SL Paper 3

a. Outline primary and quaternary protein structures. [2]

Primary protein structure:

Quaternary protein structure:

b. List **three** limiting factors of photosynthesis. [3]

Markscheme

a. a. (primary structure) is sequence of amino acids;

b. (quaternary structure) is the linking of two or more polypeptides to form one protein;

b. a. temperature;

b. pH;

c. light;

d. CO_2;

Examiners report

a. Only the better candidates could give a satisfactory outline of both the primary and secondary structure of protein.

b. N/A

Outline the differences between these two proteins.

Markscheme

a. hemoglobin is a globular protein while keratin is a fibrous protein;

b. hemoglobin folds into rounded structures while keratin remains linear;

c. hemoglobin is a soluble protein while keratin is not;

d. hemoglobin consists of four peptides/subunits while keratin does not;

e. hemoglobin has prosthetic/heme groups while keratin does not;

f. hemoglobin functions as transport molecule while keratin is a structural molecule/part of hair/nails;

Examiners report

Many candidates received 2 or 3 marks for differentiating between the globular and fibrous proteins shown as well as knowing either the differences in solubility or function. Candidates did not mention that hemoglobin consists of four polypeptides whereas keratin does not or that hemoglobin has a prosthetic/heme group while keratin does not. Many were incorrectly stating that keratin has only a secondary structure and hemoglobin has a tertiary structure which is not an accurate statement. The diagram showed links (disulphide bonds) between two alpha-helices to form the tertiary structure of keratin. Both have secondary and tertiary structure but they are different and this was not made clear.

Explain the significance of polar and non-polar amino acids in proteins.

Markscheme

polar amino acids are water soluble/hydrophilic, non-polar amino acids are not/hydrophobic;

distribution of amino acids influences the position of proteins (in membranes);

polar amino acids often found on outside of protein, non polar orientate themselves away from water/ in core of protein;

polar amino acids create hydrophilic channels through membranes;

non-polar amino acids interact with lipid bi-layer/stabilize proteins in membranes;

polarity of amino acids determines the specificity of active sites in enzymes;

polar and non-polar amino acids affect the tertiary and quaternary/3D structure of proteins;

Examiners report

It would seem that many candidates did not fully understand what was required in this question, and the meaning of the word ”significance” may have misled some students. The question was asking about proteins, but many answered solely in terms of membranes. Those who gained marks did so mainly for referring to the hydrophilic/ hydrophobic nature of amino acids and their ability to affect the tertiary/quarternary/3D structure of proteins.

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a. Define *quaternary structure* in proteins. [1]

b. Outline the importance of polar and non-polar amino acids in proteins. [2]

c. Describe non-competitive inhibition. [2]

Markscheme

a. the linking together of two or more polypeptides to form a protein

b. polar and non-polar amino acids help determine protein structure;

polar amino acids on the outside of proteins make them soluble in water;

polar amino acids in channels in membranes allow passage of polar substances/ reference to surface proteins or membranes;

polarity ***or*** non-polarity of surface amino acids on proteins determines their interaction with other molecules (substrates, hormones, signalling molecules);

c. inhibitor molecule attaches to enzyme at site away from active site/attaches to allosteric site;

binding of inhibitor molecule alters shape of active site/causes conformational change;

shape change in active site disables enzyme from accepting substrate/reduces enzyme activity/destroys enzyme functionality;

increasing substrate concentration has no effect on the inhibitor;

irreversible;

Examiners report

a. Most answers were correct.

b. Very few candidates were able to outline the importance of polar and non-polar amino acids in proteins.

c. In general candidates did know how noncompetitive inhibitors work.

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a. State **two** functions of proteins, giving a **named** example of each. [2]

b. Explain the significance of polar and non-polar amino acids. [3]

Markscheme

a. enzymes/biological catalyst – amylase/protease/lipase/catalase;

defence/immunity – immunoglobin/antibody;

structure – collagen;

movement – actin/myosin;

transport – hemoglobin;

synthesis – ligase/DNA polymerase;

hormonal communication – insulin/luteinizing hormone; *MUST be proteinaceous*

food stores – casein in milk;

pigments – opsin;

Accept any other valid responses.

b. polar amino acids have hydrophilic R groups, non-polar have hydrophobic R groups;

non-polar amino acids in centre of water-soluble proteins stabilise their structure;

non-polar amino acids cause proteins to remain embedded in membrane;

polar amino acids on surface of proteins make them water-soluble;

polar amino acids create hydrophilic channels/protein pores in membranes;

enzyme active site specificity depends on amino acids present/polar and nonpolar amino acids can play a role in substrate interactions at the active site;

Examiners report

a. This was answered well by the majority of candidates, and they could give suitable named examples.

b. Many candidates gave vague responses, and many appeared to not understand the concept of hydrophilic and hydrophobic. Few could discuss the roles of the amino acids in proteins.

