

Please check the examination details below before entering your candidate information

Candidate surname <i>StemUp Model Solution</i>		Other names	
Pearson Edexcel Level 3 GCE		Centre Number 	Candidate Number
Time 2 hours		Paper reference	9BN0/01
Biology A (Salters Nuffield) Advanced PAPER 1: The Natural Environment and Species Survival			
You must have: Calculator, HB pencil, ruler			Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Show your working in any calculation questions and include units in your answer where appropriate.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 100.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- You may use a scientific calculator.
- In questions marked with an **asterisk** (*), marks will be awarded for your ability to structure your answer logically, showing how the points that you make are related or follow on from each other where appropriate.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.
- Good luck with your examination.

Turn over ►

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Answer ALL questions.

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Climate change has been linked to the release of carbon dioxide from some power stations.

(a) The main reason that carbon dioxide acts as a greenhouse gas is because it (1)

- ☒ **A** absorbs infrared radiation reflected by the surface of the Earth
- ☐ **B** absorbs ultraviolet radiation reflected by the surface of the Earth
- ☐ **C** reflects infrared radiation absorbed by the surface of the Earth
- ☐ **D** reflects ultraviolet radiation absorbed by the Earth's atmosphere

(b) Name the plant organelle that fixes carbon dioxide from the atmosphere. (1)

Chloroplast

(c) Net primary productivity (NPP) is a measure of the increase in biomass of a plant.

Explain why respiration affects the production of biomass. (2)

NPP = GPP - R, so energy (biomass) used in respiration is lost and is not available to the plant.

Organic molecules such as glucose are broken down in respiration to provide energy (ATP) for the plant.

Therefore the more glucose used in respiration, the less is available for the production of biomass.



- (d) Some power stations burn wood chips instead of fossil fuels to produce electricity.

The photograph shows wood chips at a power station.



© Mr. Amarin Jitnathum/Shutterstock

It is thought that burning wood chips is more beneficial to the environment because in the long term it does not add carbon dioxide to the atmosphere.

Explain why burning wood chips does not increase carbon dioxide to the atmosphere in the long term.

(4)

Trees take in (absorb) carbon dioxide from the atmosphere and fix the carbon during photosynthesis, so the carbon is stored in the wood.

When the wood chips are burned, the carbon dioxide released is only the carbon dioxide that was absorbed by the trees as they grew, so it replaces that absorbed by the trees.

New trees are grown (planted) to replace those that are cut down, and these absorb the same amount of carbon dioxide again.

Therefore there is no net increase in carbon dioxide in the atmosphere: burning wood chips is carbon neutral, unlike fossil fuels which release carbon that has been locked away for millions of years.

(Total for Question 1 = 8 marks)



2 Skulls can be used as evidence for human evolution.

The only type of human present today is the modern human. In the past, another type of human, called Neanderthal, occupied the same geographical area.

The photograph shows the skulls of both types of human.



Modern human skull

Neanderthal skull

© hairyuseummatt/DrMikeBaxter

Genetic studies now show that these two types of human have interbred.

(a) Only small quantities of DNA can be extracted from the remains of Neanderthal humans.

The quantity of extracted DNA is amplified using

(1)

- ☐ A DNA profiling
- ☒ B polymerase chain reaction
- ☐ C RNA profiling
- ☐ D translation chain reaction



- (b) Devise a procedure, using electrophoresis, to compare the amplified DNA from these two types of human.

(4)

Use restriction enzymes (restriction endonucleases) to cut the amplified DNA from the modern human and from the Neanderthal into fragments, using the same enzymes for both samples.

Load the DNA samples into separate wells at one end of an agarose gel, with a DNA ladder of known fragment sizes in another well.

Apply a potential difference across the gel (pass an electric current through it). The negatively charged DNA fragments move towards the positive electrode, with smaller fragments moving further.

Add markers such as a fluorescent dye (or radioactive probes) to visualise the bands, e.g. under UV light.

