Biological Molecules

Model Answers 2

Level	A Level
Subject	Biology
Exam Board	OCR
Module	Foundations in Biology
Topic	Biological Molecules
Booklet	Model Answers 2

Time allowed: **73 minutes**

Score: **/54**

Percentage: **/100**

Grade Boundaries:

A*	A	B	C	D	E
>69%	56%	50%	42%	34%	26%

Question 1

Proteins are important biological molecules.

(a) Protein structure can be represented at four levels: primary, secondary, tertiary and quaternary.

Below is a set of features that may be used when describing the structure of a protein such as haemoglobin.

Features	Letter
hydrogen bonds	**A**
peptide bonds	**B**
α and β subunits	**C**
the sequence of amino acids	**D**
the initial folding of the polypeptide chain	**E**
the overall 3D shape	**F**
ionic bonds	**G**

(i) Select the letters of the features that describe the primary level of protein in structure. **[1]**

B and **D**

The primary structure of a protein is the base of amino acids joined together by peptide bonds.

(ii) Select the letter or letters of the feature(s) found in the secondary level of protein structure that are **not** present in the primary structure. **[1]**

A and **E**

The secondary structure of a protein is where the amino acid sequence begins to fold in on itself by hydrogen bonds between the R groups. The structure formed are alpha helices and beta pleated sheets.

(iii) Select the letter or letters of the feature(s) that are found in the tertiary level of protein structure that are **not** present in the primary and secondary structures. **[1]**

F and **G**

The tertiary structure of a protein is where the structure begins to take a 3D shape.

(iv) Select the letter or letters of the feature(s) found only in the quaternary level of protein structure. **[1]**

C

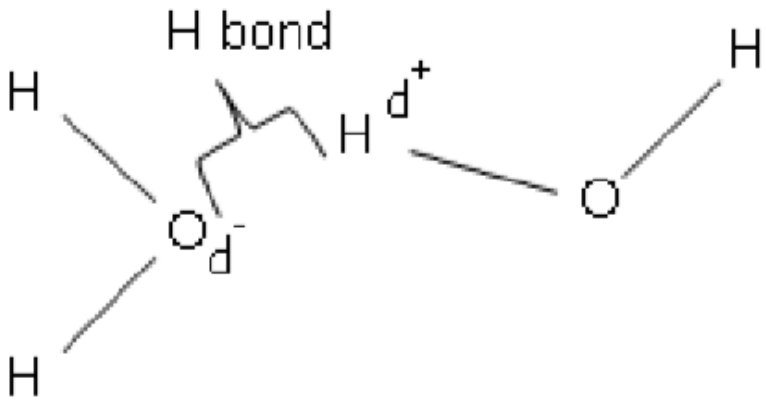
The quaternary structure includes two or more polypeptide chains joins together.

(b) Hydrogen bonds also form between water molecules.

(i) Describe the formation of a hydrogen bond between two molecules of water and explain why water can form these bonds. **[3]**

- Hydrogen bonds are formed between the O and H of adjacent molecules
- between the electropositive H and electronegative O
- Hydrogen bonds are able to form because the water molecule is polar

The first two points can also be gained by giving a diagram:



(ii) Hydrogen bonds allow water to act as a solvent.

Why is the ability of water to act as a solvent important for the survival of organisms?

[3]

The ability of water to act as a solvent is important for the survival of organisms because:

- It is a medium for metabolic reactions
- it allows ionic compounds to separate
- transport
- e.g. for blood, xylem, phloem
- so that organisms can take in mineral ions
- able to dilute toxic substances

***Exam tip**: here, you need to think of different examples where water plays a vital role by acting as a solvent.*

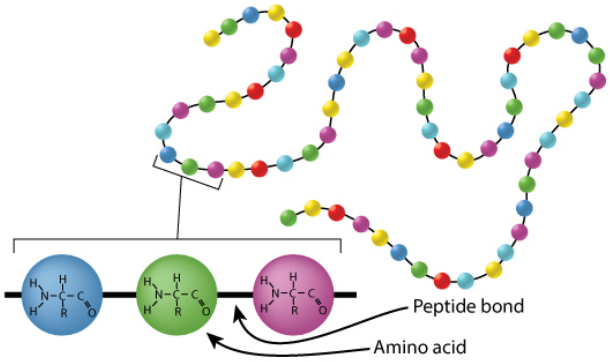
[Total: 10]

Question 2

(a) Amino acids form part of the structure of proteins.

