2.3 Proteins

Question Paper

Course	DP IB Biology
Section	2. Molecular Biology
Topic	2.3 Proteins
Difficulty	Hard

Time allowed: 70

Score: /58

Percentage: /100

Question 1a

a)
Albumin is a protein found in the plasma of the blood.

Albumin transports hormones, fatty acids, and other compounds in the blood, buffers blood pH, and maintains oncotic pressure, among other functions.

The gene that codes for human albumin is 16,961 DNA bases long. The protein is made up of 585 amino acids.

Calculate the ratio of non-coding to coding DNA in the albumin gene.

[3 marks]

[3 marks]

Question 1b

b)
Albumin is a protein that can be found in a range of vertebrate species.

Different species have slight variations in the structure of the protein. For example, bovine (cow) albumin has 583 amino acids.

Cows and humans share a common ancestor.

Suggest why it is the case that the two types of albumin are similar, but not completely the same as each other.

[3 marks]

[3 marks]

Question 1c

c)
Egg whites are mostly made of albumin.

When the albumin in egg white becomes denatured it causes the 'white' to change from being colourless to being opaque white.

A student wanted to investigate how temperature affects the denaturing of albumin.

Outline a method that the student could use in order to carry out this investigation.

[4 marks]

[4 marks]

Question 1d

d)
When the albumin in the egg white is not denatured it is soluble in the liquid, however, when it denatures it becomes insoluble. This is the mechanism that causes the colour change.

Explain how the protein can have different properties before and after denaturing.

[2 marks]

[2 marks]

Question 2a

a)
A theoretical polypeptide chain is 26 amino acids long.

Calculate how many different possible combinations of amino acids could exist within this chain.

Give your answer in standard form.

[2 marks]

[2 marks]

Question 2b

b)
An average sized polypeptide of around 400 amino acids in length is said to have an infinite number of possible amino acid combinations.

Explain why it is possible for such a vast variety of polypeptides to exist.

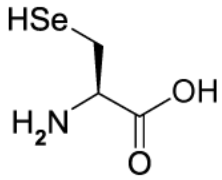
[2 marks]

[2 marks]

Question 2c

c)
In some rare circumstances, some organisms have been found to contain unusual amino acids that are not shared with the majority of other organisms.

Selenocysteine is one of them, and is shown in the image below.



Using the image, state what makes selenocysteine so unusual compared to other amino acids.

[1 mark]

[1 mark]

Question 2d

d)
Some amino acids exist that have been man-made in a lab and have never been used naturally in the proteins of living organisms.

Describe the features that must exist in these molecules in order for them to be classified as amino acids.

[3 marks]

[3 marks]

Question 3a

a)
Insulin is a protein that is produced naturally by most people, however, people with insulin-dependent diabetes rely on injecting insulin to replace the protein that they cannot produce for themselves.

Explain why the insulin must be injected into the blood instead of taken orally.

[2 marks]

[2 marks]

Question 3b

b)
Many years ago, insulin used to be taken from cows and pigs to treat people with diabetes.

Using your knowledge of protein structure, suggest why pig and cow insulin was less effective at regulating blood glucose levels than human insulin.

[2 marks]

[2 marks]

Question 3c

c)
In modern medicine, human insulin is secreted from genetically modified bacteria into large industrial vats called fermenters. This allows the insulin to be extracted and purified for human use.

Outline why the insulin produced by the genetically modified bacteria is identical to insulin produced by a human.

[3 marks]

[3 marks]

Question 3d

d)
Other organisms that can be genetically engineered to produce proteins for human medicine are goats.

Goats can be engineered to produce protein in their milk, for example, a protein called ATryn, which is used to reduce the risk of blood clots in human patients.

The goats can be milked and then the protein is extracted to be given to patients.

Compare and contrast this method of producing proteins for human medicine to the use of genetically modified bacteria for the same purpose.