Compare the position of the bands produced by the two types of human.

- (c) Explain how the results of electrophoresis could provide evidence for interbreeding between the two types of human.

(2)

Compare the location and number of bands produced by the two types of DNA, e.g. whether bands are at the same position, next to each other.

Similarities (matching bands) would indicate that interbreeding occurred in the past.

(Total for Question 2 = 7 marks)



- 3 During the civil war in Mozambique, from 1977 to 1992, 90% of the African elephants were killed for the ivory in their tusks.

Since 1992, the elephant population in Mozambique has increased.

The photograph shows a group of elephants in Mozambique.

Elephant
without tusks



Elephant
with tusks

© ALEXANDER JOE/Staff/Getty Images

A study of an elephant population in Mozambique was carried out in 2017.

The elephants studied were all born before 1992.

The table shows the number of elephants with and without tusks.

Elephants	Number of elephants
with tusks	98
without tusks	102



- (a) The presence of tusks is controlled by a single gene. The allele for tusks is known to be dominant.

The frequency of alleles in a population can be determined using the Hardy-Weinberg equation.

Calculate the frequency of the dominant and recessive alleles in this population. Give your answer to 2 decimal places.

(3)

$$p^2 + 2pq + q^2 = 1$$

$$q^2 = 102 \div 200 = 0.51$$

$$q = \sqrt{0.51} = 0.714$$

$$p = 1 - 0.714 = 0.286$$

Frequency of the dominant allele 0.29

Frequency of the recessive allele 0.71



(b) In most African elephant populations, 2% to 4% of elephants do not grow tusks.

- (i) Explain why the percentage of elephants without tusks in Mozambique will probably increase in the future.

(3)

Many of the elephants with tusks were killed for their ivory, so a large percentage of the surviving population do not have tusks.

Elephants without tusks were more likely to survive (not be poached) and breed.

Therefore they pass on the recessive alleles for not having tusks to their offspring.

This increases the frequency of homozygous recessive (tuskless) elephants in the population.

- (ii) Describe how the Hardy-Weinberg equation can be used to provide evidence for changes in the elephant population in Mozambique.

(2)

Calculate the allele frequencies (number of dominant and recessive alleles) in the elephant population in Mozambique using the Hardy-Weinberg equation.

Repeat this by regular sampling over a period of time and compare the frequencies to see if they change.

(Total for Question 3 = 8 marks)



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4 Fertilisation in humans involves the fusion of a sperm cell with an egg cell.

(a) (i) After the sperm cell nucleus fuses with the egg cell nucleus, the single fertilised cell is described as a

(1)

- ☐ A diploid gamete
- ☒ B diploid zygote
- ☐ C haploid gamete
- ☐ D haploid zygote

(ii) The fertilised cell then divides by

(1)

- ☐ A meiosis to produce genetically different cells
- ☐ B meiosis to produce genetically identical cells
- ☐ C mitosis to produce genetically different cells
- ☒ D mitosis to produce genetically identical cells

(b) Cell division of the fertilised cell produces a ball of totipotent cells.

(i) Give the meaning of the term totipotent cell.

(2)

A cell that has the ability to differentiate (specialise)

into all cell types, including the cells of the placenta.



- (ii) This ball of cells continues to divide to form the embryo. The cells of the embryo become specialised to form tissues and organs.

Describe how cells become specialised.

(3)

Chemical signals cause some genes to be activated (switched on), e.g. by transcription factors, while other genes are switched off.

Only the activated genes are transcribed to produce mRNA.

The mRNA is translated, leading to the synthesis of specific proteins, which modify the cell and determine its structure and function.

- (c) Factors such as the diet of the mother during pregnancy can cause epigenetic changes in the embryo.

Explain how epigenetic changes affect the development of tissues in the embryo.

(3)

DNA in a chromosome is wrapped around histone proteins.

