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 16 June 2023

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 ▶

P71910A

©2023 Pearson Education Ltd.
N:1/1/1/1/

P 7 1 9 1 0 A 0 1 3 6

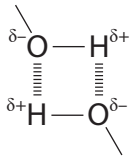
Pearson

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

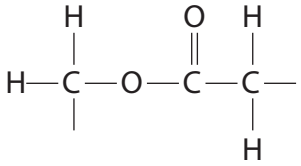
Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Carbohydrates and proteins are important biological molecules.

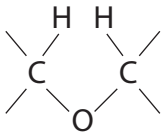
(a) The diagrams show some of the bonds found in biological molecules.



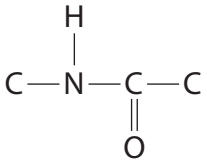
V



W



X



Y



Z

(i) Which one of the letters shows a bond that joins glucose molecules together in a disaccharide?

(1)

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(ii) Which letters show bonds that hold together the tertiary structure of a protein?

(1)

☒ **A** V and X

☒ **B** V and Z

☒ **C** W and Y

☒ **D** W and Z

(iii) Which letter shows a bond that holds together cellulose molecules within a cellulose microfibril?

(1)

☒ **A** V

☒ **B** W

☒ **C** X

☒ **D** Y

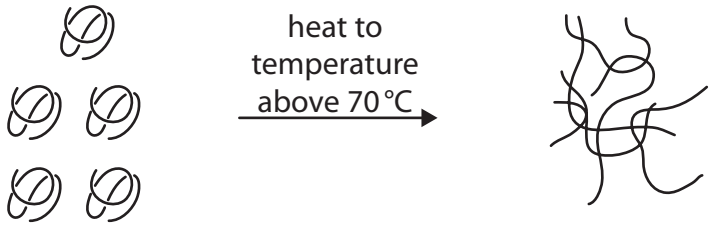
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) Raw egg white is a liquid containing dissolved ovalbumin, a globular protein.

Ovalbumin has some amino acids with polar R-groups and some amino acids with non-polar R-groups.

If raw egg white is heated to a temperature above 70 °C, it irreversibly changes into a solid.

The diagram shows how the structure of ovalbumin changes when heated.



ovalbumin in raw egg white

ovalbumin in solid egg white

Explain why heating ovalbumin to temperatures above 70 °C causes egg white to change from a liquid into a solid.

(3)

(Total for Question 1 = 6 marks)

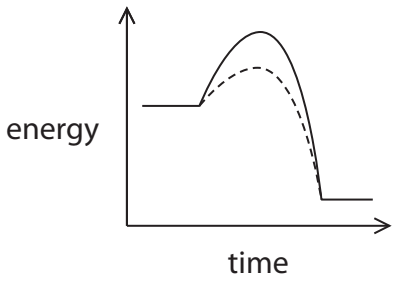
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

2 Bromelain is a protease enzyme in pineapple juice.

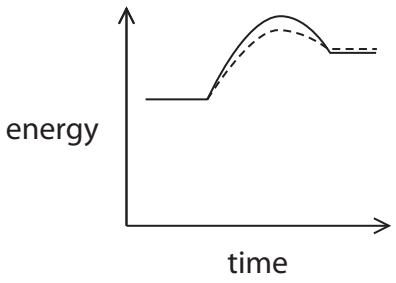
(a) Which graph shows the energy changes that occur in a typical enzyme catalysed reaction?

(1)

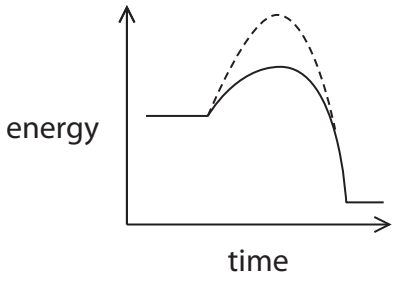
Key:
_____ without enzyme
- - - - - - with enzyme



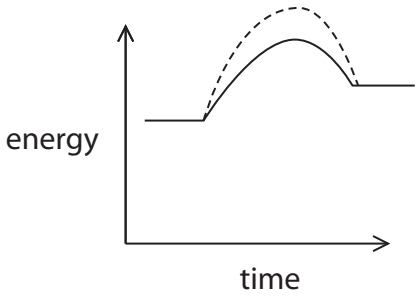
W



X



Y



Z

☒ **A** W

☒ **B** X

☒ **C** Y

☒ **D** Z

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) A student investigated the digestion of gelatine protein by pineapple juice.

This is the method used.

Step 1: Make a solid disc of gelatine protein, with a depth of 1 cm, in a Petri dish.

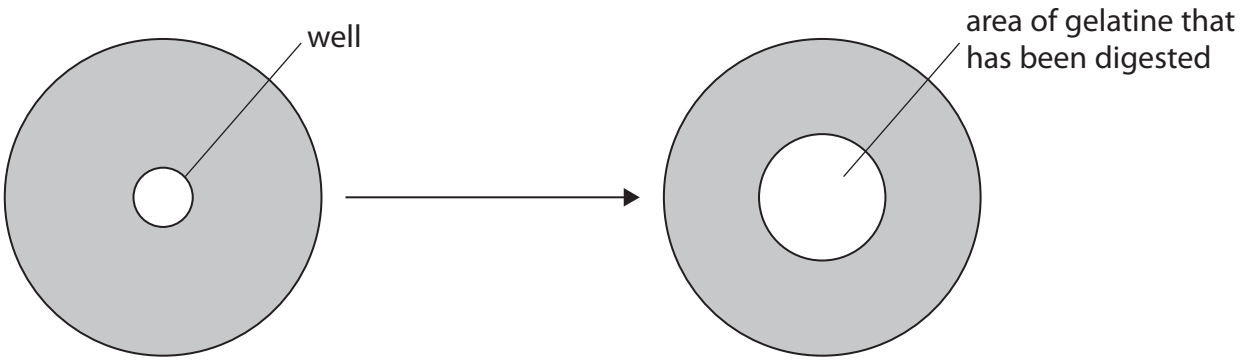
Step 2: Cut out a circular well with a diameter of 2 cm in the centre of the disc.

