Please check the examination details below before entering your candidate information

Candidate surname	Other names

Pearson Edexcel Level 3 GCE

Centre Number | Candidate Number

Monday 15 June 2020

Morning (Time: 2 hours 30 minutes) | Paper Reference **9BI0/03**

Biology B

Advanced

Paper 3: General and Practical Principles in Biology

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.
- 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.*
- You may use a scientific calculator.
- 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.

Information

- The total mark for this paper is 120.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*

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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Pearson

Answer ALL questions.

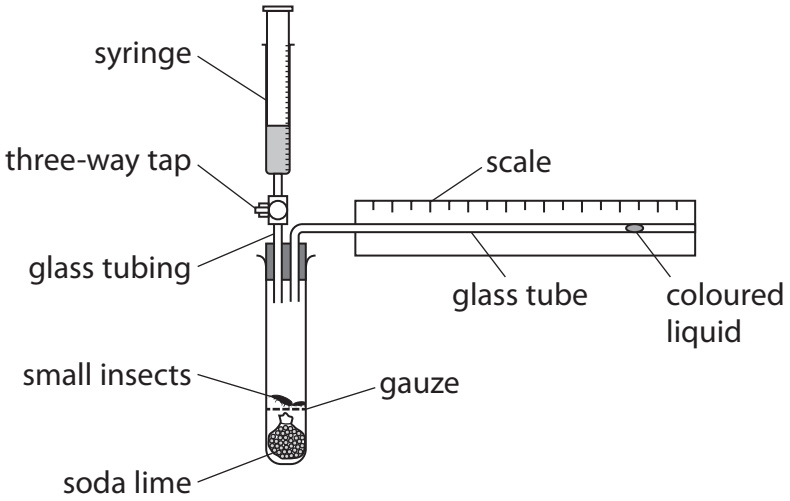
Write your answers in the spaces provided.

1 (a) Describe how oxygen from the air is able to reach insect muscle cells.

(3)

(b) A respirometer was used to compare the rate of aerobic respiration of two species of insect.

The diagram shows the respirometer.



(i) Give the units for a valid comparison of the rate of respiration of these two species of insect.

(1)

(ii) Other factors may affect the results from this respirometer.

Describe how one named factor could be controlled when using this respirometer.

(2)

(iii) Explain why the soda lime in the tube must be replaced when the other species of insect is placed in the respirometer.

(2)

(Total for Question 1 = 8 marks)

2 The egg of a hen contains albumin, a globular protein.

(a) Describe the tertiary structure of a globular protein.

(3)

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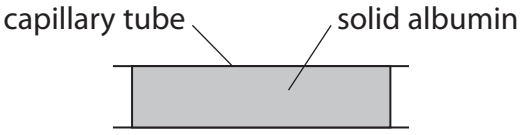
(b) Pepsin is an enzyme that digests albumin.

Albumin can be put into a 50 mm long capillary tube and then made solid by boiling in water for 10 minutes.

The diagram shows a 50 mm capillary tube containing solid albumin.



Devise an investigation into the effect of pepsin concentration on the digestion of solid albumin.

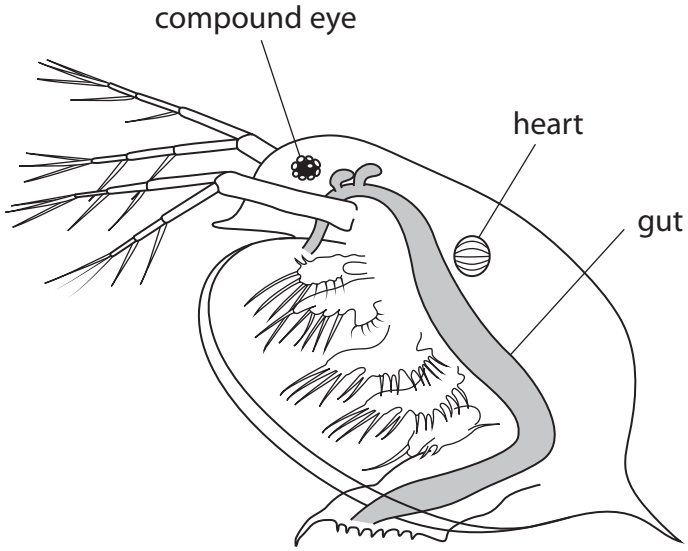
(5)

(Total for Question 2 = 8 marks)