Acetylation (modification) of the histones affects how tightly the chromosome is wound, so it affects unwinding and the binding of RNA polymerase.

Methylation of DNA affects the transcription of genes (production of mRNA).

Therefore gene expression is altered and different proteins are synthesised, changing how the tissues develop.

(Total for Question 4 = 10 marks)



5 Wildlife conservation can involve keeping animals in zoos as well as protecting habitats.

(a) Describe the roles that zoos play in animal conservation.

(3)

Protection: animals are protected from poachers and hunting, and receive vet care and medicines.

Repopulation: captive breeding programmes increase numbers, and animals can be released back into the wild.

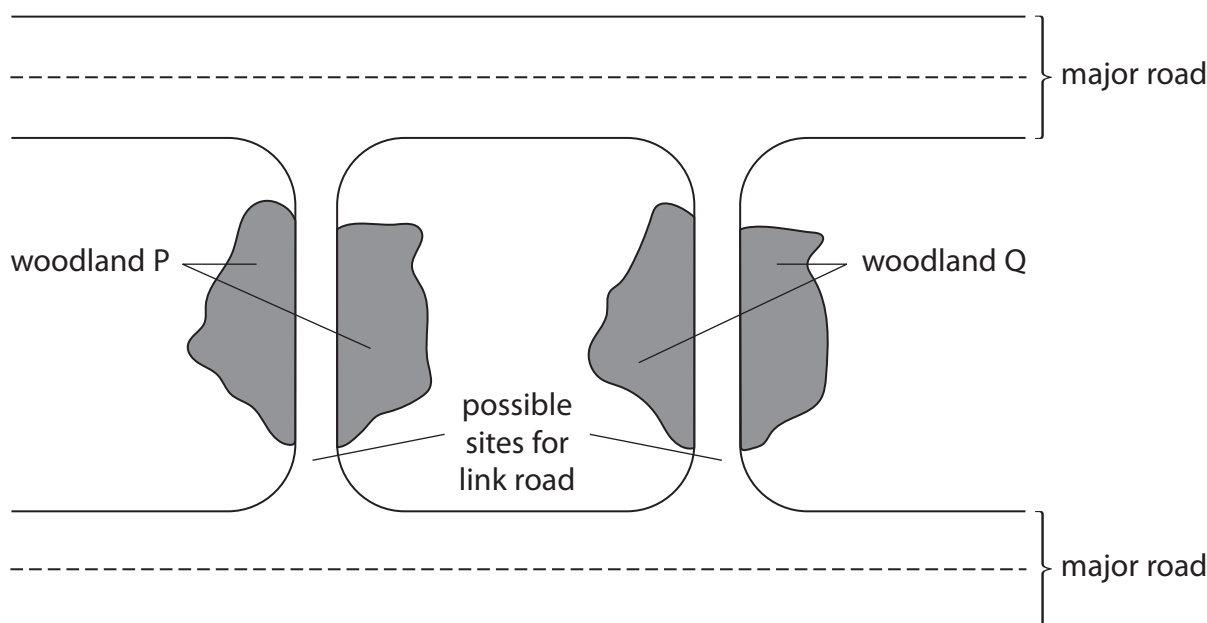
Education: visitors are educated about conservation.

Research: e.g. improving health, nutrition and breeding cycles, and developing a genetic database.

(b) Habitats can be destroyed by road building.

A link road is planned to connect two major roads.

The diagram shows the two possible sites for the link road and two woodland habitats.



(i) State what is meant by the term habitat.

(1)

The area (place) inhabited by a particular species (organism).

(ii) To decide which of the two link roads should be built, studies of the biodiversity of woodlands P and Q need to be carried out.

Discuss what information needs to be collected from the two woodlands to make a decision about the site of the link road.

(4)

Biodiversity in each woodland should be measured and compared using a diversity index.

Species richness should be assessed by counting the number of different species in each woodland.

