain the importance of the iron in each haem group. [2]

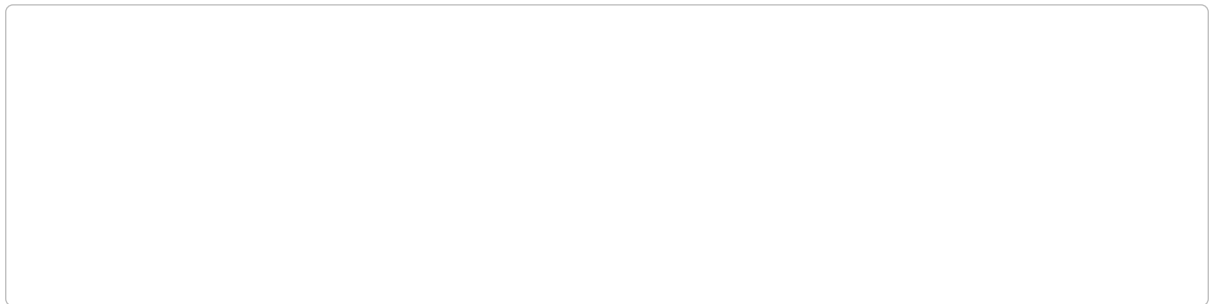
3.4 Collagen is a fibrous protein.

(a) Describe the structure of a collagen molecule and how collagen molecules form a fibre. [3]

(b) Explain how this structure makes collagen suitable for its function. [2]

3.5 Haemoglobin and collagen are both proteins, but they differ completely in structure and function.

(a) Draw the general structure of an amino acid, and describe how a peptide bond forms between two of them. [4]



(b) Explain what is meant by the primary, secondary, tertiary and quaternary structure of a protein. [4]

(c) Compare haemoglobin and collagen under **three** headings: shape, the level of structure that determines their function, and their solubility in water. [3]

(d) A mutation changes one amino acid in the haemoglobin β chain from glutamate (charged) to valine (non-polar). Explain how a single change can alter the whole molecule's behaviour. [3]

Solutions

Each answer shows the steps, then the **result**.

2.1

- peptide bond; a water molecule is removed

2.2

(a)

- quaternary

(b)

- primary

(c)

- tertiary

3.1 B

- A glycosidic bond joins sugars, not amino acids

3.2 B

- Joining 120 amino acids needs 119 peptide bonds, so 119 water molecules are released

3.3

(a)

- two or more polypeptide chains joined into one protein; haemoglobin has four chains – two α and two β – each with a haem group

(b)

- the iron atom is where one oxygen molecule binds; four haem groups let one haemoglobin carry four O₂ molecules

3.4

(a)

- three polypeptide chains wound into a triple helix held by hydrogen bonds; many molecules lie side by side, staggered and cross-linked into fibres

(b)

- the triple helix and cross-links make it very strong when pulled, suiting it to support skin, tendons and bone

3.5

(a)

- A central carbon bonded to an amino group $-\text{NH}_2$, a carboxyl group $-\text{COOH}$, a hydrogen and an R group. A peptide bond forms by **condensation**: the $-\text{OH}$ of one carboxyl group and an $-\text{H}$ of the next amino group leave as water, giving a $-\text{CO} - \text{NH}-$ link

(b)

- Primary – the sequence of amino acids. Secondary – regular folding into an α helix or β pleated sheet, held by hydrogen bonds. Tertiary – the overall three-dimensional fold, held by hydrogen, ionic and disulfide bonds and hydrophobic interactions. Quaternary – two or more polypeptide chains, plus any prosthetic group, assembled into one functional molecule

(c)

- Haemoglobin is **globular**, collagen **fibrous**; haemoglobin's function depends on tertiary and quaternary structure – the haem pockets – while collagen's depends on its primary structure, the glycine at every third residue that lets three chains wind together; haemoglobin is soluble because its hydrophilic R groups face outwards, collagen is insoluble

(d)

- The R group is part of the tertiary structure, so exchanging a charged R group for a non-polar one changes which bonds can form; a hydrophobic patch now sits on the outside of the molecule; molecules stick to one another and the haemoglobin polymerises, distorting the whole cell – so one substitution changes the quaternary behaviour