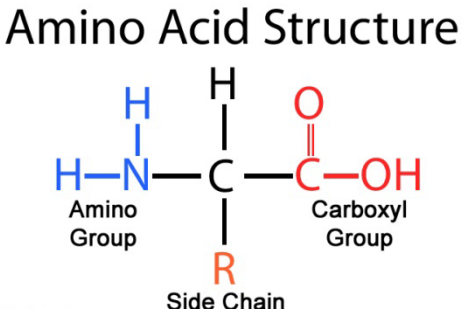
(i) State the name given to the sequence of amino acids in a protein molecule. **[1]**

The sequence of amino acids is the primary structure of a protein



(ii) Draw the **general structure** of an amino acid molecule in the space below. **[3]**

- Amino group at one end
- Carboxyl group at other end
- Central carbon atom



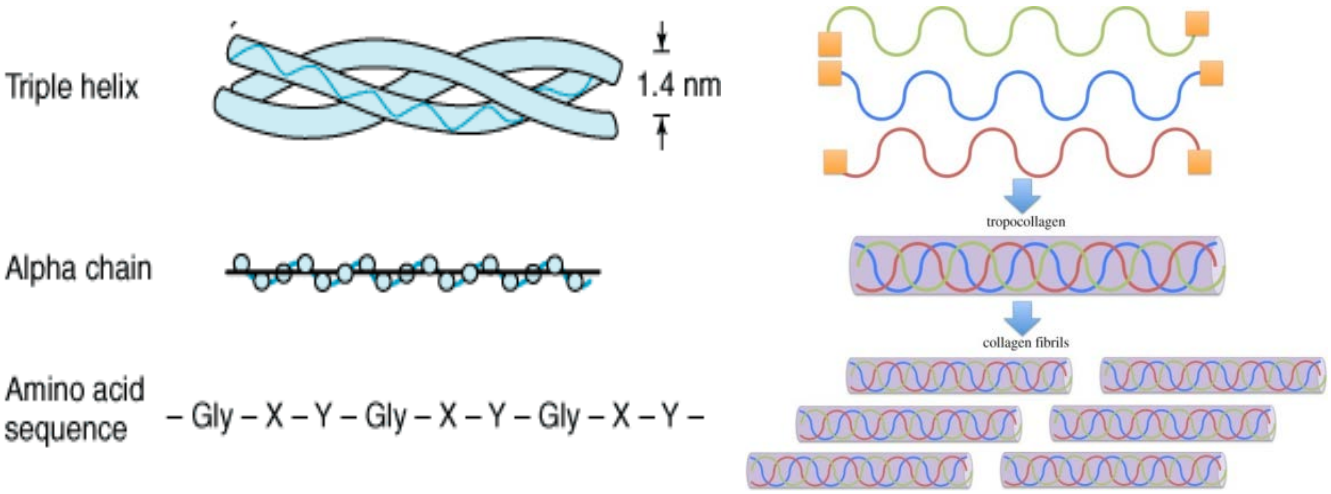
(b) Collagen is an important fibrous protein which forms part of the wall of blood vessels.

(i) State **one** property of collagen that makes it a useful component of blood vessel walls. **[1]**

Collagen is used in the walls of blood vessels because it is very strong

(ii) Describe the **structure** of the collagen molecule. **[6]**

- Collagen consists of amino acids joined by peptide bonds
- Every third amino acid is glycine
- It is arranged in a spiral or helix
- The helix is left-handed
- Glycine is the smallest amino acid and allows the chain to twist
- Collagen consists of three polypeptide chains
- Hydrogen bonds join the polypeptide chains together
- Collagen has very few hydrophilic R groups on the outside of the molecule
- Adjacent molecules of collagen are joined by cross links
- Cross links exist at the end of the molecule where they are staggered



(c) Another protein that is important in mammals is haemoglobin.