The genetic diversity of the populations (species) in each woodland should be measured.

The presence of any endemic or rare (endangered) species, at risk of extinction, should be recorded.

The road should be built through the woodland with lower biodiversity.

(Total for Question 5 = 8 marks)



P 6 5 4 5 8 A 0 1 3 3 2

6 Hereditary spherocytosis is a condition that affects red blood cells.

This inherited condition is caused by a gene mutation that affects the shape of the cell surface membrane.

(a) Describe the structure of the cell surface membrane.

(3)

The cell membrane is made mainly of phospholipids and proteins.

The phospholipids form a bilayer, with hydrophilic phosphate heads facing outwards and hydrophobic fatty acid tails facing inwards.

The proteins float in the phospholipids and can change position: this is the fluid mosaic model.

Some proteins span the bilayer (intrinsic) while others are located in only one layer (extrinsic).



- (b) The red blood cells of individuals with spherocytosis are spherical instead of having a biconcave disc shape.

Explain the effect of spherocytosis on the uptake of oxygen by red blood cells.

(3)

Oxygen enters the red blood cells by diffusion.

The spherical shape reduces the surface area to volume ratio and increases the diffusion distance compared with a biconcave disc.

Therefore gas exchange decreases and less oxygen enters the cells.

- (c) Most cases of hereditary spherocytosis are caused by a dominant allele.

Use a genetic diagram to determine the probability of a child inheriting this condition if one parent is heterozygous and the other parent does not have the condition.

(2)

S = condition (dominant), s = normal

Parents: Ss × ss

	S	s
s	Ss	ss
s	Ss	ss

Ss = affected, ss = unaffected

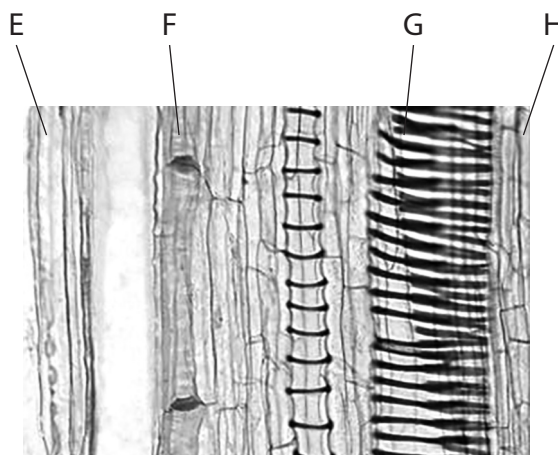
Answer *0.5 (50%)*

(Total for Question 6 = 8 marks)



7 The stems of plants contain tissues involved in transport and in support.

(a) The photograph shows a longitudinal section through one plant stem.



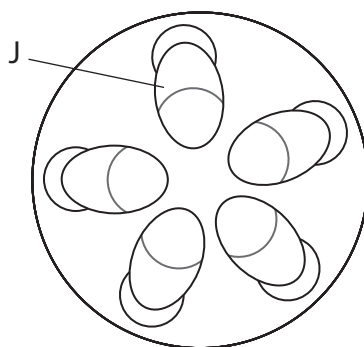
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(i) Which labelled structure in the photograph contains lignin?

(1)

- ☐ A E
- ☐ B F
- ☒ C G
- ☐ D H

(ii) The diagram shows a transverse section through a plant stem.