Step 3: Fill the well with pineapple juice.

Step 4: Incubate the dish for one hour at 37 °C.

Step 5: Measure the diameter of the area that has been digested by the bromelain enzyme.

The diagram shows a gelatine disc before and after incubation with the pineapple juice.



The diameter of the circular area that had been digested after one hour was 6 cm.

Calculate the volume of gelatine that had been digested.

Give your answer, in mm^3, to two significant figures.

Volume of a cylinder = $\pi r^2 l$

$\pi = 3.14$

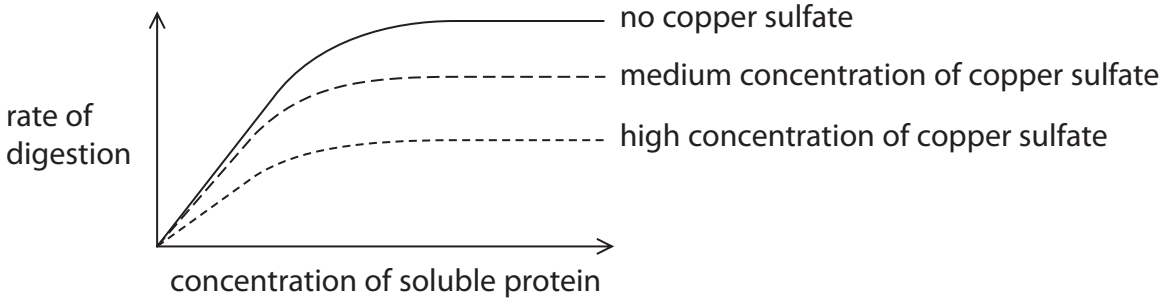
(3)

Answer ..... mm^3

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(c) Bromelain also digests other proteins.
The student also investigated the effects of changing the concentration of a soluble protein, and the addition of copper sulfate on the rate of digestion of this soluble protein by bromelain.

The results are shown in the graph.



(i) Explain the effect of increasing substrate concentration on the rate of digestion of the soluble protein.

(2)

(ii) Explain the effect of copper sulfate on the rate of digestion of the soluble protein.

(2)

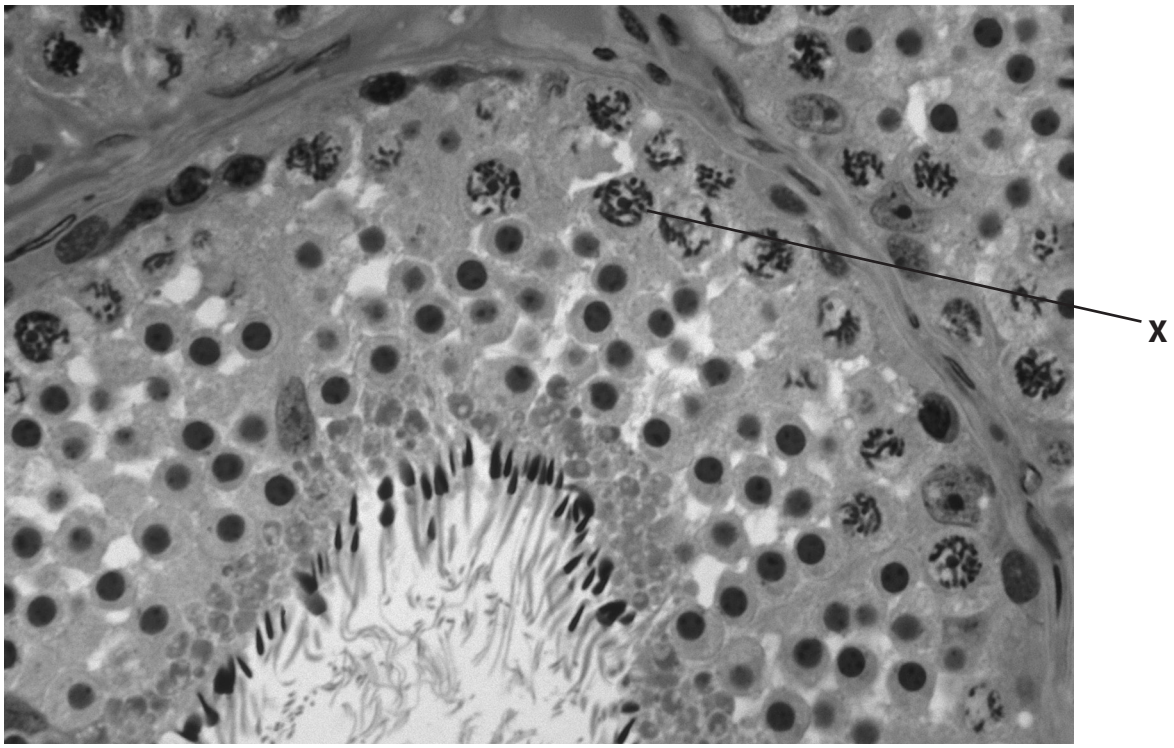
(Total for Question 2 = 8 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

BLANK PAGE

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

3 The photograph shows part of a testis, as seen using a light microscope.



(Source: © M. I. WALKER / SCIENCE PHOTO LIBRARY)

(a) The cell labelled X is a primary spermatocyte.

(i) At which stage of cell division is cell X?

(1)

☒ **A** prophase I of meiosis

☒ **B** prophase II of meiosis

☒ **C** prophase I of mitosis

☒ **D** prophase II of mitosis

(ii) In the photograph, cell X has a width of 0.8 cm.

The magnification of the photograph is ×1500.

Calculate the actual width, in micrometres (μm), of cell X.

Give your answer to one decimal place.

(2)

Answer ..... μm

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) Some pregnancies do not develop to full term, so no baby is born.