(i) State **one** function of haemoglobin. **[1]**

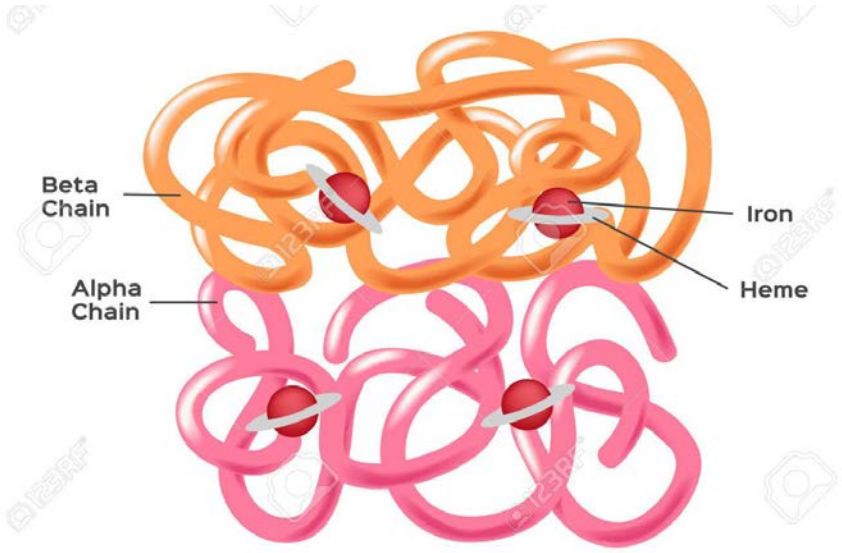
- The function of haemoglobin is to transport oxygen
- Haemoglobin also buffers the hydrogen ions involved in the transport of carbon dioxide

(ii) Haemoglobin contains a prosthetic group known as haem.

Collagen does not contain a prosthetic group.

Describe **three** other ways in which the structure of haemoglobin differs from that of collagen. **[3]**

- Haemoglobin is a globular protein
- Haemoglobin has hydrophobic R groups on the inside and hydrophilic or polar R groups on the outside
- Haemoglobin contains four subunits or polypeptide chains
- The subunits are two different types, two alpha subunits and to beta subunits
- Haemoglobin is twisted into regions of alpha helix
- Haemoglobin has the same proportion of glycine to other amino acids or it does not have a regular sequence of glycine



[Total: 15]

Question 3

(a) Glucose is a hexose sugar and is a monomer in many carbohydrates.

Name the precise group of carbohydrate molecules of which glucose is an example. **[1]**

- Glucose is a monosaccharide

(b) Fig. 6.1 represents the structure of a **β-glucose** molecule.

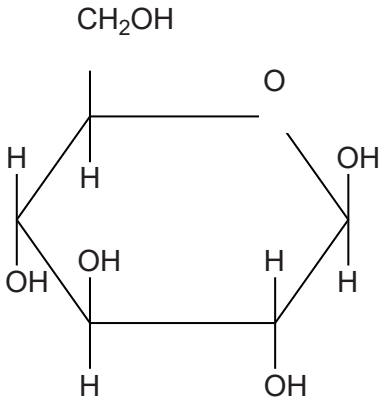
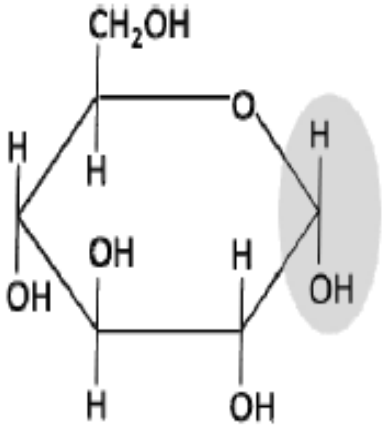


Fig. 6.1

(i) Use Fig. 6.1 to draw a similar representation of an **α-glucose** molecule in the space provided below. **[2]**

A correct diagram as shown below = 2 marks



(i) The cells of living organisms require glucose.

State and explain **two** ways in which the glucose molecule is well suited to its function in living organisms. **[2]**