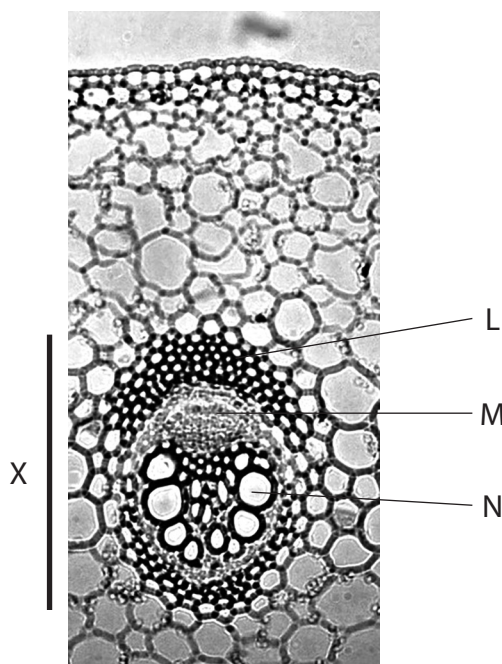
Which of the labelled structures in the photograph is located in the area labelled J in the diagram?

(1)

- ☐ A E
- ☒ B F
- ☐ C G
- ☐ D H

(b) The photograph shows a cross section of part of the stem of a plant.

Fibres can be extracted from stems similar to this one and used instead of fibres produced from oil-based plastics.



John Bebbington FRPS Science and Plants for schools – <https://www.saps.org.uk>

(i) The part of the stem labelled L contains

(1)

- ☐ A phloem that transports organic solutes
- ☒ B sclerenchyma fibres that provide support
- ☐ C sieve tubes that transport water
- ☐ D xylem vessels that transport water and mineral ions

(ii) The part of the stem labelled M contains

(1)

- ☒ A phloem that transports organic solutes
- ☐ B sclerenchyma fibres that transport water
- ☐ C sieve tubes that synthesise organic solutes
- ☐ D xylem vessels that transport water and mineral ions

(iii) The structure labelled N is a

(1)

- ☐ **A** part of the phloem that transports water
- ☐ **B** sclerenchyma fibre that provides support
- ☐ **C** sieve tube that transports organic solutes
- ☒ **D** xylem vessel that transports water and mineral ions

(iv) The line labelled X on the photograph represents the width of the vascular bundle.

The actual width of the vascular bundle is $320\text{ }\mu\text{m}$.

Calculate the magnification of the image.

(3)

Length of line X = 36 mm

$36\text{ mm} = 36\,000\text{ }\mu\text{m}$

magnification = image size $\div$ actual size

$= 36\,000 \div 320 = 112.5$

Answer *$\times 112.5$*



- (c) Fibres can be extracted from the stems of nettle plants and used to make clothing.

Explain why the production of fibres from nettles is more sustainable than fibres produced from crude oil.

(3)

Nettle plants can be grown again (replanted) each year, so they are renewable and will not run out.

Crude oil is non-renewable and will run out.

So the use of fibres from nettles will still be available to future generations.

Clothing made of nettle fibres is also biodegradable, so it does not persist in the environment like plastic.

(Total for Question 7 = 11 marks)



8 Penicillin is an antibiotic. It was discovered in 1928. Since then many antibiotics have been identified and are widely used in the treatment of bacterial infections.

(a) State what is meant by the term bacteriostatic antibiotic.

(1)

A substance that inhibits the growth (prevents the multiplication) of bacteria, without killing them.

(b) Scientists have recently discovered a new class of antibiotics that bind to ribosomes.

(i) Explain why these antibiotics could affect the production of proteins in bacteria.

(3)

The antibiotic binds to the bacterial ribosome, so the shape of the ribosome is altered.

mRNA is prevented from binding to the ribosome, or the binding of tRNA is changed.

Therefore translation cannot occur.

So the protein (polypeptide) is not synthesised, or a faulty protein is produced.



- (ii) These new antibiotics attach to a site on the ribosome not affected by any known antibiotics.

Deduce why these new antibiotics might be used to treat bacteria that are resistant to other antibiotics.

(2)

The bacteria have developed resistance to other antibiotics by natural selection (evolving), but have not been exposed to the new antibiotics before, so they have no mechanisms to make them resistant.

Therefore there has been no advantage to possessing a mutation to bypass the new antibiotic, so no mutation giving resistance is present.

