Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel Level 3 GCE

Friday 13 June 2025

Morning (Time: 1 hour 45 minutes)

Paper reference **9BI0/02**

Biology B

Advanced

PAPER 2: Advanced Physiology, Evolution and Ecology

You must have:
Scientific 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.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- In question(s) 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.

Turn over ▶

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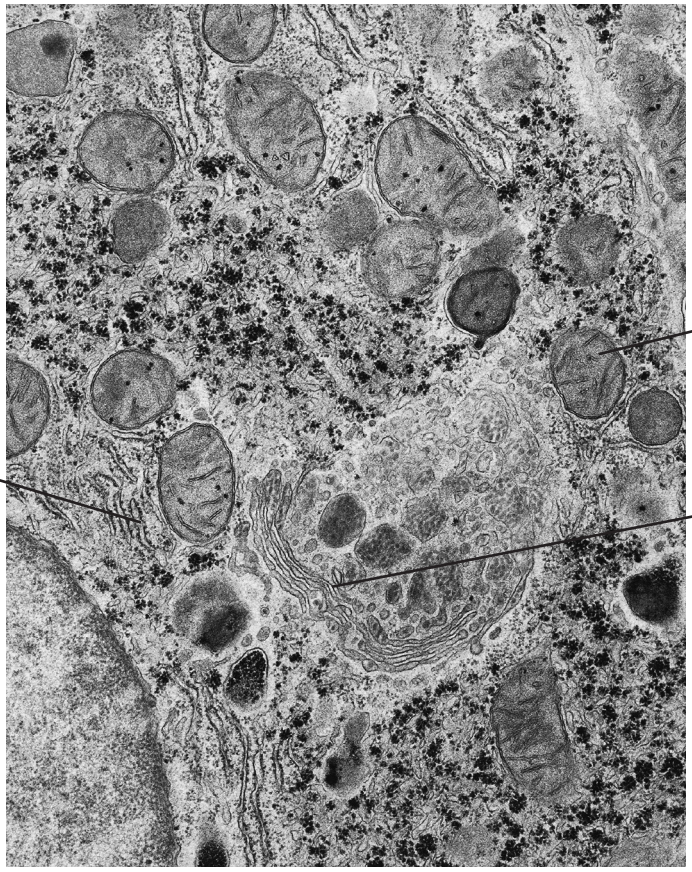
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Answer ALL questions. Write your answers in the spaces provided.

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 The photograph shows part of a liver cell, as seen using an electron microscope.



(Source: © Keith R. Porter/SCIENCE PHOTO LIBRARY)

(a) Describe the roles of the labelled organelles in a liver cell.

(3)

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(b) Hepatitis B is a DNA virus that infects liver cells. The DNA of the virus replicates inside liver cells.

(i) Describe the process of DNA replication.

(3)

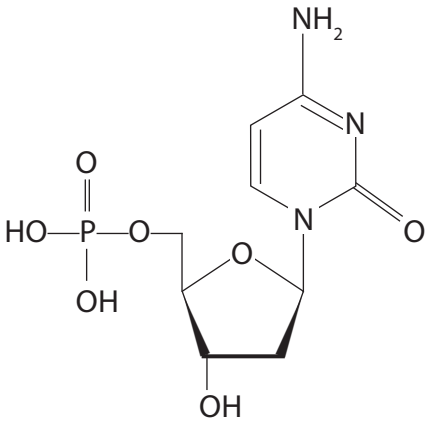
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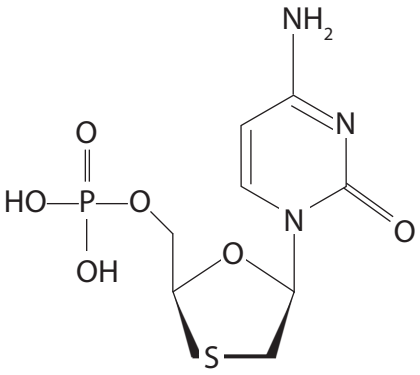
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(ii) The drug lamivudine is used to treat infections by the hepatitis B virus. It causes the production of altered nucleotides containing cytosine.

The diagram shows a normal nucleotide and an altered nucleotide.



normal nucleotide



altered nucleotide

Explain how lamivudine reduces replication of the hepatitis B virus in liver cells.

(2)

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(Total for Question 1 = 8 marks)

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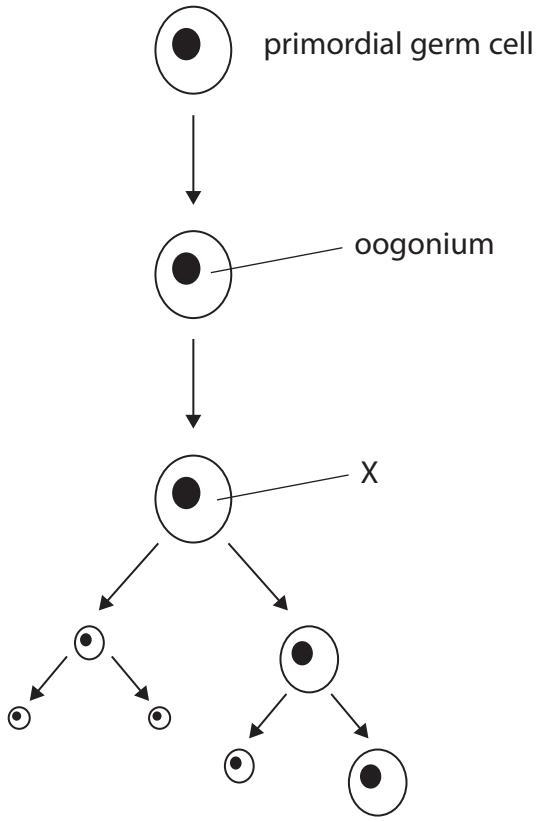
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2 The diagram shows the process of oogenesis.