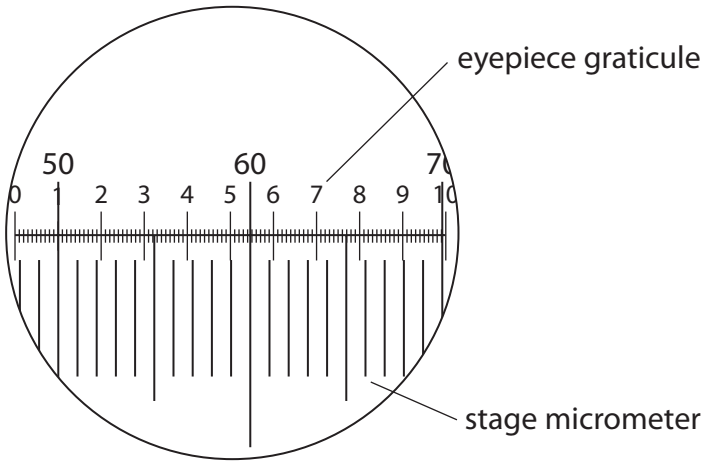
3 Water fleas are small animals that live in pond water.

A student observed a water flea using a light microscope.

The diagram shows the student's drawing of the water flea.



The diagram shows an eyepiece graticule and a stage micrometer used by the student to measure the diameter of the heart in this water flea.



(Source: http://biology4alevel.blogspot.com/2014/07/2-cell-structure-microscopy.html)

Each small division on the stage micrometer is 0.01 mm.

The diameter of the heart was found to be 0.2 mm.

(a) Determine the number of eyepiece units that equal the diameter of the water flea heart.

(1)

Answer .....

(b) The water flea has a spherical heart with a diameter of 0.2 mm.

Cardiac output is the volume of blood pumped out of a heart in one minute.

The resting heart rate of a water flea is 200 beats min^{-1}.

The volume of a sphere is calculated using the formula

$$\frac{4}{3}\pi r^3$$

where $\pi = 3.142$

(i) Calculate the cardiac output of a water flea at rest using the formula

cardiac output = stroke volume × heart rate

(3)

Answer ..... $dm^3\ min^{-1}$

(ii) The cardiac output of a human heart at rest is 5.0 $dm^3\ min^{-1}$.

Give one reason why the cardiac output of a human heart at rest needs to be greater than the cardiac output of a water flea at rest.

(1)

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(c) A student investigated the effect of adrenaline and acetylcholine on the heart rate of water fleas using the following method:

- place a water flea in pond water on a microscope slide
- count the number of heart beats in one minute
- repeat with two other water fleas
- repeat this procedure using three water fleas placed in adrenaline solution and three water fleas placed in acetylcholine solution.

The table shows the results of this investigation.

Treatment	Heart rate / beats min^{-1}				Standard deviation (SD)
	Water flea 1	Water flea 2	Water flea 3	Mean	
Pond water	195	185	190	190	
Adrenaline solution	240	236	238	238	±2.0
Acetylcholine solution	116	120	118	118	±2.0

(i) Calculate the standard deviation for the mean heart rate in the pond water.

Use the formula

$$SD = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$

(2)

Answer .....

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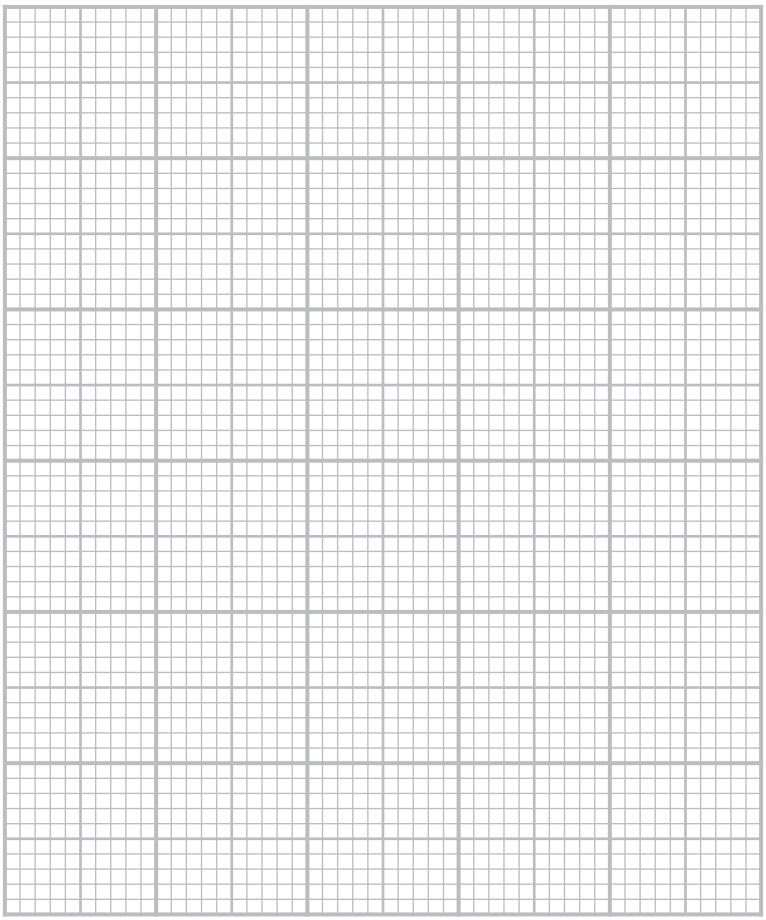
(ii) Plot a graph to show the data for the mean heart rate and SD in each treatment.