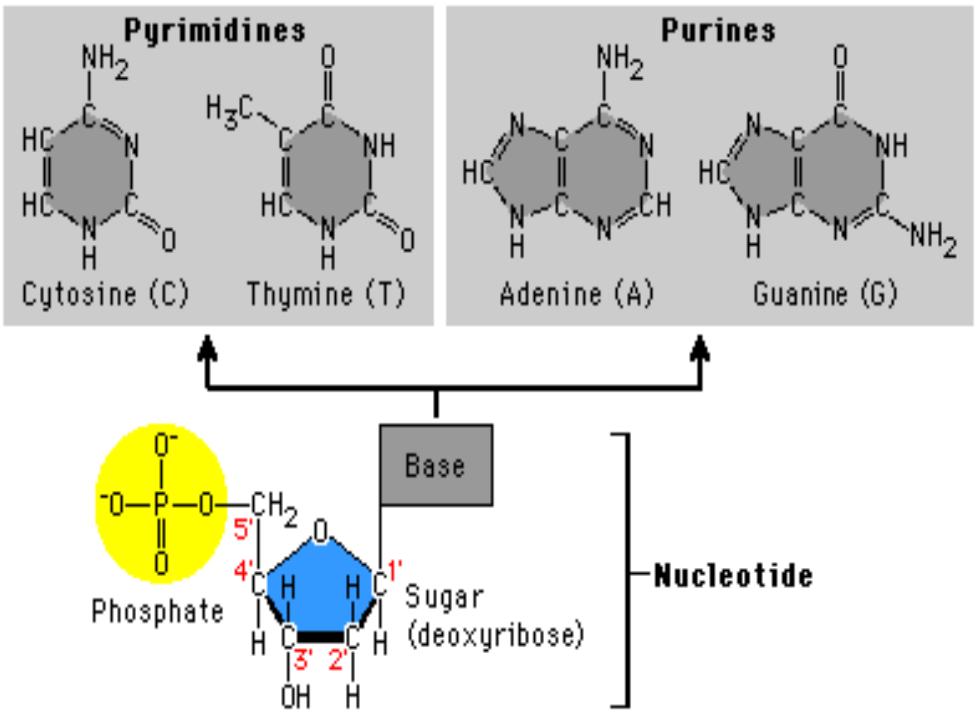
- Glucose is well suited to its function as it is soluble and can be transported around the organism
- It is a small molecule and can be transported easily across cell membranes
- It can be quickly respired to release energy as ATP
- Glucose can be easily joined to form disaccharides and polysaccharides such as starch and cellulose.

(c) Deoxyribose is a pentose sugar that is a component of the double-stranded DNA molecule.

Describe the structural relationship between deoxyribose and the other components of the DNA molecule.

[3]

- The deoxyribose sugar is part of a nucleotide
- It is attached to a base such as adenine and a phosphate
- The phosphate is joined to carbon 5 of one sugar and carbon 3 of another
- Deoxyribose sugar is part of the backbone of DNA
- Nucleotides are the repeating units or monomers of DNA



A good plan for this answer is to draw a diagram. If you have time, perhaps at the end of the exam, you could include an annotated diagram as part of the answer. Sometimes it's easier to gain marks this way.

(d) Cellulose is a carbohydrate.

A student described the structure of cellulose as follows:

The cellulose molecule is insoluble. It contains only the elements carbon, hydrogen and oxygen. It is made up of α-glucose subunits. The glucose subunits are linked by 1-4 glycosidic bonds formed by hydrolysis reactions. It also has some 1-6 glycosidic bonds. It is made of many long chains. The chains have branches.

(i) Identify **three** mistakes made by the student when describing the structure of cellulose. **[3]**

- The student described cellulose as containing alpha glucose when in fact it is made from beta glucose
- Cellulose does not have 1,6 bonds
- The glucose subunits are not joined by hydrolysis but condensation reactions
- Cellulose is a straight chain and does not have branches

(ii) Suggest the name of a molecule that closely matches the student's description. **[1]**

- The student's description more closely matches that of glycogen or amylopectin

[Total: 12]

Question 4

Biological molecules are held together by a variety of bonds.

(a) The diagram in Fig. 1.1 represents an amino acid.

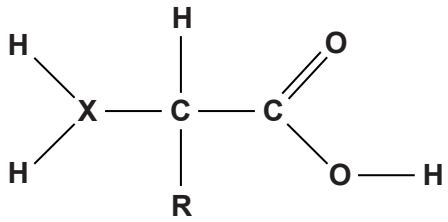


Fig. 1.1

(i) One of the atoms that make up an amino acid has been replaced with the letter **X**. State the chemical symbol of the atom represented by the letter **X** in Fig. 1.1. **[1]**