- *(iii) Scientists have isolated these new antibiotics and tested their effectiveness against bacteria that are resistant to other types of antibiotic.

Devise a laboratory procedure to compare the effectiveness of penicillin with one of the new antibiotics.

(6)

Use a strain of bacteria known to be resistant to other antibiotics. Using aseptic technique, spread the same volume of the bacterial culture over sterile nutrient agar plates to produce a bacterial lawn.

Prepare solutions of the new antibiotic and of penicillin. Make a range of concentrations of each by serial dilution, e.g. 1, 0.1, 0.01 and 0.001 mg cm⁻³, using the same concentrations and volume for both antibiotics.

Soak sterile paper discs of the same size in each solution (or add the same volume to wells cut in the agar), with one antibiotic per plate. Use a disc soaked in sterile water as a control.

Incubate all the plates at the same temperature, e.g. 25 °C, for the same time, e.g. 48 hours.



Measure the diameter of the clear zone of inhibition around each disc and calculate its area. A larger zone of inhibition shows a more effective antibiotic. The range of concentrations gives the minimum effective dose of each.

Repeat at least three times for each concentration and calculate the mean, then use a statistical test such as a t-test to see whether the difference between the two antibiotics is significant.

Repeat with several different strains of resistant bacteria to see if the new antibiotic is effective against all of them.

(Total for Question 8 = 12 marks)



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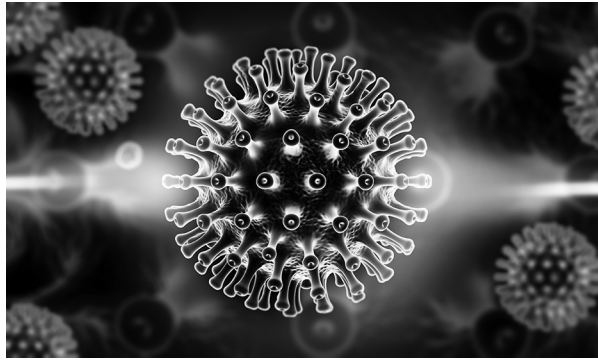
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- 9 The human immunodeficiency virus (HIV), shown in the image, causes acquired immunodeficiency syndrome (AIDS).



© Liya Graphics/Shutterstock

(a) HIV particles contain

(1)

- ☐ A DNA and DNA polymerase
- ☐ B DNA and reverse transcriptase
- ☐ C RNA and DNA polymerase
- ☒ D RNA and reverse transcriptase

(b) HIV enters and destroys T helper cells. This can cause AIDS.

(i) Describe how HIV particles are able to enter T helper cells.

(3)

Glycoproteins (gp120) on the surface of the virus bind to CD4 receptors on the surface of the T helper cells.

The viral envelope then fuses with the cell membrane of the T helper cell.

The viral RNA (and reverse transcriptase) enters the cell.



(ii) Explain why the destruction of T helper cells causes the symptoms of AIDS.

(4)

The lack of T helper cells reduces the production of cytokines.

This reduces the activation and cloning of B cells, so fewer B effector cells and plasma cells are produced.

This reduces antibody production (and fewer T killer cells are activated).

Therefore there is an increased risk of opportunistic infections such as TB, which cause the symptoms of AIDS.

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(c) A small number of people have been identified who are resistant to HIV.

They have a mutation in a gene coding for a protein in the cell membrane.

(i) Deduce why this mutation makes these people resistant to HIV infection.

(2)

The protein is the receptor in the cell surface membrane of T helper cells that HIV binds to.

The mutation changes its shape, so the glycoprotein (GP120) is unable to bind with the receptor and the viral RNA cannot enter the cell.

(ii) Stem cell therapy can be used to treat patients infected with HIV.

The bone marrow of these patients can be destroyed using radiotherapy.

The patients can then be given stem cells from the bone marrow of a donor who has this mutation.

Explain why these stem cells may prevent HIV causing AIDS.