(2)



(iii) Explain why abiotic variables should be controlled in this investigation.

(2)

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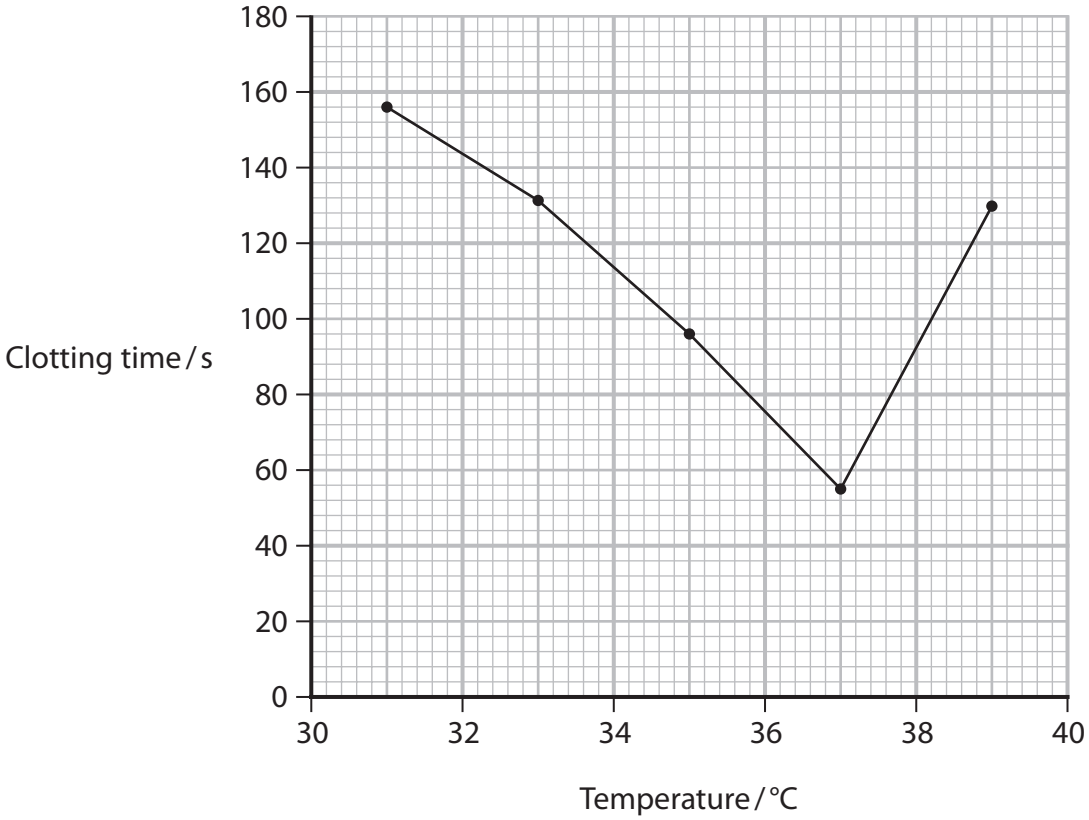
(Total for Question 3 = 11 marks)

4 A scientist investigated the effect of temperature on the time it takes for blood to clot.

The graph shows the results of this investigation.



(a) Explain how these results show that enzymes are involved in blood clotting.

(3)

(b) Prothrombin is involved in the blood clotting process.

The *F*2 gene codes for the synthesis of prothrombin.

This gene is located from base pair 46 719 191 to base pair 46 739 504 on chromosome 11.