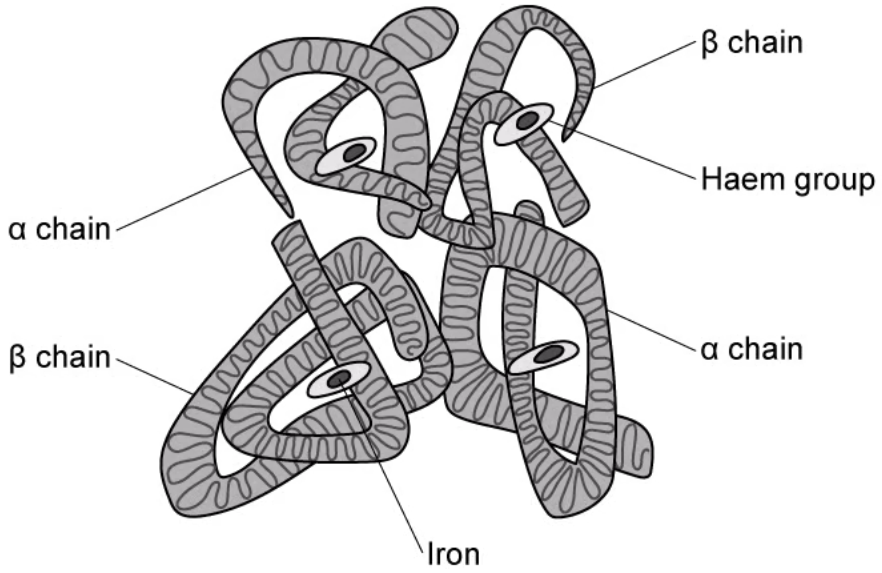
[5 marks]

[5 marks]

Question 4a

a)
Haemoglobin is an example of a protein.

Using the diagram below and your own knowledge, describe the structure of haemoglobin.



[3 marks]

[3 marks]

Question 4b

b)
During a human's lifetime, they use different forms of haemoglobin.

Fetal haemoglobin varies in structure to normal haemoglobin and it is adapted to absorb oxygen when the oxygen concentration is lower.

Why would this benefit the foetus?

[3 marks]

[3 marks]

Question 4c

c)
Foetal haemoglobin is phased out quite early on in development and is replaced with adult haemoglobin.

This is an example of how the proteome changes throughout an individual's lifetime.

Unlike the proteome, the genome remains fixed.

Outline how it is possible for the proteome to vary throughout an individual's lifetime, even though the genome stays the same.

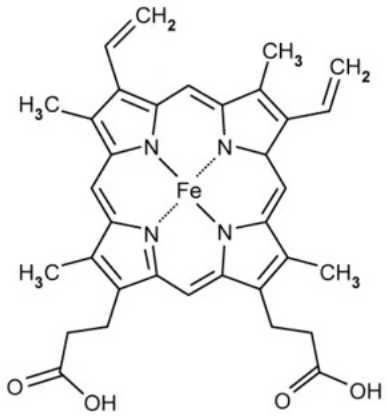
[2 marks]

[2 marks]

Question 4d

d)
The image below shows the part of haemoglobin that binds to oxygen to deliver it around the body.

Is this an amino acid? Explain your reasoning.



[3 marks]

[3 marks]

Question 5a

One mark is available for clarity of communication throughout this question.

a)
State the essential properties of membrane-bound proteins.

[3 marks]

[3 marks]

Question 5b

b)
Explain why studying the proteomes of a variety of different species is beneficial to humans.

Use specific examples in your answer.

[5 marks]

[5 marks]

Question 5c

c)
If a person has been infected with the influenza virus in the past they possess the necessary immunoglobulins to provide immunity to that virus again in the future.

Influenza viruses contain RNA as their genetic information.

State, with reference to RNA and protein structure, why it is possible for people to get the flu several times in their life.

[7 marks]

[7 marks]