(4)

Stem cells from the bone marrow can differentiate into specialised cells.

The donor stem cells will differentiate into T helper cells that have the mutated protein, so are resistant to HIV.

Normally T helper cells are destroyed by HIV, so the patient cannot produce an immune response.

The mutated (CD4) receptor prevents HIV entering the replacement T helper cells.

So the T helper cells are not destroyed, HIV does not remain in the blood and AIDS does not develop.

(Total for Question 9 = 14 marks)



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10 Anthropogenic climate change is linked to an increase in carbon dioxide in the atmosphere.

- (a) The World Meteorological Association recorded carbon dioxide levels of 405 ppm in 2017.

This is an increase of 46% since 1817.

Calculate the level of carbon dioxide in 1817.

(2)

$$405 \div 1.46$$

$$= 277.4$$

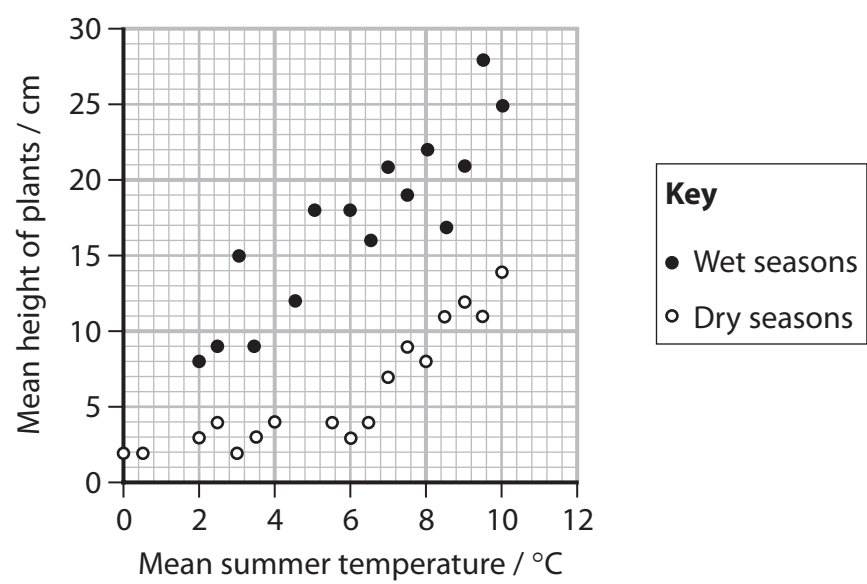
..... 277.4 ppm



(b) A study has investigated the effect of temperature changes on plants growing in the Arctic. This is an area with cold and short growing seasons.

Warming in the Arctic is leading to a change in the community of plants. The mean height of plants in the area was studied in both dry and wet growing seasons over a 30-year period. The summer temperatures over this period were recorded.

The results are shown in the graph.



Explain the effect of these environmental factors on the mean height of the plants.