Determine the number of codons in this gene.

(1)

Answer .....

(c) A mutation of the *F*2 gene causes thrombophilia, a condition that results in the production of excess prothrombin.

In this gene mutation, guanine is replaced with adenine.

(i) Name this type of mutation.

(1)

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(ii) People without this mutation have a 1 in 1000 risk of producing a blood clot in an artery.

The mutation increases this risk by 20 times.

State the probability of producing a blood clot for people with this mutation.

(1)

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(iii) Explain why thrombophilia increases the risk of producing a blood clot in an artery.

(3)

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(d) A genetic test can be used to find out if a person has thrombophilia.

The test involves using a restriction endonuclease to obtain genetic material from white blood cells.

This genetic material is then used in the polymerase chain reaction (PCR).

(i) State the role of a restriction endonuclease.

(1)

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(ii) Describe the process of PCR.

(3)

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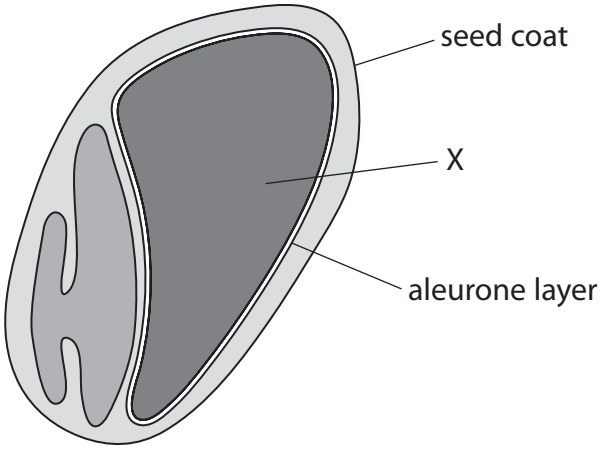
(Total for Question 4 = 13 marks)

5 Gibberellin stimulates cells in the aleurone layer of cereal grains, such as barley, to produce the enzyme amylase.

The diagram shows the location of the aleurone layer in a barley grain.

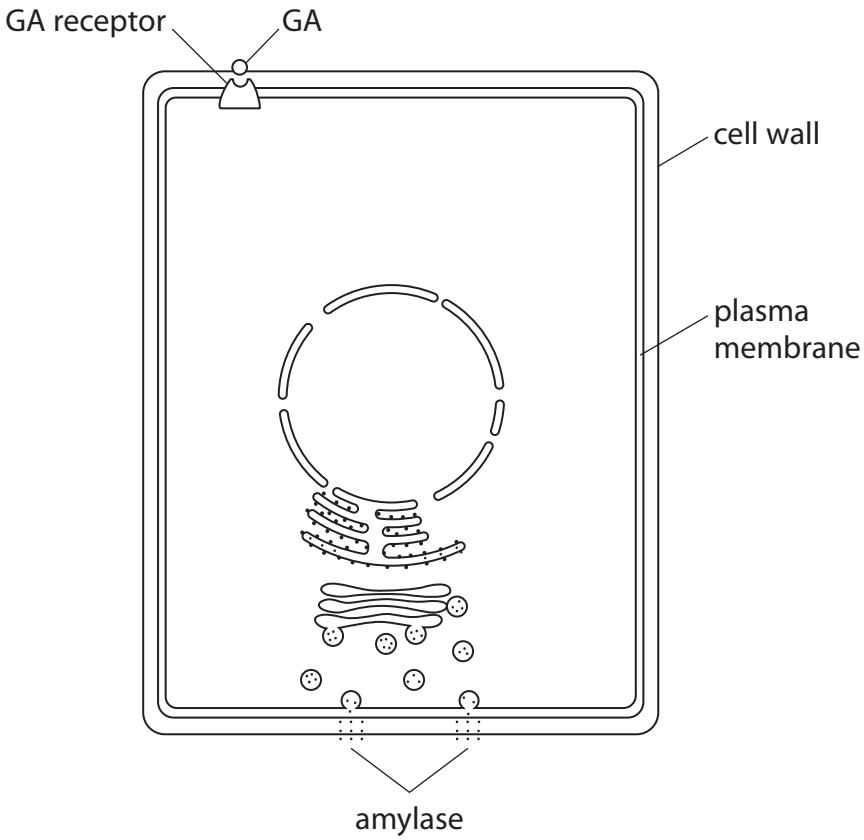


(a) The part labelled X contains triploid cells.

Name the part labelled X.

