11.1 Proteins

Name: _____ Class: _____ Date: _____ **Total: 24 marks**

KEY WORDS amino acid • peptide bond • polypeptide • denaturation • R group R • essential amino acid

Objective

Build the skills to answer exam questions on **proteins** : amino acids, peptide bonds, the variety of proteins and denaturation.

You must be able to:

- draw the general structure of an amino acid and show how a peptide bond forms
- explain how the sequence of amino acids gives proteins their great variety
- explain how heat and pH denature proteins
- explain why some amino acids are essential in the diet
- describe the primary, secondary, tertiary and quaternary structure of proteins, and compare globular and fibrous proteins

1 Key knowledge and worked examples

Proteins

Amino acid: a central carbon with an **amine group** ($-NH_2$), a **carboxyl group** ($-COOH$), a hydrogen and an **R group**. There are **20** amino acids in proteins; they differ only in the R group. **Essential** amino acids cannot be made by the body, so they must come from the diet.

Peptide bond: a condensation reaction joins the carboxyl group of one amino acid to the amine group of the next, releasing water. A chain is a **polypeptide**.

Variety: a chain of n amino acids can have 20^n sequences, so the number of possible proteins is huge. The sequence decides how the chain folds, and the shape decides the function.

Denaturation: high temperature or extreme pH breaks the bonds that hold the shape (hydrogen bonds, ionic bonds), so the protein loses its shape and function. It is usually **permanent**.

HL: primary structure = the sequence; **secondary** = α-helix and β-pleated sheet, held by hydrogen bonds between backbone groups; **tertiary** = the 3-D fold of one chain, held by R-group bonds (hydrogen, ionic, disulfide bridges, hydrophobic interactions); **quaternary** = two or more chains (haemoglobin has four, plus haem groups: a **conjugated** protein). **Globular** proteins are round and soluble (enzymes); **fibrous** are long and insoluble (collagen).

Worked example. A dipeptide forms from two amino acids: **one** peptide bond, **one** water released. A chain of 3: $20^3 = \mathbf{8000}$ possible sequences.

Answer shapes: heat → bonds break → shape changes → active site / function lost.

2 Practice

2.1 Draw the general structure of an amino acid and label the R group. [2]

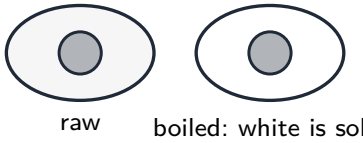
2.2 Explain how two amino acids join to form a dipeptide. [3]

$$H_2N{-}CHR_1{-}COOH \quad H_2N{-}CHR_2{-}COOH$$

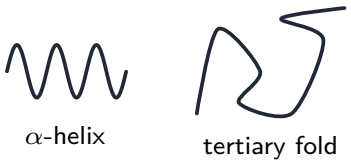
these groups react

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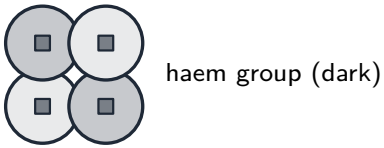
2.3 Explain why boiling an egg changes the egg-white protein permanently. [3]



2.4 Distinguish between the secondary and tertiary structure of a protein. [2]



2.5 Haemoglobin is a conjugated protein with quaternary structure. Explain both terms. [2]



3 Exam-style questions

3.1 A student counted the possible sequences of short polypeptides.



$20^2 = 400$



$20^3 = 8000$

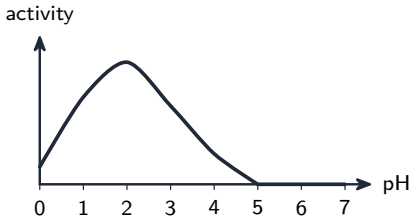
(a) Calculate the number of possible sequences for a chain of 4 amino acids. [1]

(b) Explain why the sequence of amino acids decides the function of a protein. [2]

(c) State what is meant by an essential amino acid. [1]

(d) Suggest why a vegan diet should include a mix of plant proteins. [2]

3.2 The graph shows the activity of a protein-digesting enzyme at different pH values.



(a) State the optimum pH of this enzyme. [1]

(b) Suggest where in the body this enzyme works. [1]

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(c) Explain why the activity is zero at pH 6. [2]

(d) State two types of bond that hold the shape of a protein. [2]

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