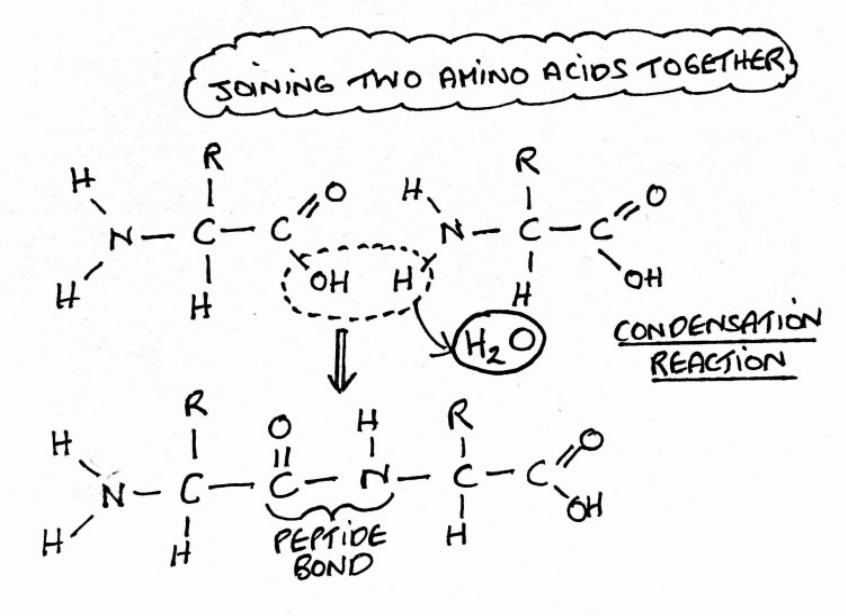
- The chemical symbol is N for nitrogen

(ii) Name the polymer formed from a chain of amino acids. **[1]**

- The polymer formed from a chain of amino acids is a polypeptide

(iii) Name the bond that is formed when two amino acids are joined together. Describe the formation of this bond.

- Peptide bond
- This bond is formed between the amine group of amino acid and the carboxyl group of another
- The hydrogen from an amino group combines with the hydroxyl from the carboxyl group
- This is a condensation reaction which involves the production of water



(b) Fig. 1.2 shows a hydrogen bond between two water molecules.

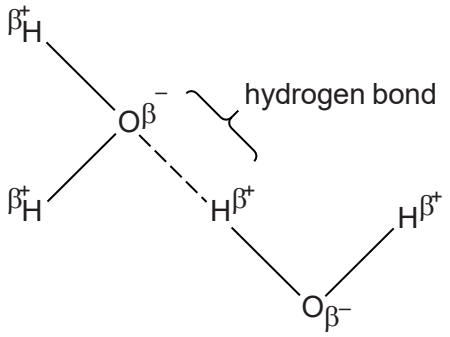


Fig. 1.2

(i) Many of the physical properties of water arise as a result of these hydrogen bonds.

Describe ways in which the physical properties of water allow organisms to survive over a range of temperatures.

In your answer you should make clear links between the properties of water and the survival of organisms. **[9]**

- Water has a high latent heat of vaporisation
- Evaporation is used to cool the organism, good examples are sweating and panting
- Water has a high specific heat capacity
- This provides a stable environment for organisms that live in water

- It takes a lot of energy to change the temperature of an organism
- Temperature is important for enzymes to function correctly
- Ice is less dense than water so it floats on the surface
- Ice on the surface provides a habitat for organisms
- Ice also insulates the water underneath from the cold air so it does not freeze
- Water is a good solvent
- Water provides a medium for reactions to take place in, such as the cytoplasm of the cell
- Water shows cohesion and adhesion, cohesion maintains the column of water in the xylem
- At the surface of water a surface tension exists
- Surface tension provides a habitat for animals such as pond skaters

Water molecules are attracted to each other by hydrogen bonding. For water to evaporate more energy is needed to break the hydrogen bonds before the molecules of water can change from liquid to gas. The energy for this process is taken from the surface of the organism such as the leaves of a plant or the skin of animal.

Water also has a high specific heat capacity, so a large amount of energy is needed to change the temperature of water. This, once more, is due to hydrogen bonding. To gain kinetic energy as the temperature increases the water molecules must first break the hydrogen bonds between them, this means that for organisms which contain a large amount of water the temperature is thermally stable, this is important for enzymes which are very sensitive to changes in temperature. Water is needed for all metabolic reactions to take place in as it provides a medium in which they can take place. As water is polar it is a very good solvent and is an excellent transport medium. Water is needed to hydrolyse molecules such as starch to glucose and proteins to amino acids.

(ii) List **three other** examples of where hydrogen bonds are found in biological molecules. **[3]**

- Hydrogen bonds are found in the secondary structure of proteins, when they form an alpha helix
- Hydrogen bonds are also involved in the tertiary structure
- In quaternary structures such as haemoglobin, polypeptide chains are held together by hydrogen bonding
- Hydrogen bonds are found between chains of cellulose
- They are also found between complementary base pairs in DNA

[Total: 17]