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a. List **three** functions of proteins, giving a **named** example of each. [3]

b. Explain the significance of polar amino acids and non-polar amino acids in membranes. [2]

Markscheme

a. catalysts/digestion – amylase/protease/lipase/catalase;

defense – immunoglobin / fibrinogen;

structure – collagen;

movement – actin/myosin;

transport – hemoglobin;

synthesis – ligase/DNA polymerase;

hormonal communication – insulin/luteinizing hormone;

light detection – rhodopsin / plant phytochromes;

storage – ferritin/gluten/casein;

Accept any other valid responses.

b. non-polar amino acids for hydrophobic part of the bilipid layer;

polar amino acids for hydrophilic environment;

polar amino acids allow hydrophilic channels;

integral proteins are held in place by polar amino acids;

*To award **[2 max]** both polar and non-polar should be addressed.*

Accept answers in the form of a diagram.

Examiners report

a. Here some candidates did not read the entire question and only listed the functions without a named example.

b. C3 (b) seemed to be very difficult and very few got this question right. Some candidates did mention the polarity and hydrophobicity of the amino acids, but did not mention the significance of them to membranes. This is clearly an area that needs reinforcing.

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b. Distinguish between the secondary structure and tertiary structure of proteins. [3]

c. Explain what is meant by allosteric inhibition. [3]

Markscheme

b.

secondary structure refers to regular repeating regions within the overall protein structure	while tertiary structure refers to the protein overall / 3-D;
secondary structure α helix/β sheets	while tertiary is globular/fibrous;
forces between amino and carboxyl groups/atoms within backbone in secondary structure	while intramolecular forces between R-groups for tertiary structure;
H-bonds	H-bonds / disulfide bonds / ionic bonds / hydrophobic interactions;

To award a mark responses must refer to both secondary and tertiary structures.

c. form of non-competitive inhibition;

(inhibitor) binds to a site that is not the active site;

causing conformational change;

changes the active site;

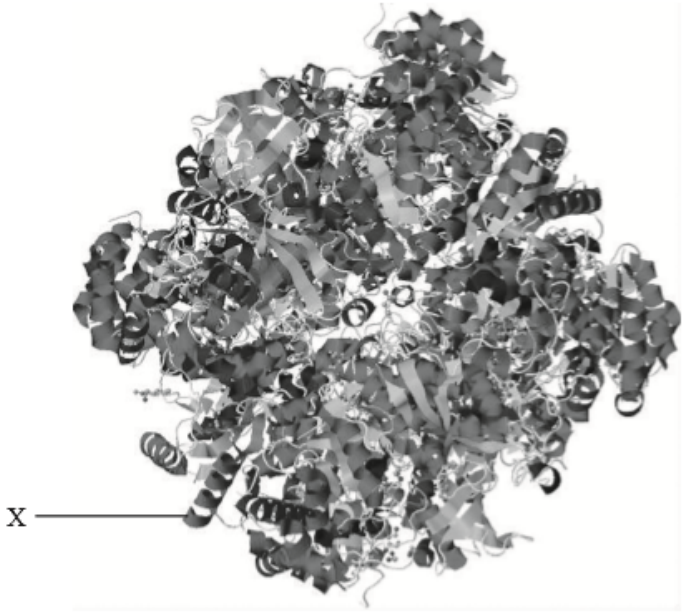
so substrate can no longer bind to active site;

Examiners report

b. Many candidates forgot to distinguish between the secondary and tertiary structures of proteins. This command term requires showing the differences between them, not just a description of one of them.

c. Allosteric inhibition was well understood by a number of candidates.

The following image represents a model of ribulose bisphosphate (RuBP) carboxylase (also known as Rubisco) from the green alga *Chlamydomonas*.



[Source: Image from the RCSB Protein Data Bank: http://www.pdb.org/pdb/explore/jmol.do?structureId=1GK8&bionumber=1]

a (i). Identify the level of protein structure of the part labelled X. [1]

a (ii). State the role of ribulose bisphosphate (RuBP) carboxylase in the Calvin cycle. [1]

c. Explain non-competitive inhibition. [2]

Markscheme

a (i). secondary (structure) / α helix

a (ii). fixes/adds carbon/CO_2 to RuBP

c. a. inhibitor binds to enzyme at different location than active site;

b. this causes a change in the shape/conformational change of active site;

c. thus preventing the substrate from binding to the active site / resulting in a decrease of enzyme activity/speed of reaction;

Examiners report

a (i). A relatively small number of candidates answered this option, but those who did generally achieved well.

In C2 (a) (i) most answers were correct.

a (ii). A relatively small number of candidates answered this option, but those who did generally achieved well.

A comment on a G2 suggested that the examination should have used the abbreviation Rubisco as this is found in many texts rather than ribulose bisphosphate. Although many texts may use this abbreviation, the examination was based on the terminology used in the subject guide. Teachers who do not use the terminology of the guide may disadvantage students, as appears to have been possible with this question.

c. A relatively small number of candidates answered this option, but those who did generally achieved well.

In C2 (c) in general candidates did know how non-competitive inhibitors work. This is a standard question that revision of past papers would have prepared candidates well for.