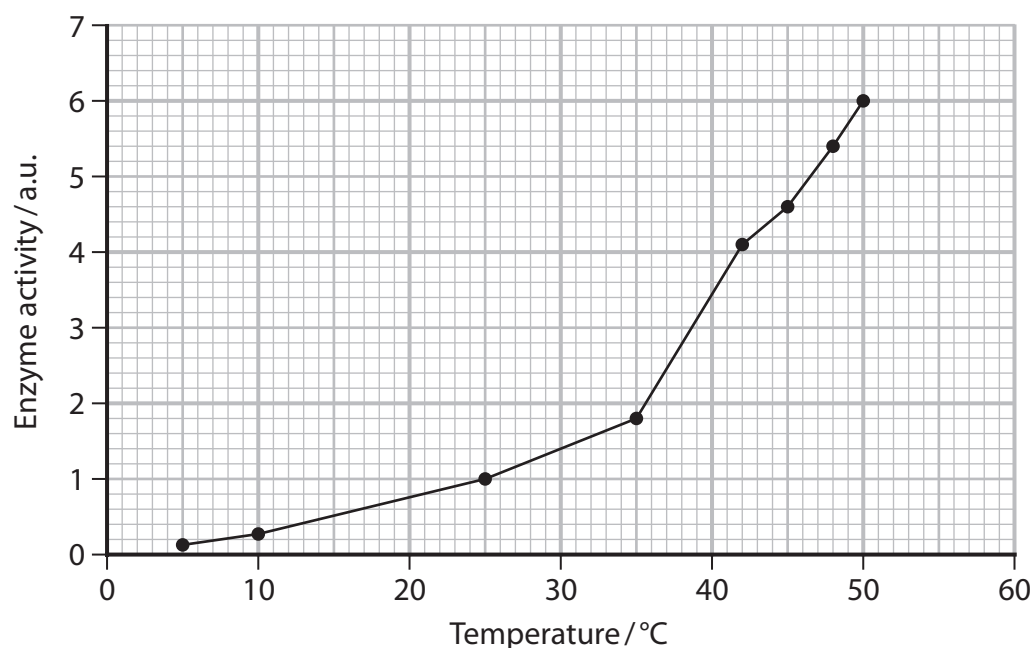
(2)

The plants increase in height as the temperature increases from 3 °C to 10 °C, as the rate of photosynthesis increases, leading to an increase in growth.

The increase is greater in wet seasons because water is also needed for photosynthesis and growth.

(c) The effect of temperature on the activity of RUBISCO was studied.

The results are shown in the graph.



Analyse the data to explain why temperature affects the growth of plants.

(4)

The light-independent stage of photosynthesis (Calvin cycle) is catalysed by enzymes such as RUBISCO.

The activity of RUBISCO increases as the temperature increases, e.g. from 0.3 a.u. at 10 °C to 6.0 a.u. at 50 °C, increasing most steeply above 35 °C.

So more carbon is fixed in the Calvin cycle, as more carbon dioxide reacts with RuBP.

This gives a greater rate of production of GP, GALP and glucose, leading to an increase in growth.



*(d) The world is divided into climate zones based on temperature and rainfall.

Details of some of the climate zones are shown in the table.

Climate zone	Mean temperature	Mean precipitation (rain or snow) / mm year ⁻¹
Polar (e.g. Arctic)	Warmest month below 10 °C	150 to 250
Temperate	Coolest month above 0 °C but below 18 °C Warmest month above 10 °C	500 to 2000

Results from the two studies described in this question can be used to explain how climate affects plant growth.

Discuss how anthropogenic climate change can affect the growth of plants in polar and temperate climate zones.

(6)

At present, growth is greater in the temperate zone than the polar zone, because the temperature is higher and there is more rainfall. In the Arctic, plants grew taller in wetter seasons.

Anthropogenic climate change increases the global temperature. As the rate of photosynthesis increases with temperature, because the activity of RUBISCO increases, more carbon is fixed in the Calvin cycle, so plant growth could increase in both zones.

The increase is likely to be greater in the polar zone, as its lower temperature currently limits photosynthesis and growth, and the growing season would be longer.

In the temperate zone, temperature may not be the limiting factor. Photosynthesis may be limited by carbon dioxide concentration, which limits the light-independent stage, or by light intensity, which limits the light-dependent stage. If the rate of photosynthesis does not increase, growth will not increase.

However, climate change is linked to an increase in carbon dioxide, which may itself increase the rate of photosynthesis and growth.

If temperatures rise too high, enzymes such as RUBISCO may denature, slowing growth. Changes in rainfall patterns could cause drought, which would reduce growth as water is



needed for photosynthesis, or flooding.

Some current species may die out as they are not adapted to the temperature rise, the range of some species may change, and effects on the life cycles of other organisms such as pollinators and pests may affect plant growth and food chains.

(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 100 MARKS

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