(1)

(b) The diagram shows a cell from the aleurone layer with some of the structures involved in the production of amylase.



Gibberellin binds to a protein receptor in the cell surface membrane and this stimulates transcription in the nucleus.

(i) Describe the process of transcription in the nucleus of this cell.

(2)

(ii) Describe the processes occurring after transcription that result in the release of amylase from the cell shown in the diagram.

(5)

(c) Global warming may cause sea levels to rise and salty seawater to flood land used for growing crops.

A student read that salt (NaCl) inhibits gibberellin synthesis.

This could affect amylase production in cereal grains.

Devise an investigation to show the effect of salt concentration on amylase production in cereal grains.

(5)

(Total for Question 5 = 13 marks)

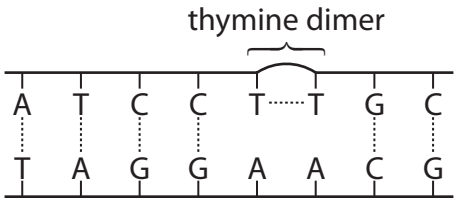
6 Ultraviolet (UV) radiation damages DNA and is used in microbiology to produce aseptic conditions.

The UV radiation changes the bonding found in DNA.

This change in bonding creates thymine dimers in which covalent bonds form between adjacent thymine nucleotides.

Thymine dimers bend the DNA backbone. This prevents replication of DNA.

The diagram shows the change in bonding caused by UV radiation.



(a) Name the bonds that are lost when thymine dimers are formed.

(1)

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(b) Explain why preventing the replication of DNA produces aseptic conditions.

(2)

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(c) Aseptic conditions are used when growing bacteria in laboratories.

Justify two methods, other than UV radiation, for ensuring aseptic conditions.

(2)

(d) The effectiveness of UV radiation was investigated, using three species of pathogenic bacteria.

The table provides information about the bacteria used in this investigation.

Bacteria	Gram staining	Infected part of body
P. aeruginosa	negative	blood
S. aureus	positive	lung
E. coli	negative	intestine

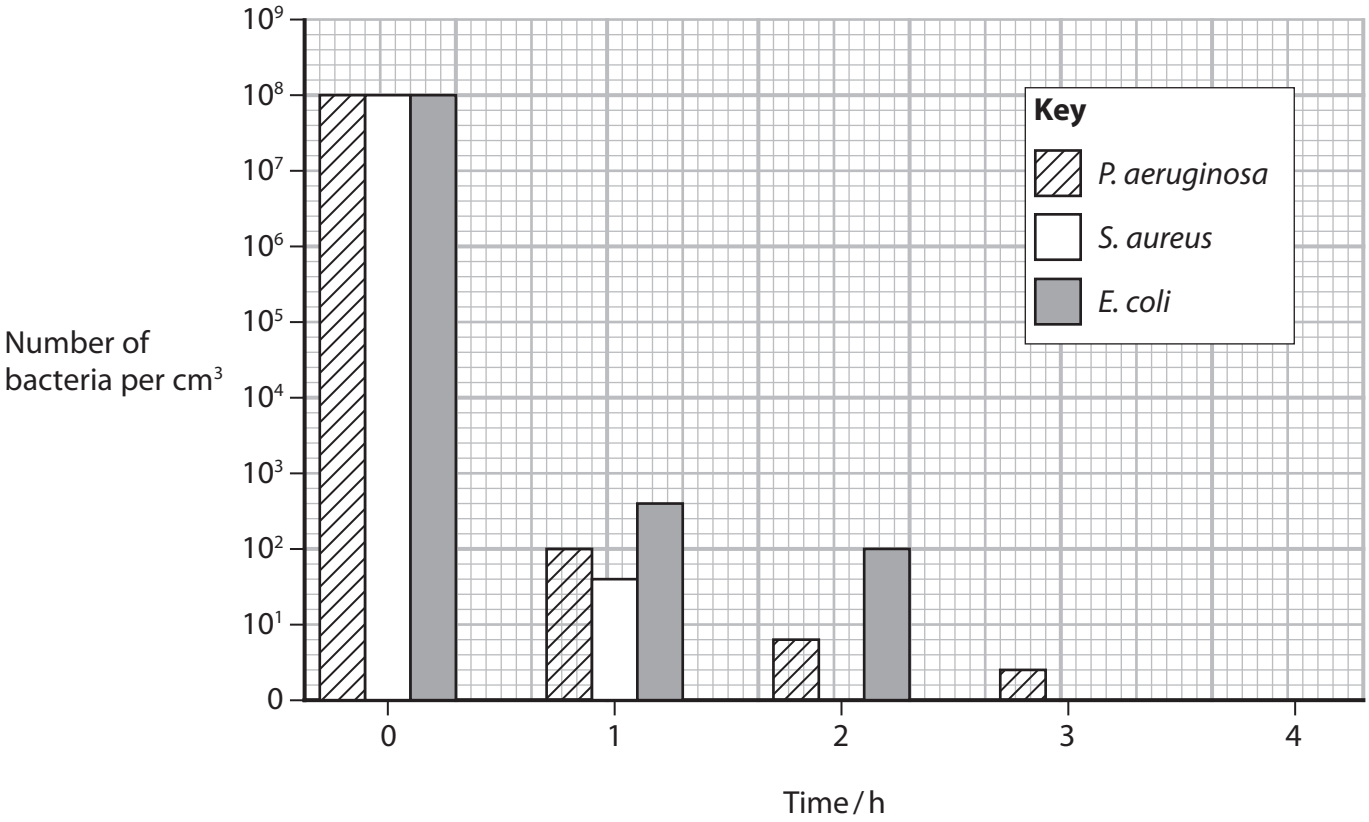
(i) Compare and contrast the structure of the wall of Gram positive bacteria and Gram negative bacteria.