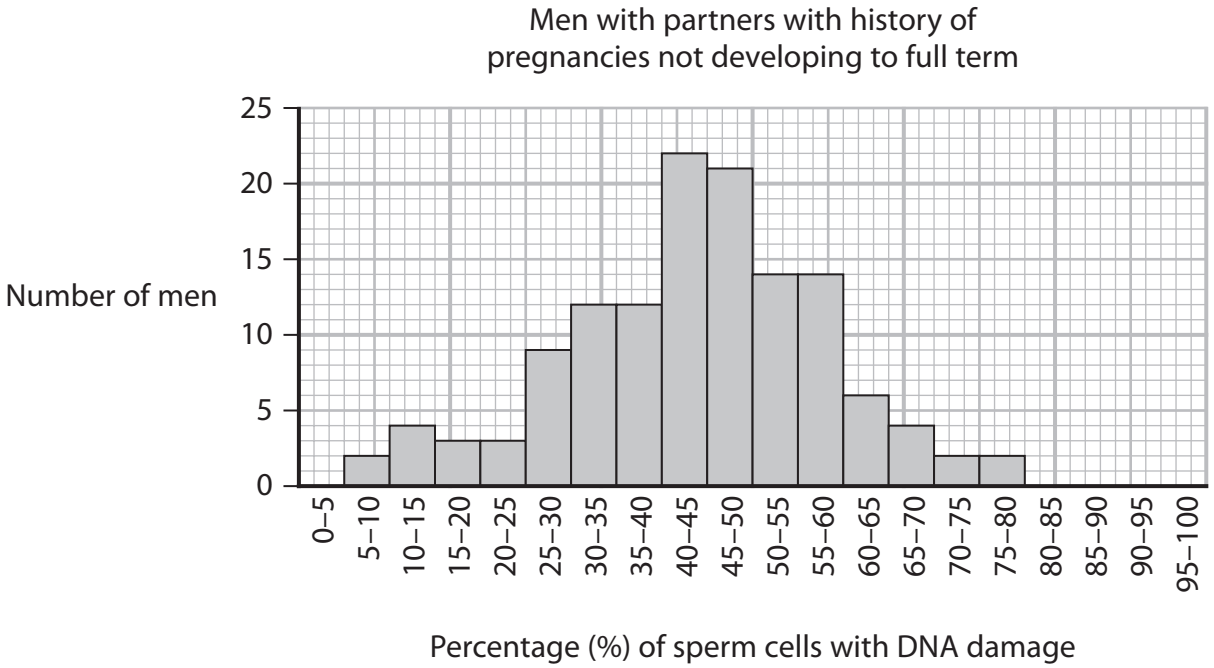
Damage to the DNA of sperm is thought to be one cause of pregnancies not developing to full term.

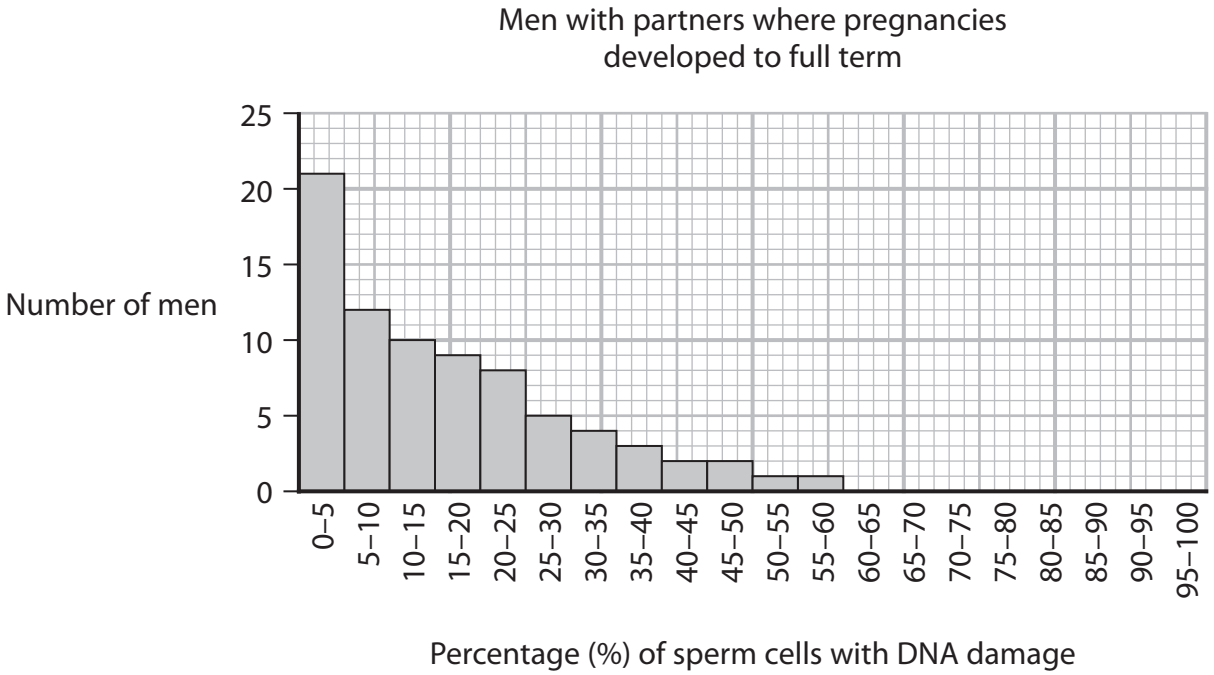
Scientists investigated if there is an association between the production of sperm with damaged DNA and the risk of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was determined for 130 men where there was a history of pregnancies not developing to full term.

The percentage of sperm cells with DNA damage was measured for 78 men where pregnancies developed to full term.

The graphs show the results of this investigation.





DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(i) Calculate the number of men with partners that have a history of pregnancies not developing to full term that had 25% or less of sperm with DNA damage.

(1)

Answer .....

(ii) The scientists concluded that having more than 25% of sperm with damaged DNA leads to a high risk of pregnancies not developing to full term.

Analyse the data to evaluate this conclusion.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 3 = 8 marks)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

4 Saltmarshes are coastal habitats where silt (mud) is deposited. Saltmarshes are colonised by different species of plants and are regularly flooded with seawater.