(a) (i) Which is the name of the cell labelled X?

(1)

- ☒ **A** ovule
- ☒ **B** ovum
- ☒ **C** primary oocyte
- ☒ **D** secondary oocyte

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(ii) Meiosis is involved in oogenesis.

Describe the events of prophase I during oogenesis.

(3)

(iii) Compare and contrast the process of oogenesis with spermatogenesis.

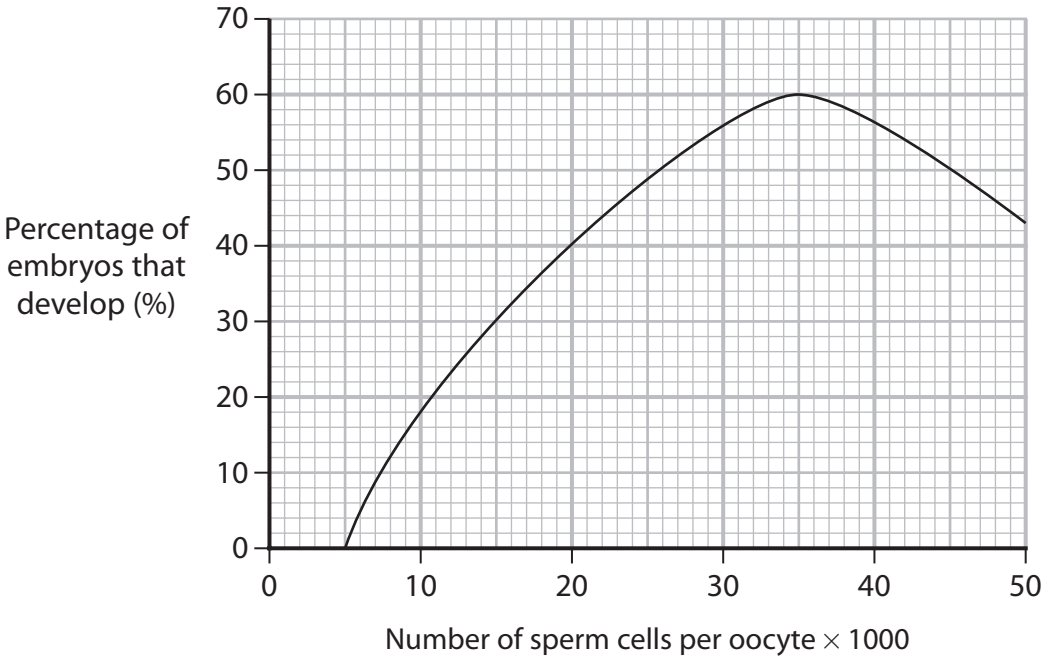
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(b) During in vitro fertilisation (IVF), oocytes are fertilised with sperm cells in a culture medium.

If more than one sperm cell fertilises an oocyte, the embryos do not develop.

The graph shows the effect on the production of embryos that develop when different numbers of sperm cells are added to oocytes during IVF.



(i) Calculate the number of sperm cells that need to be added to four oocytes so that 60% of embryos develop.

(1)

Answer .....

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(ii) Analyse the data to explain the effects of increasing the number of sperm cells per oocyte on the percentage of embryos that develop.

(2)

(Total for Question 2 = 10 marks)

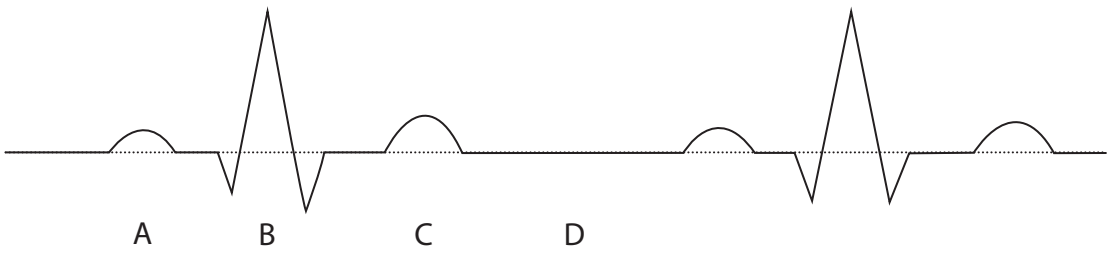
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3 Stress can change the heart rate of a person.

(a) The diagram shows an ECG trace for a student at rest.



(i) Which of the letters on this ECG trace represents the time when ventricular systole occurs?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(ii) Describe how myogenic stimulation maintains the heart rate of the student when at rest.