(3)

(ii) In this investigation, living bacteria of each species were exposed to UV radiation for four hours.

The numbers of living bacteria were counted each hour during the four-hour period.

The graph shows the results of this investigation.



Calculate the percentage change in numbers of living *E. coli* after two hours of exposure to UV radiation.

(2)

Answer ..... %

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(iii) A student concluded from this investigation that if food is exposed to UV radiation, it would remove all risk of food poisoning.

Criticise the validity of this conclusion.

(4)

(Total for Question 6 = 14 marks)

7 The photograph shows a wood mouse, *Apodemus sylvaticus*.

(Source: © Eric Isselee/Shutterstock)

A scientist measured the population size of these mice living in a woodland habitat.

The scientist used the capture-mark-recapture method (CMR) to sample the population.

This is the CMR method used by the scientist:

- randomly place mammal traps in the woodland for one day
- put a coloured band on a leg of each captured mouse (S1)
- release these marked mice
- after one week place mammal traps in the woodland again for one day
- count the number of mice captured (S2)
- count the number of mice with leg bands in this second sample (L).

The table shows some of the results.

Number of mice captured	
S1	S2
200	250

(a) The scientist calculated that the number of mice in the woodland was 1000, using the formula

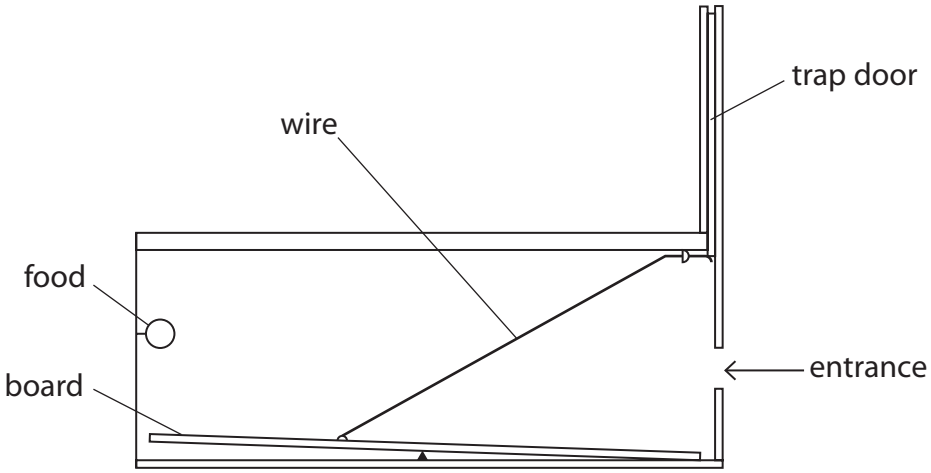
$$\text{number of mice} = \frac{S1 \times S2}{L}$$

Determine the number of mice that had leg bands (L) in the second sample.

(1)

Answer .....

(b) The diagram shows a section of the trap used by the scientist.



Explain how the design of the trap is effective for capturing mice.

(3)

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(c) Wood mice are small mammals.

They cannot maintain their body temperature and will die if left in the trap for a long period of time.

Explain why wood mice cannot maintain their body temperature if left in the trap.