The photograph shows an area of salt marsh.



(Source ©BOB GIBBONS / SCIENCE PHOTO LIBRARY)

(a) Conditions close to the sea are very windy.

(i) Which row in the table causes the highest rate of transpiration from a plant?

(1)

		Temperature	Wind speed	Air humidity
☒	**A**	high	high	high
☒	**B**	high	high	low
☒	**C**	high	low	high
☒	**D**	low	high	low

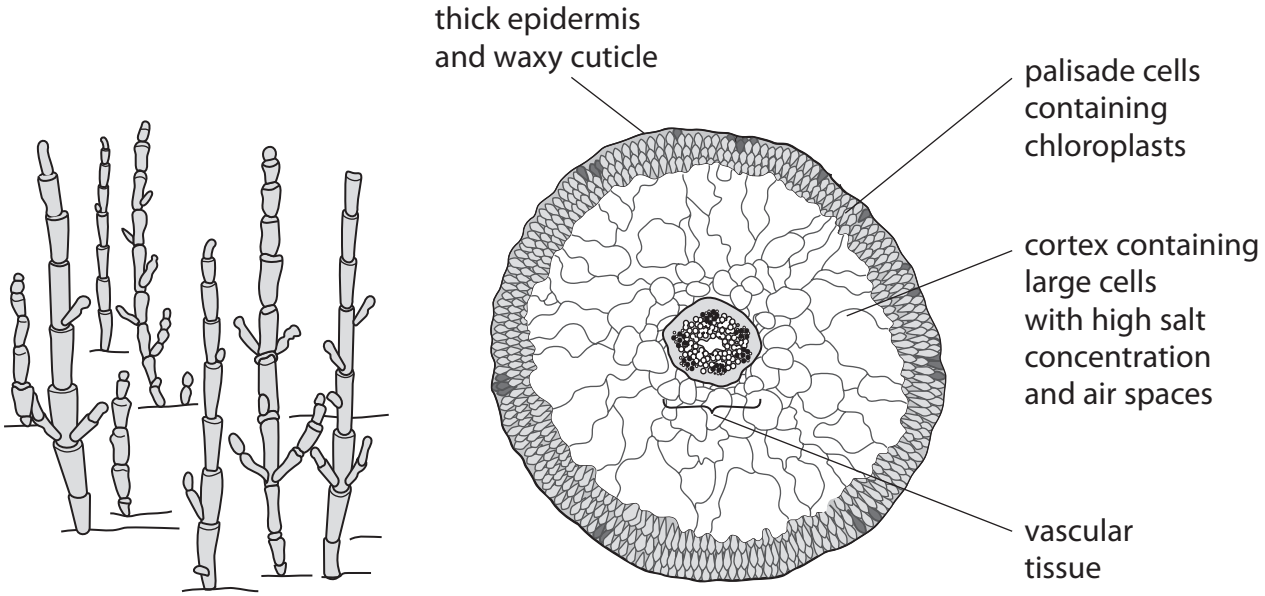
DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(ii) Samphire is one of the few plants that can grow in the areas close to the sea. Samphire plants have very small leaves and swollen stems.

The diagrams show a samphire plant and a cross section through the stem of a samphire plant.



Explain how samphire is adapted to grow in areas of saltmarshes closest to the sea.

(4)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) A group of students investigated succession in a saltmarsh.

The students measured several factors at 5 m intervals along a transect, starting at the edge of the sea.

The factors measured were:

- ACFOR scales for samphire, sea lavender, and scurvy grass
- index of diversity of all plant species
- percentage of silt (mud) made up of organic material.

The results are shown in the table.

Factor		Distance from sea / m				
		0	**5**	**10**	**15**	**20**
ACFOR scales	**Samphire**	Abundant	Common	Rare	Absent	Absent
	Sea lavender	Absent	Rare	Common	Common	Rare
	Scurvy grass	Absent	Absent	Rare	Occasional	Abundant
Index of diversity for all plant species		0.20	0.54	0.85	2.54	2.85
Percentage of silt made up of organic material (%)		15	10	25	35	55

(i) Give **two** limitations of using ACFOR scales to compare the distribution of different plant species.

(2)

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(ii) Saltmarshes are produced by deposits of silt (mud) from rivers.

As the distance from the sea increases, the age of the saltmarsh increases.

Explain the changes in distribution of the species as distance from the sea increases.

(4)

(Total for Question 4 = 11 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

5 The human retina contains photoreceptors called rod cells and cone cells.

(a) (i) Which of the following occur in the rod cell when it is stimulated by light?

(1)

1 rhodopsin breaks down into retinal and opsin

2 there is a decrease in the release of neurotransmitter molecules

3 there is more diffusion of sodium ions into the rod cell

☒ **A** 1 and 2

☒ **B** 1 and 3

☒ **C** 1, 2 and 3

☒ **D** 2 and 3

(ii) Explain why the centre of the retina is less sensitive to low intensity light than the outer areas.

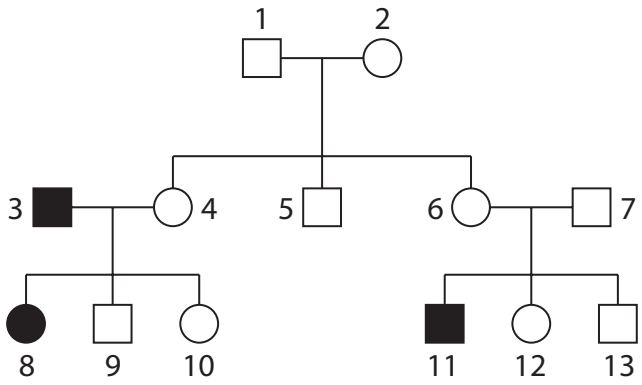
(2)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) Red-green colour blindness is a sex-linked genetic condition. People with this condition are unable to detect differences between red and green colours.

The pedigree diagram shows the inheritance of red-green colour blindness in a family.