(3)

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(b) Scientists investigated the effect of an anti-anxiety drug on the change in heart rate of a student after a sudden fright.

In this investigation:

- The resting heart rate of the student was measured.
- The student was given a sudden, unexpected fright and their heart rate was measured again.
- This was repeated four more times.
- The investigation was then repeated after the student had taken the anti-anxiety drug.

The table shows the results of this investigation.

Fright number	Heart rate / beats per minute			
	without anti-anxiety drug		with anti-anxiety drug	
	resting	after fright	resting	after fright
1	64	135	46	70
2	56	125	54	65
3	55	125	48	70
4	75	110	56	105
5	72	105	48	65

(i) The mean volume of blood pumped around the body in one minute after a fright without the anti-anxiety drug is 18 dm^3.

The stroke volume of the student's heart was 150 cm^3.

Calculate the mean volume of blood pumped around the body in one minute after a fright, when taking the anti-anxiety drug.

Give your answer in dm^3 and to the **nearest whole number**.

(2)

Answer ..... dm^3

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(ii) The anti-anxiety drug has a similar shape to noradrenaline.

Analyse the data to comment on the results of this investigation.

(4)

(Total for Question 3 = 10 marks)

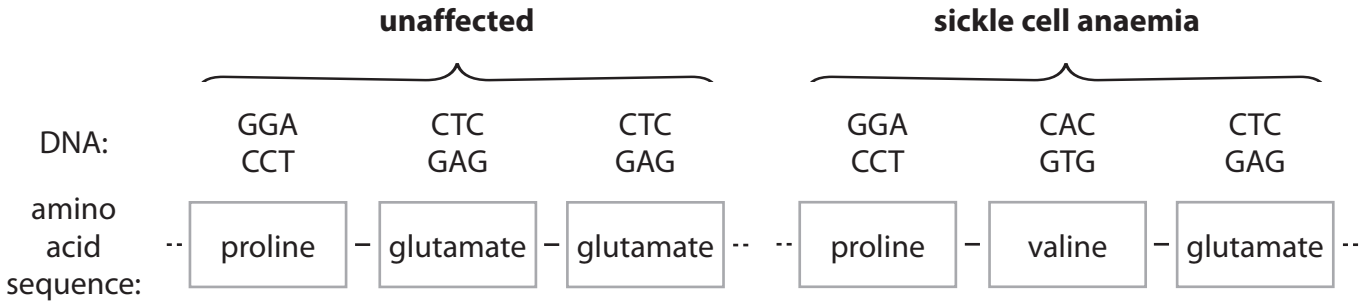
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4 Sickle cell anaemia is a condition caused by a mutation and a change in the structure of haemoglobin.

The diagram shows the changes that occur in the DNA sequence and the amino acid sequence for this condition.



(a) (i) Which type of bond is used when forming both the secondary structure and tertiary structure of proteins?

(1)

☒ **A** disulfide

☒ **B** hydrogen

☒ **C** ionic

☒ **D** peptide

(ii) Which type of mutation has occurred to produce the allele for sickle cell anaemia?

(1)

☒ **A** insertion

☒ **B** deletion

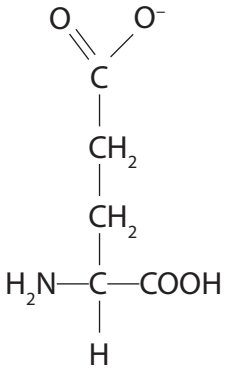
☒ **C** substitution

☒ **D** translocation

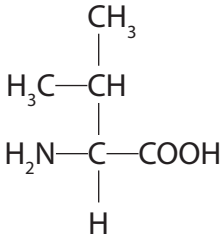
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(iii) Glutamate is a charged, polar amino acid. It is located on the outer surface of unaffected haemoglobin molecules.

The diagram shows the structure of the amino acids glutamate and valine.



glutamate



valine

Explain why the mutation in sickle cell anaemia causes haemoglobin molecules to bind together.

(2)

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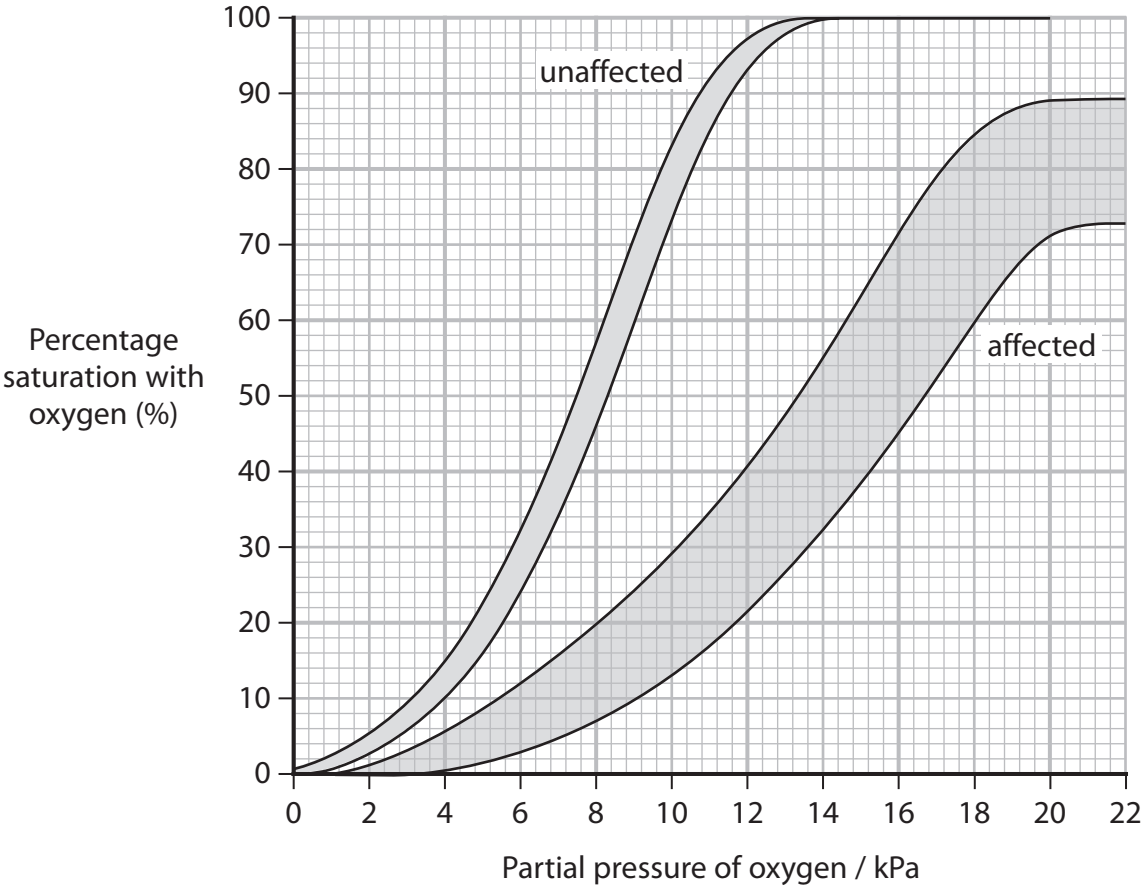
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(b) The graph shows the range of oxygen dissociation curves for haemoglobin taken from people who do not have sickle cell anaemia (unaffected) and from people with sickle cell anaemia (affected).

The shaded areas represent the ranges for each blood sample.



(i) Compare and contrast the properties of haemoglobin from these two groups of people.

(2)

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(ii) There is only one known allele that causes sickle cell anaemia.

State how the graph suggests that other genes affect the phenotype of people affected by sickle cell anaemia.

(1)

(iii) Explain why the oxygen dissociation curve for people with sickle cell anaemia means that they have difficulty exercising.

(3)

(Total for Question 4 = 10 marks)

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5 Auxin is a plant growth substance.

(a) Which of the following are functions of auxin?

1. inhibiting lateral shoot growth
2. stimulating the elongation of cells in plant stems
3. stimulating flowering

(1)