(4)

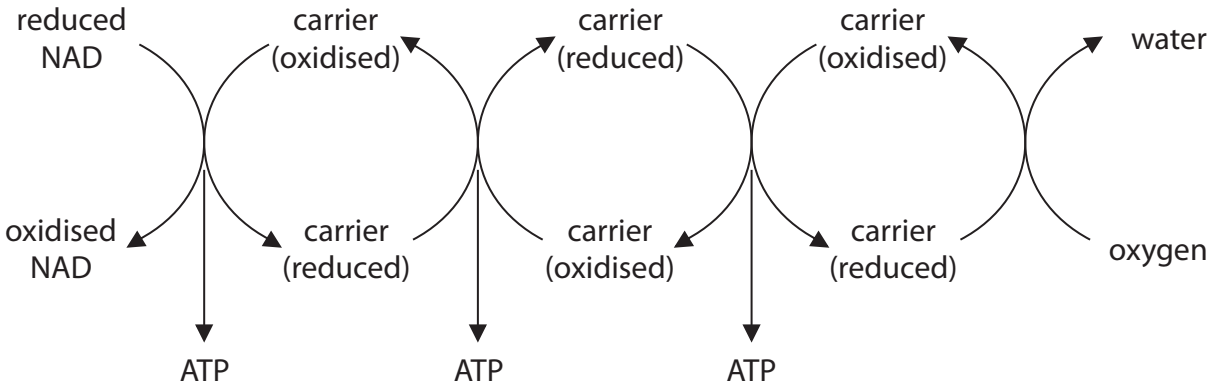
(d) Comment on the claim that the CMR method produces an accurate measure of the population size of mice in the woodland.

(5)

(Total for Question 7 = 13 marks)

8 The electron transport chain generates ATP.

The diagram shows the electron transport chain.



(a) State the location of the electron transport chain in a mitochondrion.

(1)

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(b) Hydrogen cyanide gas is a poison that can kill an animal if it is inhaled.

Cyanide is a non-competitive inhibitor of the enzyme cytochrome oxidase.

Cytochrome oxidase is the last carrier in the electron transport chain.

(i) Explain why hydrogen cyanide gas can kill an animal.

(5)

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(ii) A dose of 1.0 mg of hydrogen cyanide per kilogram of body mass is fatal.

An animal with a body mass of 10 kg inhaled air containing 0.24 mg dm^{-3} of hydrogen cyanide.

The animal breathed at a rate of 15 dm^3 of air per minute.

Calculate how many minutes it would take for this animal to obtain a fatal dose.

Give your answer to three significant figures.

(3)

Answer ..... minutes

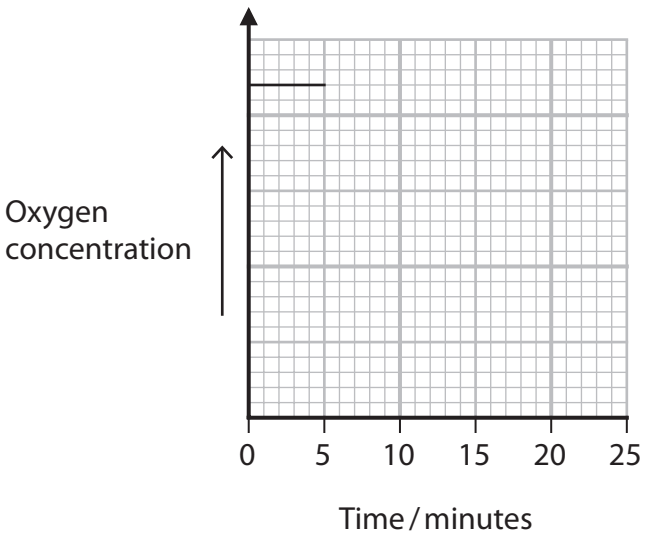
(c) The effect of cyanide on oxygen uptake by mitochondria was investigated using the following method:

- suspend mitochondria in a flask containing a buffer solution
- measure the concentration of oxygen in the flask for the first five minutes
- then add a respiratory substrate and ADP to the flask
- measure the concentration of oxygen in the flask for the next 10 minutes
- then add cyanide solution to the flask
- measure the concentration of oxygen in the flask for the next 10 minutes.

The graph shows the results for the first five minutes.

Complete the graph to show the results for the next 20 minutes.

(2)



(Total for Question 8 = 11 marks)

9 Biodiversity is monitored by conservationists.

Biodiversity can be calculated using the formula

$$D = \frac{N(N-1)}{\sum n(n-1)}$$

(a) Give the symbol in this formula that represents the total number of organisms of all species.

(1)

.....

(b) The photograph shows a hedge.

(Source: © 1000 Words/Shutterstock)

Many fields in the UK are separated by hedges.

Conservationists investigated biodiversity in hedges of different ages.

Hedges of different ages were sampled at random and the number of species of woody plants was counted.

The graph shows the results of this investigation.

Analyse the data to explain why conservationists object to the destruction of hedgerows to increase the size of fields.

(4)

(c) State why random sampling was used in this investigation.

(1)

(d) The conservationists observed that the plants in older hedges contained more wood than the plants in younger hedges.

Wood consists of xylem tissue.

(i) Give an advantage for older plants of containing more wood.

(1)

(ii) Describe a method to show that the stem of an older plant contains more wood.

(3)

(e) A student thought that the age of a plant affects the water potential of its tissue.

The student used potatoes of different ages to test this hypothesis.

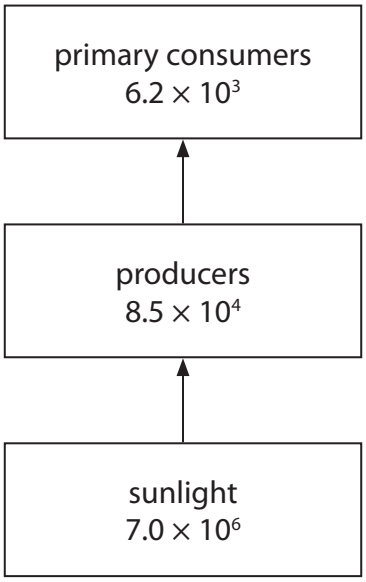
Justify each step of a method the student could use to compare the water potential of potato tissue of different ages.

(5)

(Total for Question 9 = 15 marks)

10 The diagram shows the flow of energy in an ecosystem.

The numbers represent the energy in $kJ\,m^{-2}\,yr^{-1}$ in each category.



(a) (i) Calculate the percentage efficiency of energy transfer from sunlight to the producers.

(2)

Answer ..... %

(ii) Give one reason why the energy transfer from sunlight to the producers is less than 100% efficient.

(1)

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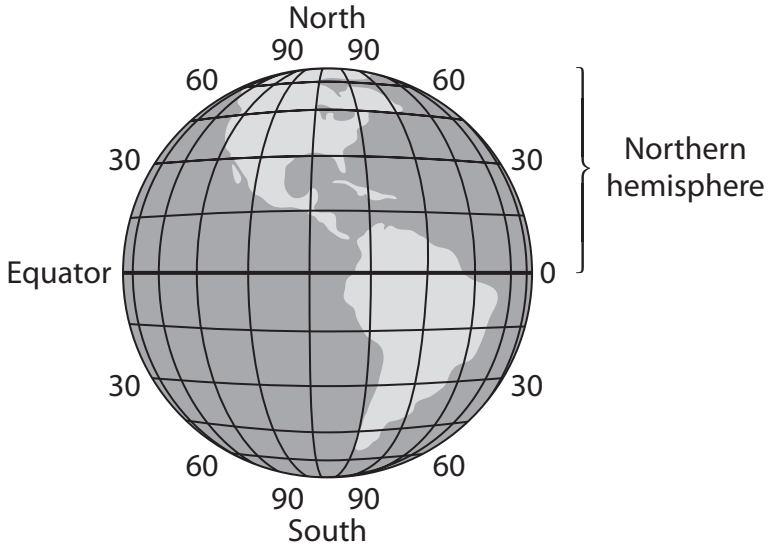
(iii) Explain the energy difference between the producers and the primary consumers.

(2)

(b) Plant productivity is affected by the abiotic and biotic factors that exist at different latitudes.

The diagram shows latitudes of the Earth.



The table shows the productivity of plants growing on land at different latitudes in the Northern hemisphere.

Latitude / degrees	Productivity / g m^{-2} yr^{-1}
0 to 10 (equatorial conditions)	900 to 1500
30 to 40 (warm temperate conditions)	400 to 800
40 to 60 (cool temperate conditions)	200 to 600
60 to 70 (alpine to arctic conditions)	0 to 200

A student concluded that primary productivity is determined by abiotic factors that affect the light-dependent and light-independent stages of photosynthesis.

Discuss the validity of this conclusion.

(9)

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(Total for Question 10 = 14 marks)

TOTAL FOR PAPER = 120 MARKS

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