The allele for red-green colour blindness, X^r, is recessive to the allele for colour vision, X^R.



Key:

- male without colour blindness
- male with colour blindness
- female without colour blindness
- female with colour blindness

(i) How many of the individuals in the family must have a genotype of X^RX^r?

(1)

- ☒ **A** 2
- ☒ **B** 3
- ☒ **C** 4
- ☒ **D** 5

(ii) Explain how this pedigree diagram demonstrates that red-green colour blindness is caused by a recessive allele.

(2)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

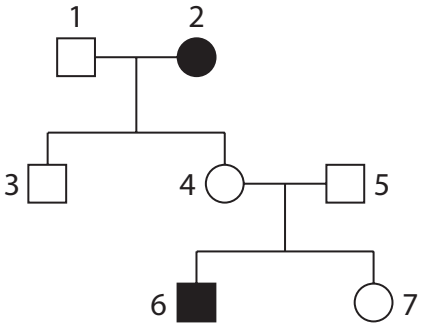
DO NOT WRITE IN THIS AREA

(c) Pingelap is an isolated island in the Pacific Ocean.

On Pingelap, between 4% and 10% of the population has a condition called achromatopsia. This means that they are unable to see any colour.

In most other countries, the incidence of achromatopsia is around 0.003%.

(i) The pedigree diagram shows the people who are and are not affected with achromatopsia in a family.



Key:

- male without achromatopsia
- male with achromatopsia
- female without achromatopsia
- female with achromatopsia

Deduce how achromatopsia is inherited.

Use the information in the pedigree diagram to support your answer.

(3)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) In 1755, a tsunami reduced the population to 20 people and there has been little immigration to the island.

In 2022, the human population of Pingelap was approximately 250.

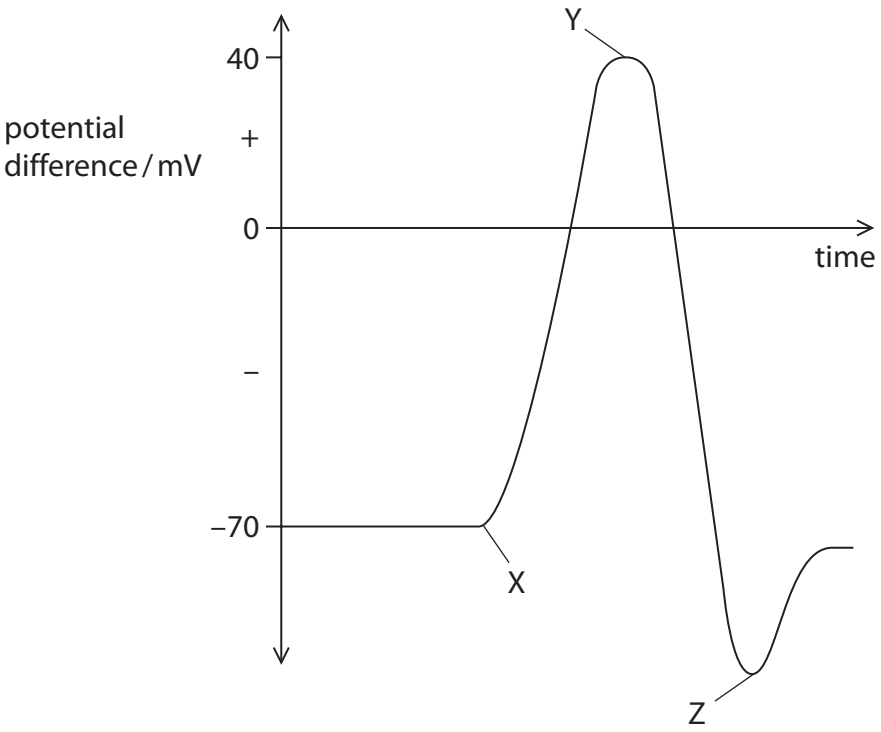
Explain why the incidence of achromatopsia is higher in Pingelap than in other countries.

(2)

(Total for Question 5 = 11 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

6 The diagram shows an action potential in a neurone.



(a) (i) Which of the following causes the change in potential between X and Y?

(1)

- ☒ **A** movement of calcium ions out of the neurone
- ☒ **B** movement of potassium ions out of the neurone
- ☒ **C** movement of sodium ions into the neurone
- ☒ **D** movement of sodium ions out of the neurone

(ii) Explain how membrane proteins cause the change in potential between Y and Z.

(2)

.....

.....

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(b) The photograph shows an African crested rat.



(Source: © https://commons.wikimedia.org/wiki/File:Lophiomys_imhausi.jpg)

This rat has several adaptations to prevent it being eaten by predators.

These adaptations include:

- The rat chews the bark of a tree called the arrow tree. The bark of this tree contains a poison called ouabain.
- The rat rubs the poison onto its fur, which is hollow to absorb the poison.
- The rat produces proteins in its saliva that prevent the ouabain harming it.

(i) Which types of adaptation has the rat evolved?

1 anatomical

2 behavioural

3 physiological

(1)