☒ **A** 1 and 2

☒ **B** 1, 2 and 3

☒ **C** 1 and 3

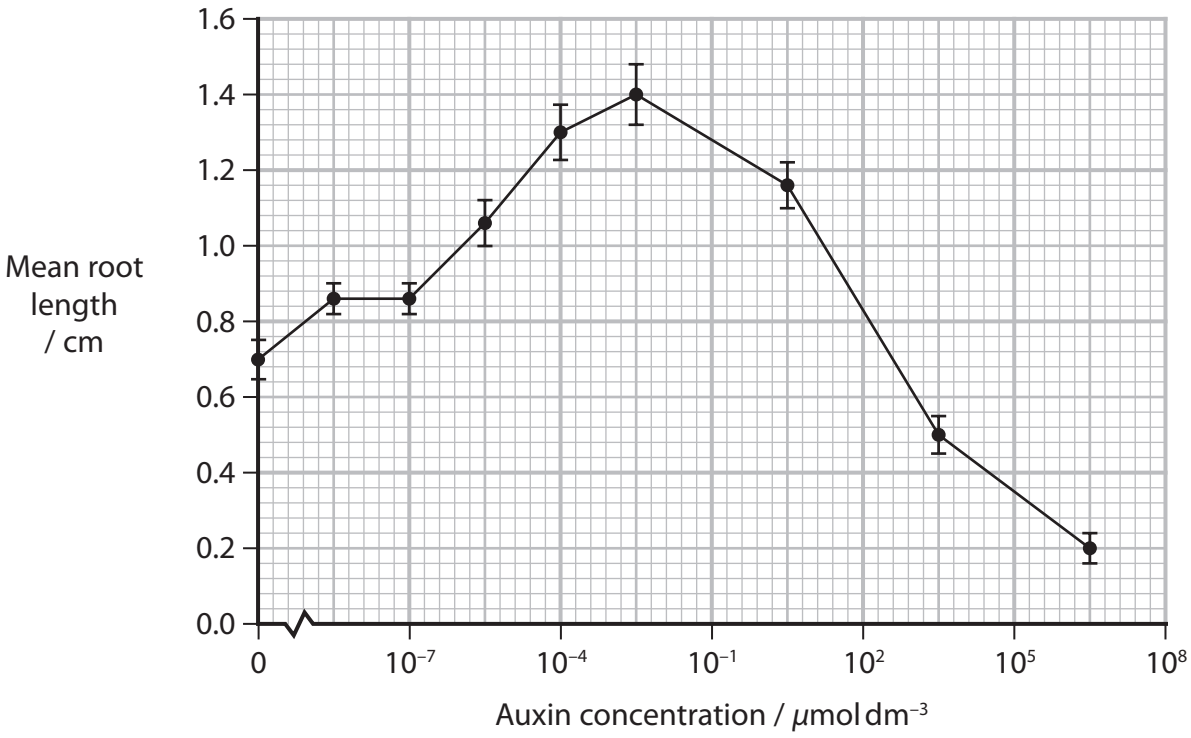
☒ **D** 2 and 3

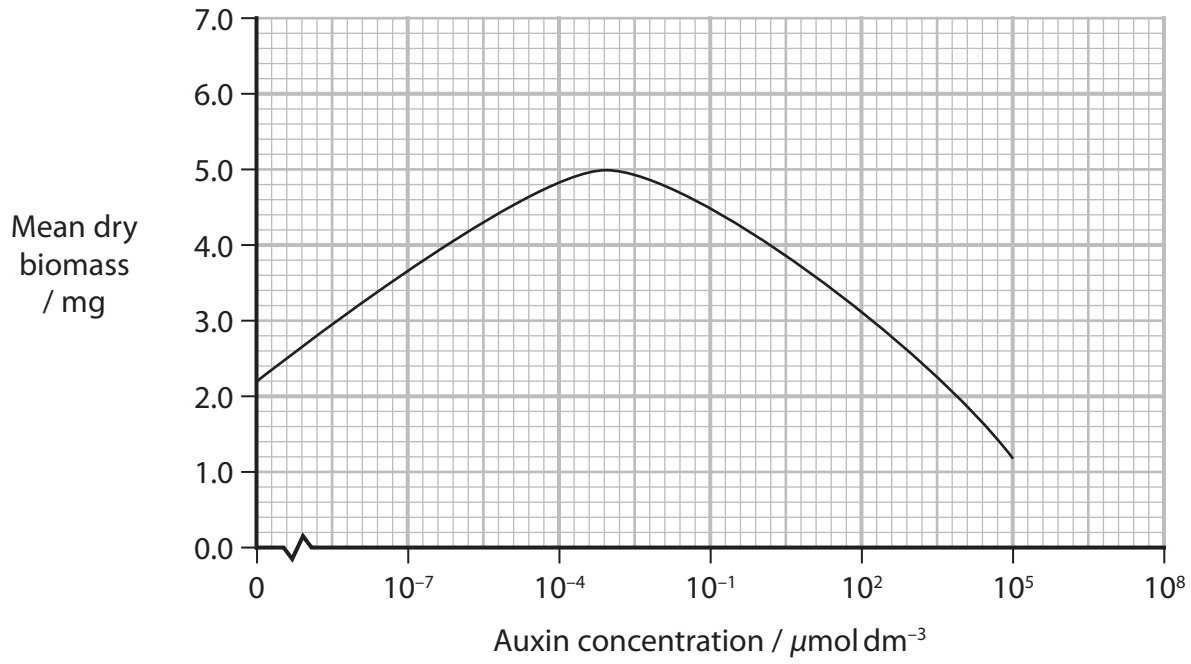
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(b) In an investigation, wheat seedlings were exposed to different concentrations of auxin.

The mean lengths of the roots and the mean dry biomass of the seedlings were calculated.

The graphs show the results of this investigation.





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(i) Calculate the percentage increase in mean root length when given an auxin concentration of 10^{-4} μmol dm^{-3} compared with no auxin.

Give your answer to the **nearest whole number**.

(1)

Answer .....

(ii) Analyse the data to discuss the effects of auxin on the growth of wheat seedlings.

(4)

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(Total for Question 5 = 6 marks)

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6 The photograph shows a brown rat, *Rattus norvegicus*.



(Source: © DK IMAGES/SCIENCE PHOTO LIBRARY)

(a) The classification hierarchy for the brown rat is:

- Domain: Eukarya
- Kingdom: Animalia
- Phylum: Chordata
- Mammalia
- Rodentia
- Muridae
- Genus: *Rattus*
- Species: *norvegicus*.

(i) Which family, order and class does the brown rat belong to?

(1)

		Family	Order	Class
☒	**A**	Mammalia	Muridae	Rodentia
☒	**B**	Mammalia	Rodentia	Muridae
☒	**C**	Muridae	Rodentia	Mammalia
☒	**D**	Muridae	Mammalia	Rodentia

(ii) State **one** method that scientists use to determine the evolutionary relationships of the brown rat compared with other species.

(1)

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(b) Warfarin is a poison that is often used to control brown rat populations.

In areas where large amounts of warfarin have been used, many rats have developed resistance to warfarin.

Three genotypes occur in rat populations:

W^NW^N – rats that are not resistant to warfarin

W^RW^R – rats that are resistant to warfarin but require large amounts of vitamin K in their diet to survive

W^NW^R – rats that are resistant to warfarin and **do not** require large amounts of vitamin K to survive.

After the introduction of warfarin, scientists determined the change in numbers of rats that were resistant to warfarin, and the number that were not resistant to warfarin.

The table shows their results.

Type of rat	Genotypes of rats	Number of rats		
		before warfarin was used	two years after warfarin use started	five years after warfarin use started
Resistant to warfarin	W^RW^R and W^NW^R	35	195	180
Not resistant to warfarin	W^NW^N	265	105	120

(i) Calculate the expected number of rats that would be resistant to warfarin but **do not** require large amounts of vitamin K to survive, before warfarin was used.

Use the Hardy-Weinberg equation

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

(3)

Answer .....

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(ii) Explain why, after two years, there is a change in the number of rats that are resistant to warfarin.

(2)

(iii) Warfarin is highly toxic to rats that have no resistance.

Explain why, after five years, there are still many rats that are not resistant to warfarin.

(2)

(Total for Question 6 = 9 marks)

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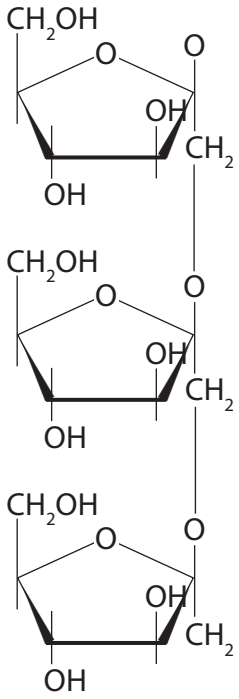
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7 Inulin is a polysaccharide made of fructose that is used as a storage molecule by some plant species.

The diagram shows part of a molecule of inulin.



(a) (i) The inulin molecule in the diagram contains fructose.

Which of these carbohydrates also contain fructose?

(1)

☒ **A** lactose, maltose, and sucrose

☒ **B** lactose and sucrose

☒ **C** maltose and sucrose

☒ **D** sucrose

(ii) Which is the name of the chemical bond that joins the monosaccharides in inulin?

(1)

☒ **A** ester

☒ **B** glycosidic

☒ **C** hydrogen

☒ **D** peptide

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(iii) Fructose has the same molecular formula as glucose.

Which is the molecular formula of a molecule of inulin consisting of four fructose sugars?

(1)

☒ **A** $C_{24}H_{42}O_{21}$

☒ **B** $C_{24}H_{44}O_{22}$

☒ **C** $C_{24}H_{48}O_{21}$

☒ **D** $C_{24}H_{48}O_{24}$

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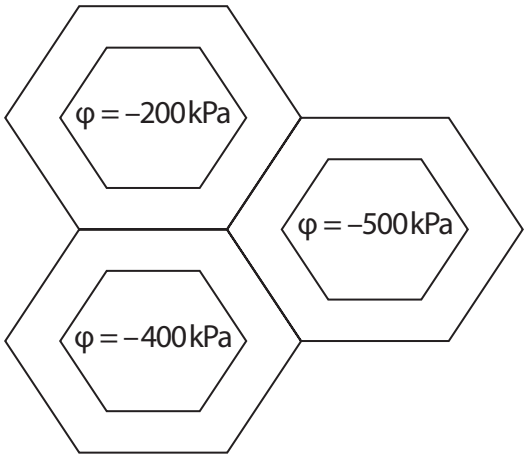
(b) The number of fructose molecules in inulin can vary from 10 to 70.

Inulin with high numbers of fructose molecules is less soluble in water.

(i) The diagram shows three plant cells with different water potentials.

Draw arrows on the diagram to show the direction of water movement between the cells.

(1)



(ii) Explain why some plant species make inulin with fewer fructose molecules in dry weather and inulin with more fructose molecules in wet weather.

(2)