☒ **A** 1 and 2

☒ **B** 1, 2 and 3

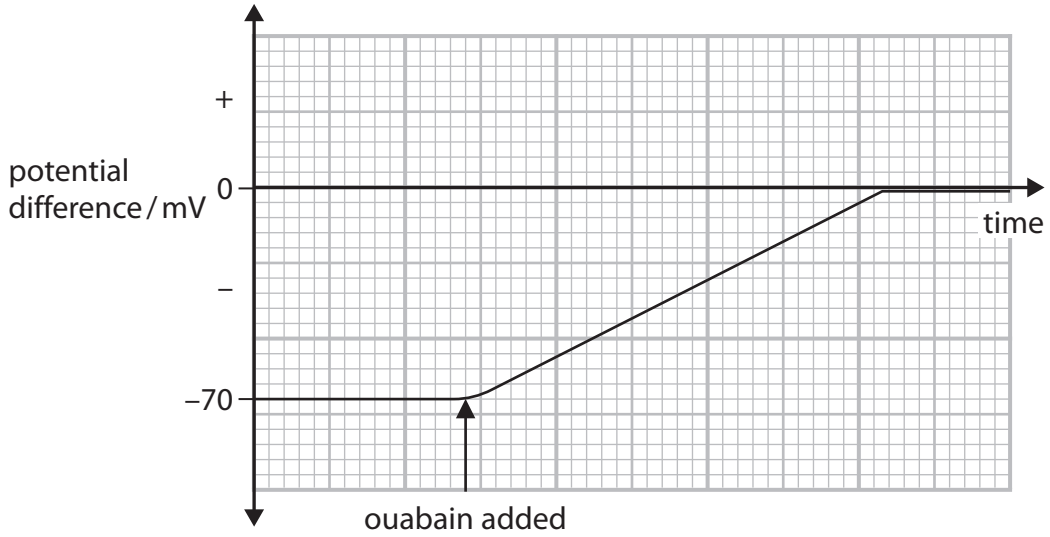
☒ **C** 1 and 3

☒ **D** 2 and 3

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) Ouabain inhibits sodium–potassium exchange pumps.

The diagram shows the effect of ouabain on the potential difference across a motor neurone membrane.



Explain how ouabain prevents the transmission of nerve impulses.

(3)

(Total for Question 6 = 7 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

7 Scientists investigated the role of ex-situ conservation of plant species on genetic biodiversity.

The scientists investigated the variability of DNA sequences of 30 different genes for a number of species of plants in seed banks and in the wild.

(a) (i) Which row gives correct statements about the genetic code in eukaryotes?

(1)

		Overlapping	Degenerate	Contains introns in genes
☒	**A**	yes	yes	yes
☒	**B**	yes	no	yes
☒	**C**	no	yes	no
☒	**D**	no	yes	yes

(ii) Explain why the DNA sequences of genes are more variable than the sequences of amino acids in the proteins coded for by these genes.

(2)

(iii) Describe how the scientists could use technology to find out whether gene sequences of two species are similar.

(2)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

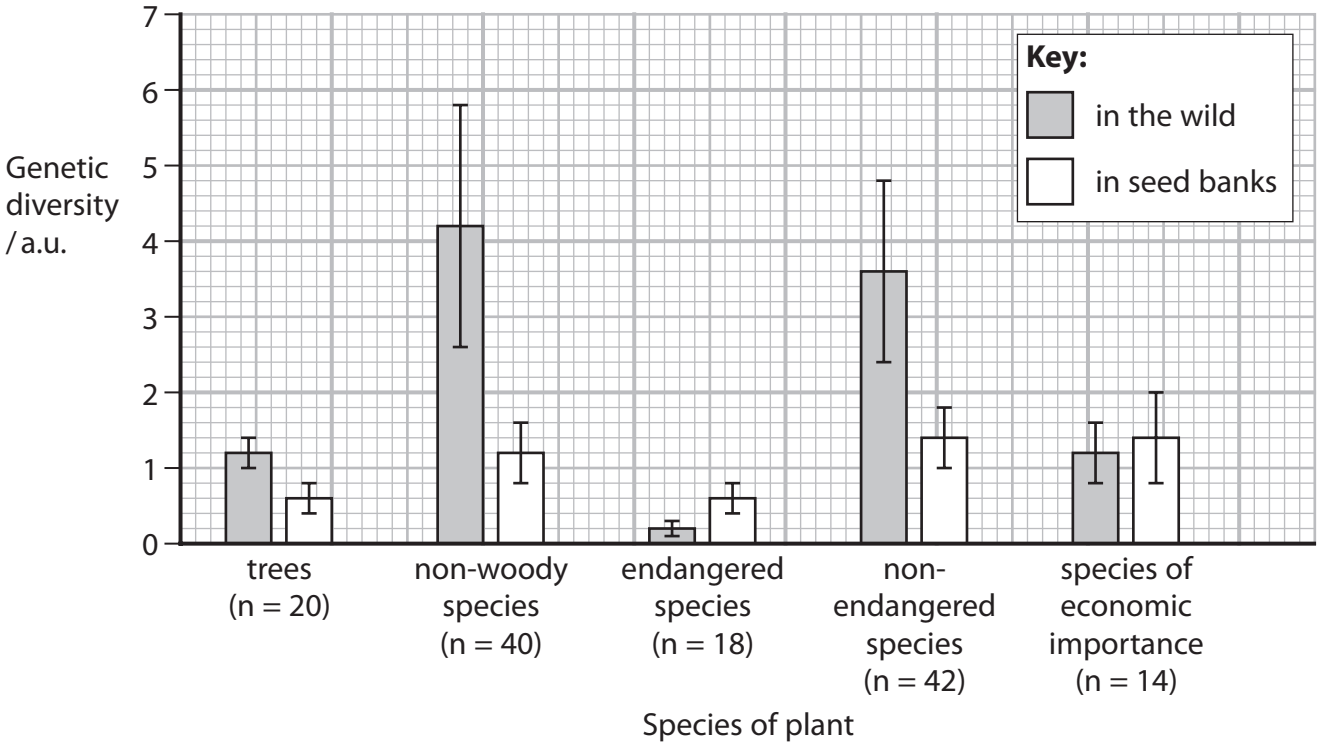
*(b) The scientists measured the mean genetic diversity of species in the wild and the mean genetic diversity of the same species in seed banks.

The species examined included:

- trees
- non-woody species of plant
- plant species classed as endangered
- plant species classed as not endangered
- plants of economic importance that are harvested by people.

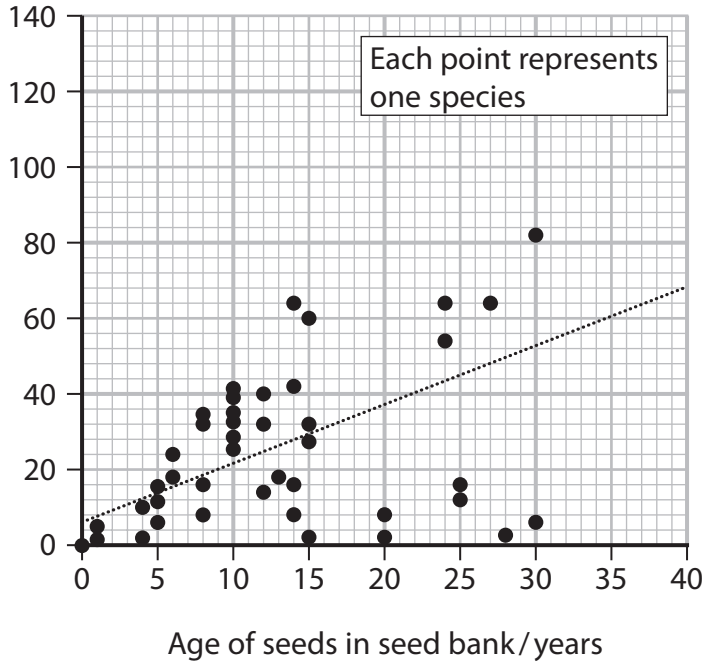
The scientists also measured the mean number of differences in the DNA sequences of the seeds that had been stored for different lengths of time compared with plants in the wild.

The graphs show the results.



Error bars represent +/−1 standard deviation
n = number of different species

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA



Analyse the data to discuss the results of this investigation.

(6)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(Total for Question 7 = 11 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

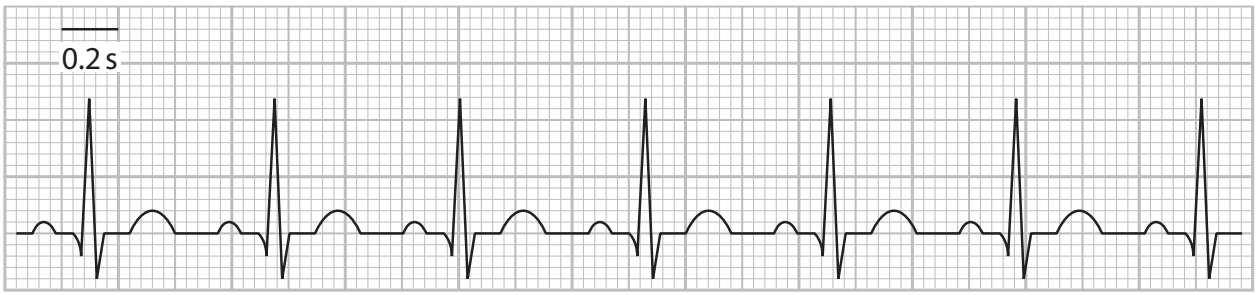
BLANK PAGE

8 (a) Explain why a double circulatory system enables mammals to have a high metabolic rate.

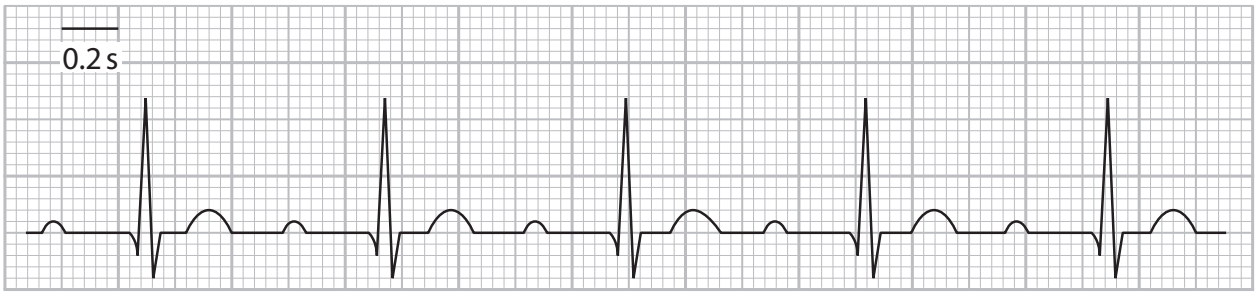
(2)

(b) Abnormal heart rhythms can be identified in ECG traces.

The diagram shows ECG traces of a person with a regular, healthy heart rhythm and a person with an abnormal heart rhythm.



Person with regular heart rhythm



Person with abnormal heart rhythm

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(i) Calculate the heart rate, in beats per minute, of the person with an abnormal heart rate.

Give your answer to the nearest whole number.

(2)

Answer ..... beats per minute

(ii) Explain how the ECG traces show this abnormal heart rhythm is due to damage to the septum in the centre of the heart between the left and right sides.

(2)

.....

.....

.....

.....

.....

.....

.....

.....

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

(iii) Bradycardia is a heart condition that results in a heart rate that is slower than normal.

Atropine is a drug that can be used to treat some forms of bradycardia.

Atropine is a competitive inhibitor of acetylcholine.

Explain why atropine will lead to an increase in heart rate.

(3)

(iv) Describe how exercise leads to the stimulation of the cardiac centre in the medulla oblongata.

(4)

(Total for Question 8 = 13 marks)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

9 Phytoplankton are producer organisms in marine ecosystems.

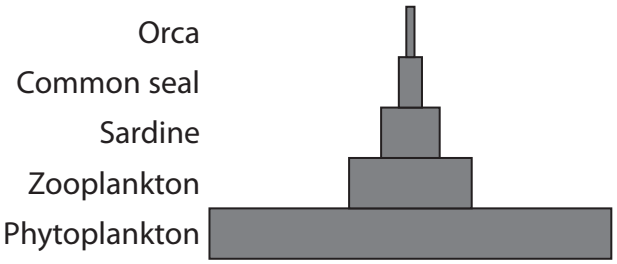
Zooplankton are small animals that live in the surface waters of the oceans.

The diagram shows a food chain for the South Atlantic Ocean.