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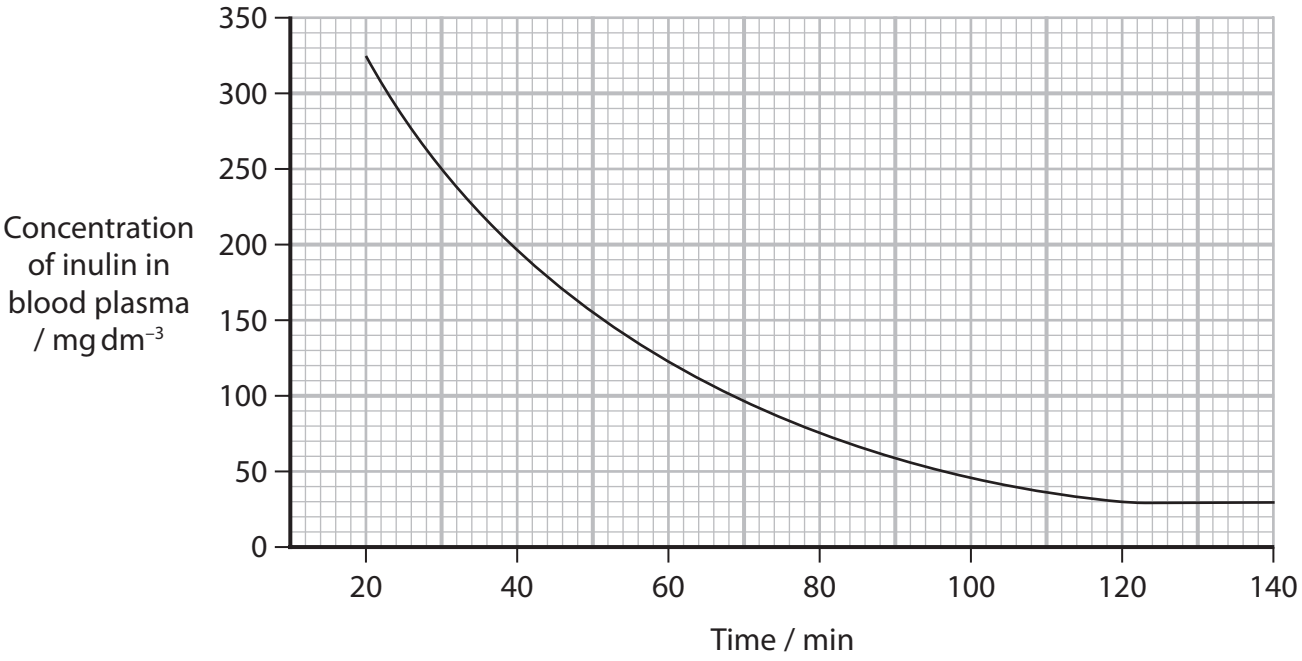
(c) Inulin is used to measure the rate of filtration by the kidneys.

A saline solution containing inulin is injected into the vein of a patient.

The concentration of inulin in the blood plasma is then measured over time.

The rate of filtration is a measure of the maximum rate that inulin is removed from the blood by the kidneys.

The graph shows the concentration of inulin in the blood plasma after an injection of 5 g of inulin.



(i) Calculate the maximum rate that the inulin is removed from the blood.

Give your answer to **two decimal places** with appropriate units.

(2)

Answer .....

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(ii) Explain how inulin passes from the blood plasma into the proximal convoluted tubule of a nephron.

(2)

(iii) Explain why all the inulin is released into the urine.

(2)

(Total for Question 7 = 12 marks)

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8 The photograph shows a grouse on a heather moor. Heather moors are areas of countryside that are dominated by heather plants.



(Source: © Ben Hall/2020VISION/Nature Picture Library/SCIENCE PHOTO LIBRARY)

Heather moors are habitats for a variety of plants and animals. They are also used for sheep farming and as areas to raise grouse.

The net primary productivity (NPP) of a heather moor decreases with the age of the heather plants.

(a) Which of the following is the correct formula to calculate NPP?

(1)

- ☒ **A** NPP = gross primary productivity (GPP) – respiration
- ☒ **B** NPP = gross primary productivity (GPP) + respiration
- ☒ **C** NPP = gross primary productivity (GPP) + photosynthesis
- ☒ **D** NPP = gross primary productivity (GPP) – photosynthesis

(b) As heather plants age, the ratio of leaf area to area of woody stem changes.

A student investigated the relationship between the age of heather plants and the ratio of leaf area : woody stem area.

The student carried out a Spearman's rank correlation test using the data in the table.

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Age of heather plant / years	Rank of age of heather plant	Ratio of leaf area : woody stem area	Rank of leaf area : woody stem area	d	d^2
16	4	0.7	4.5	–0.5	0.25
15	5	0.4	8	–3	9
12	6	0.6	6	0	0
4	9	2.0	1	8	64
7	8	1.1		5.5	30.25
22	1	0.2	10	–9	81
20	2	0.3	9	–7	49
3	10	1.1			
17	3	0.5	7	–4	16
11	7	0.7	4.5	2.5	6.25

(i) Calculate the missing values to complete the table.
Write your answers in the table.

(2)

(ii) Calculate the Spearman's rank correlation coefficient for the data in the table.
Use the formula

$$r_s = 1 - \frac{6\sum d^2}{n\left(n^2 - 1\right)}$$

(3)

Answer .....

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(iii) The table gives some critical values for the Spearman's rank correlation coefficient.

n	Level of significance	
	$P = 0.05$	$P = 0.01$
5	1.000	–
6	0.886	1.000
7	0.786	0.929
8	0.738	0.881
9	0.700	0.833
10	0.648	0.794
11	0.618	0.755

Comment on the relationship between the age of the heather and the ratio of leaf area to woody stem area.

Use your calculated value of Spearman's rank correlation coefficient and the table.

(3)

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*(c) Farmers manage heather moors by burning the heather every 10 years. This removes older heather and allows younger plants to grow.

Managing heather moors by burning is controversial.

It has been suggested that instead of burning the heather, the moors should be left to return to nature as part of a rewilding strategy.

Rewilding strategies aim to return areas of farmland to the original ecosystems that existed before the heather moors.

Several factors have to be considered before a decision on rewilding is made.

- The heather moors are areas of peat containing dead organic waste that decomposes very slowly.
- Heather moors are an area of income for farmers.
- Over time, heather becomes very dominant and lies flat over the ground, blocking light.
- A variety of small species of plants live around areas of older heather.
- Heather seeds need to be heated to germinate efficiently.
- Some endangered species consume grouse.
- Grouse are raised by humans for profit.
- Heather moors have been managed for many years and many species that lived in the area are now extinct.

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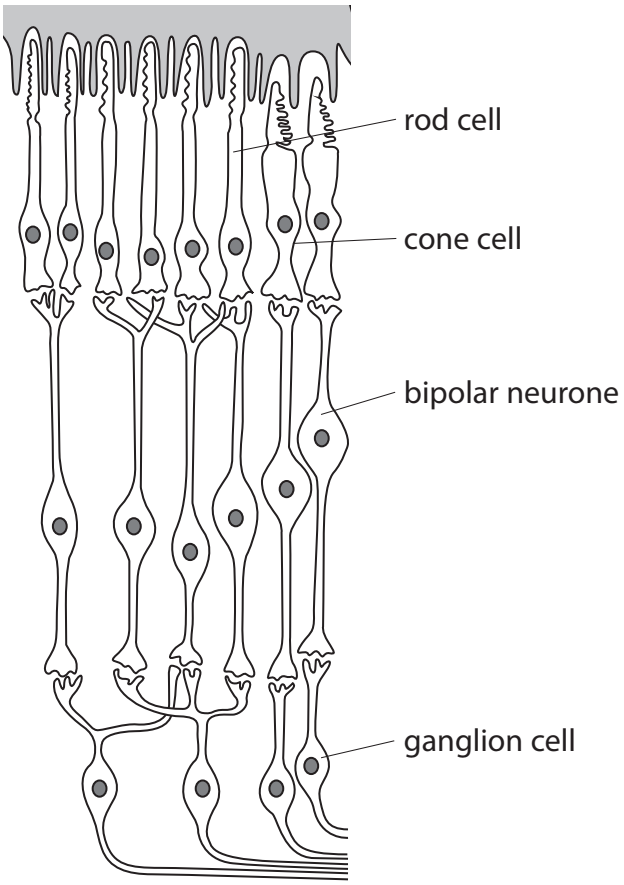
Analyse all the information in the question to discuss the effects of rewilding the moors compared with management by burning.

(6)

(Total for Question 8 = 15 marks)

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9 The diagram shows a section through the central area of a human retina.



(a) (i) Draw an arrow on the left of the diagram to show the direction that light travels through the retina.

(1)

(ii) Describe how light absorbed by rhodopsin in a rod cell leads to a change in release of neurotransmitter from the rod cell.

(3)

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*(b) A student investigated the retinal structures of different mammals.

The student collected information about:

- the structure of the retina of the cat (a predator that hunts at night)
- the distribution of rods and cones in the retina of humans and cats
- the total number of rods and cones in the retinas of species active in the day and species active at night.

The diagram shows part of the retina of a cat.

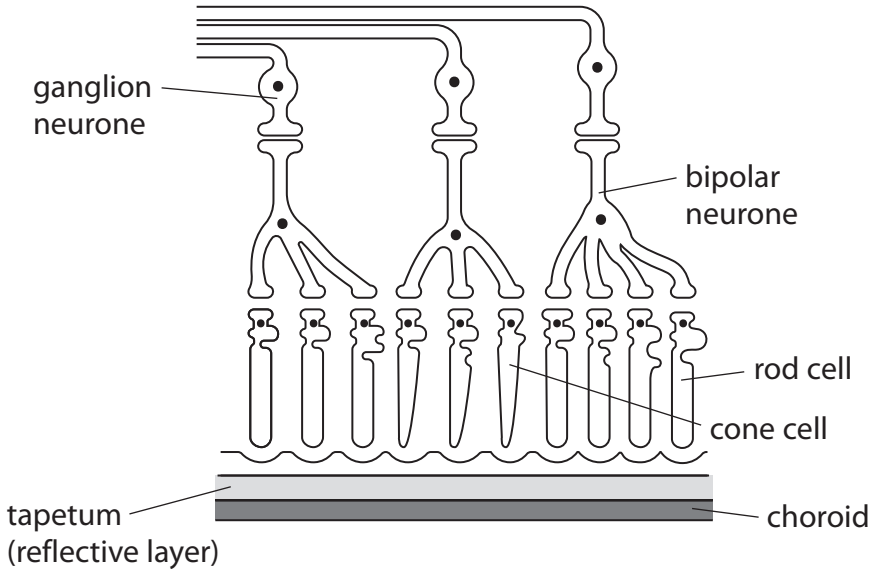


Table 1 and Table 2 show some of the data collected by the student.

Table 1

Distribution of rods and cones	Density of cells in retina / cells per mm^2	
	human	cat
Highest cone density	199 000	27 000
Highest rod density	160 000	460 000
Cone density around edge of retina	5 000	$<$3 000
Rod density around edge of retina	40 000	250 000

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Table 2

Species	When active	Total number of cells $\times 10^6$	
		rod cells	cone cells
Rat	night	30	3
Night monkey	night	150	3
Marmoset monkey	day	6	11
Saimiri monkey	day	30	10

Discuss how the retinas of animals are adapted to their activity at different times of the day.

(6)

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(Total for Question 9 = 10 marks)

TOTAL FOR PAPER = 90 MARKS

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