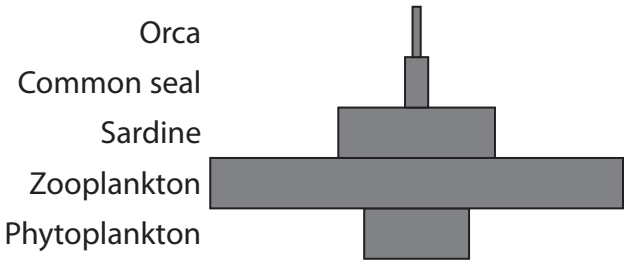
phytoplankton → zooplankton → sardine → common seal → orca

The diagrams below show ecological pyramids for this food chain.

Pyramid of biomass for November



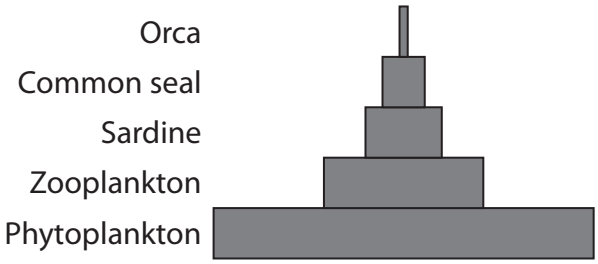
Pyramid of biomass for December



The units for biomass are kg m^{-3}

The units for energy are kJ m^{-3} yr^{-1}

Pyramid of energy for one whole year

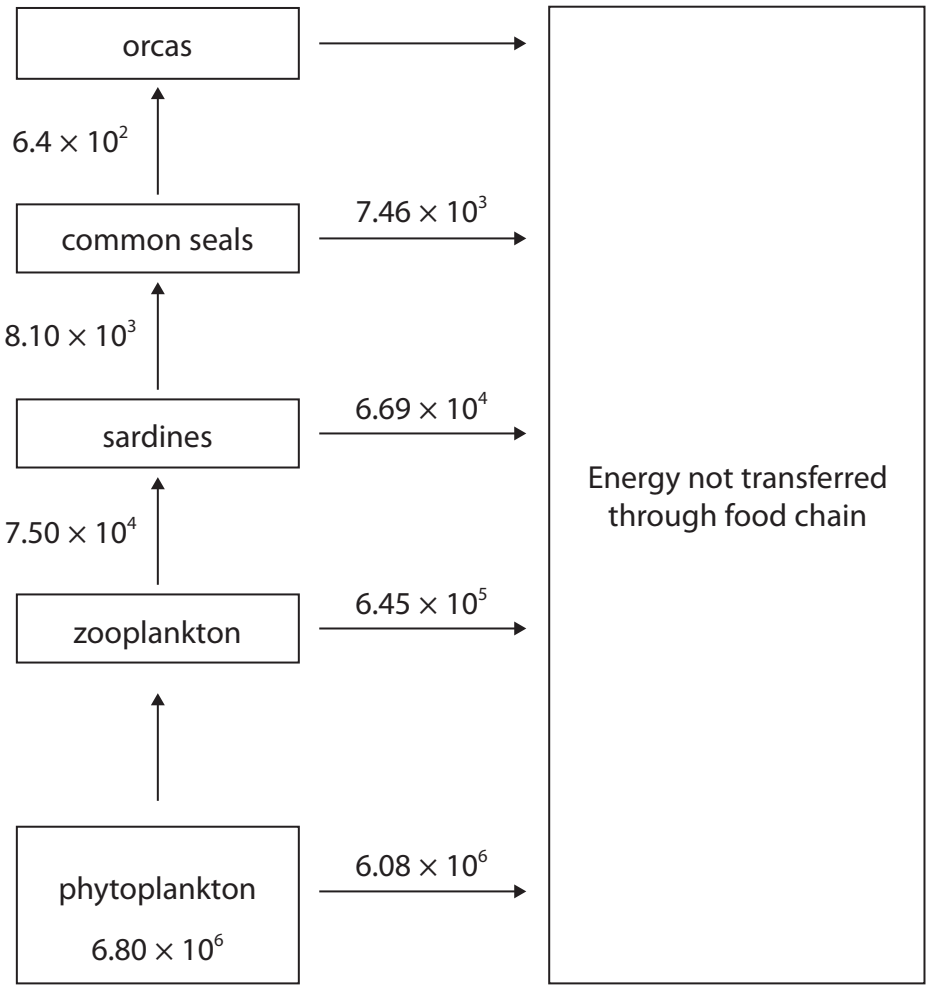


(a) Comment on the shapes of these three ecological pyramids.

(3)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(b) The diagram shows the flow of energy through this food chain.



All values are measured in $kJ\,m^{-3}\,yr^{-1}$

(i) Calculate the percentage efficiency of energy transfer between the phytoplankton and the zooplankton.

Give your answer to the nearest whole number.

(2)

Answer ..... %

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(ii) Common seals and orcas are endotherms.

Sardines are ectotherms.

Explain why the transfer of energy from sardines to orcas is less efficient than the transfer of energy from zooplankton to common seals.

(3)

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

(c) Scientists investigated the impact of global warming on marine productivity.

They determined the effect of temperature and light intensity on the net primary productivity (NPP) of phytoplankton.

Phytoplankton were exposed to different light intensities at three different temperatures for one month. After one month, the scientists measured the increase in dry biomass of phytoplankton.

The results are shown in the table.

Light intensity / arbitrary units	Mean increase in dry biomass of phytoplankton / g		
	10 °C	20 °C	30 °C
5	4	6	2
10	8	10	4
15	10	20	15
20	12	24	28
25	12	28	35

(i) State what is meant by the term net primary productivity (NPP).

(1)

.....

.....

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

*(ii) Some effects of global warming include the following:

- Atmospheric carbon dioxide could cause an increase in temperature.
- Increased atmospheric temperature could increase cloud cover.
- Increased ocean temperature could reduce the movement of nutrients such as nitrates from the seabed to the surface water.
- The scientists concluded that if the use of fossil fuels is not reduced, there will be a fall in populations of orcas in the South Atlantic Oceans.
- Analyse the data in the table and the information given to discuss this conclusion.

(6)

(Total for Question 9 = 15 marks)

TOTAL FOR PAPER = 90 MARKS

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

BLANK PAGE

DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA