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EDEXCEL A LEVEL BIOLOGY B: QUESTIONS BY TOPIC

Exchange and Transport (4)

A Level Biology B Topic 4

131 questions · 1313 marks · Mark schemes included

Pearson Edexcel AS (8BI0) and A Level (9BI0) Biology B, June 2016 - June 2025

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HOW TO USE THIS BOOKLET

Questions are grouped by specification sub-topic; within each sub-topic they run from the lowest mark tariff to the highest.
Click any heading or question row below to jump straight to it.
On every question page, click ANSWER in the top-right corner to jump to its mark scheme.
Diagrams, graphs, tables and data are printed exactly as they appeared in the original papers.

	QUESTION		SOURCE	MARKS	PAGE
4(a)	**CELL MEMBRANES AND TRANSPORT ACROSS THEM**		33 questions · 335 marks		**6**
1.	**Q1**		A Level Paper 1 June 2025	4	**7**
2.	**Q1**		A Level Paper 2 June 2018	5	**9**
3.	**Q1**	*also Topic 1*	AS Paper 1 June 2024	5	**10**
4.	**Q2**		AS Paper 2 June 2017	6	**12**
5.	**Q1**		A Level Paper 3 June 2019	6	**15**
6.	**Q3**	*also Topic 9*	A Level Paper 2 October 2020	6	**17**
7.	**Q1**	*also Topic 1*	A Level Paper 1 June 2023	6	**19**
8.	**Q1**		AS Paper 2 June 2025	7	**21**
9.	**Q10**		A Level Paper 3 June 2017	8	**23**
10.	**Q6**	*also Topic 2*	A Level Paper 2 June 2017	9	**25**
11.	**Q2**		AS Paper 2 June 2018	9	**27**
12.	**Q4**	*also Topic 2*	A Level Paper 1 June 2019	9	**30**
13.	**Q4**	*also Topic 1*	A Level Paper 1 June 2025	9	**32**
14.	**Q1**	*also Topic 8*	AS Paper 2 June 2016	10	**35**
15.	**Q7**		AS Paper 2 June 2018	10	**38**
16.	**Q6**	*also Topic 1*	A Level Paper 1 June 2022	10	**40**
17.	**Q6**		AS Paper 2 October 2020	11	**43**
18.	**Q5**		AS Paper 2 June 2022	11	**46**
19.	**Q6**		AS Paper 2 June 2023	11	**49**
20.	**Q7**	*also Topic 8*	A Level Paper 3 June 2017	12	**53**
21.	**Q4**		AS Paper 2 November 2021	12	**55**
22.	**Q7**	*also Topic 9*	A Level Paper 3 November 2021	12	**58**
23.	**Q6**		A Level Paper 3 June 2023	12	**60**
24.	**Q3**		A Level Paper 3 June 2024	12	**62**
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4(b) GAS EXCHANGE		20 questions · 196 marks		**97**
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40. **Q1**		A Level Paper 3 October 2020	8	**109**
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43. **Q3**	*also Topic 1*	A Level Paper 1 June 2018	9	**114**
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84.	**Q5**		AS Paper 2 June 2025	10	**215**
85.	**Q3**		A Level Paper 2 June 2025	10	**218**
86.	**Q4**	*also Topic 1*	A Level Paper 2 June 2025	10	**221**
87.	**Q5**		A Level Paper 2 June 2018	11	**225**
88.	**Q3**		AS Paper 2 June 2019	11	**229**
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118. **Q4**		AS Paper 2 June 2019	10	**313**
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121. **Q7**	*also Topic 10*	A Level Paper 2 October 2020	11	**320**
122. **Q4**	*also Topic 10*	A Level Paper 2 June 2023	11	**324**
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125. **Q8**		AS Paper 2 June 2018	13	**334**
126. **Q6**		AS Paper 2 June 2022	13	**336**
127. **Q9**		A Level Paper 3 June 2022	13	**340**
128. **Q9**		A Level Paper 3 June 2025	13	**343**
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QUESTIONS

131 questions · 1313 marks · grouped by sub-topic, lowest tariff first

SUB-TOPIC 4(a)

CELL MEMBRANES AND TRANSPORT ACROSS THEM

33 questions in this sub-topic · 335 marks · lowest tariff first

~~answer, put a line through the box ☒ and then mark your new answer with a cross ☒.~~

1 Active transport is one type of cell transport mechanism.

(a) What happens during active transport?

(1)

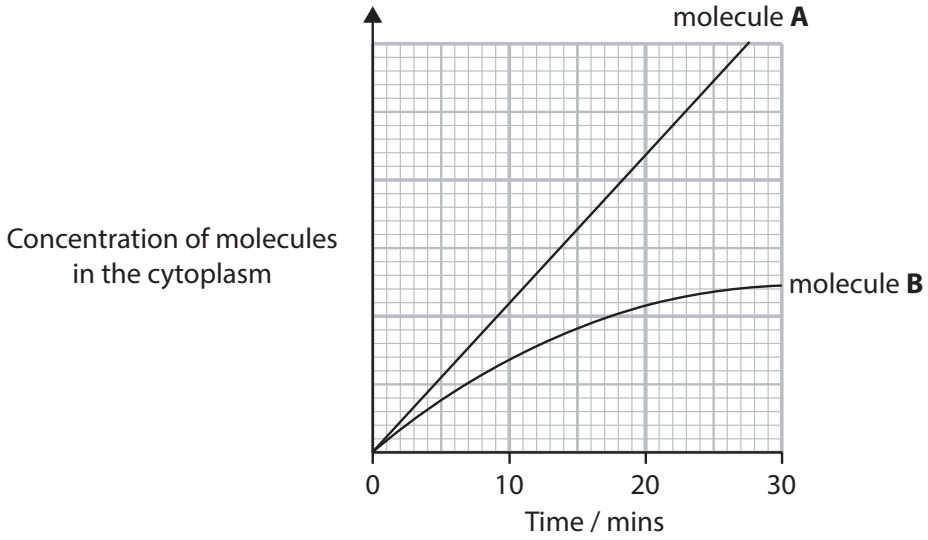
- ☒ **A** ATP is hydrolysed releasing energy
- ☒ **B** ATP is hydrolysed using energy
- ☒ **C** ATP is phosphorylated releasing energy
- ☒ **D** ATP is phosphorylated using energy

(b) Which substance is transported against a concentration gradient by active transport?

(1)

- ☒ **A** hydrophilic molecule
- ☒ **B** large hydrophobic molecule
- ☒ **C** small hydrophobic molecule
- ☒ **D** water

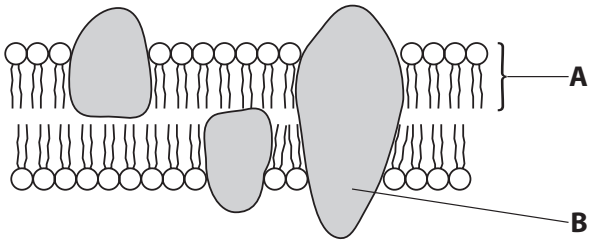
(c) The graph shows the change in concentration of molecule **A** and molecule **B**, as they are transported into the cytoplasm of a cell.



Explain the differences in the changes in concentration of molecule **A** and molecule **B** between 0 and 10 minutes and between 20 and 30 minutes.

(2)

1 The diagram shows the structure of a cell membrane.



(a) Name the parts labelled **A** and **B**.

(1)

.....

.....

(b) Explain how the structure of the membrane controls the transport of polar molecules.

(4)

.....

.....

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.....

.....

1 (a) Plants take up magnesium ions and nitrate ions from the soil. These inorganic ions are dissolved in the water in the soil.

(i) Magnesium ions and nitrate ions are incorporated into molecules made by the plant.

Which row in the table shows the molecules that incorporate these ions?

(1)

	amino acids	chlorophyll	nucleotides
☒ **A**	magnesium ions	nitrate ions	magnesium ions
☒ **B**	magnesium ions	nitrate ions	nitrate ions
☒ **C**	nitrate ions	magnesium ions	nitrate ions
☒ **D**	nitrate ions	magnesium ions	magnesium ions

(ii) Explain why these ions dissolve in water.

(2)

.....

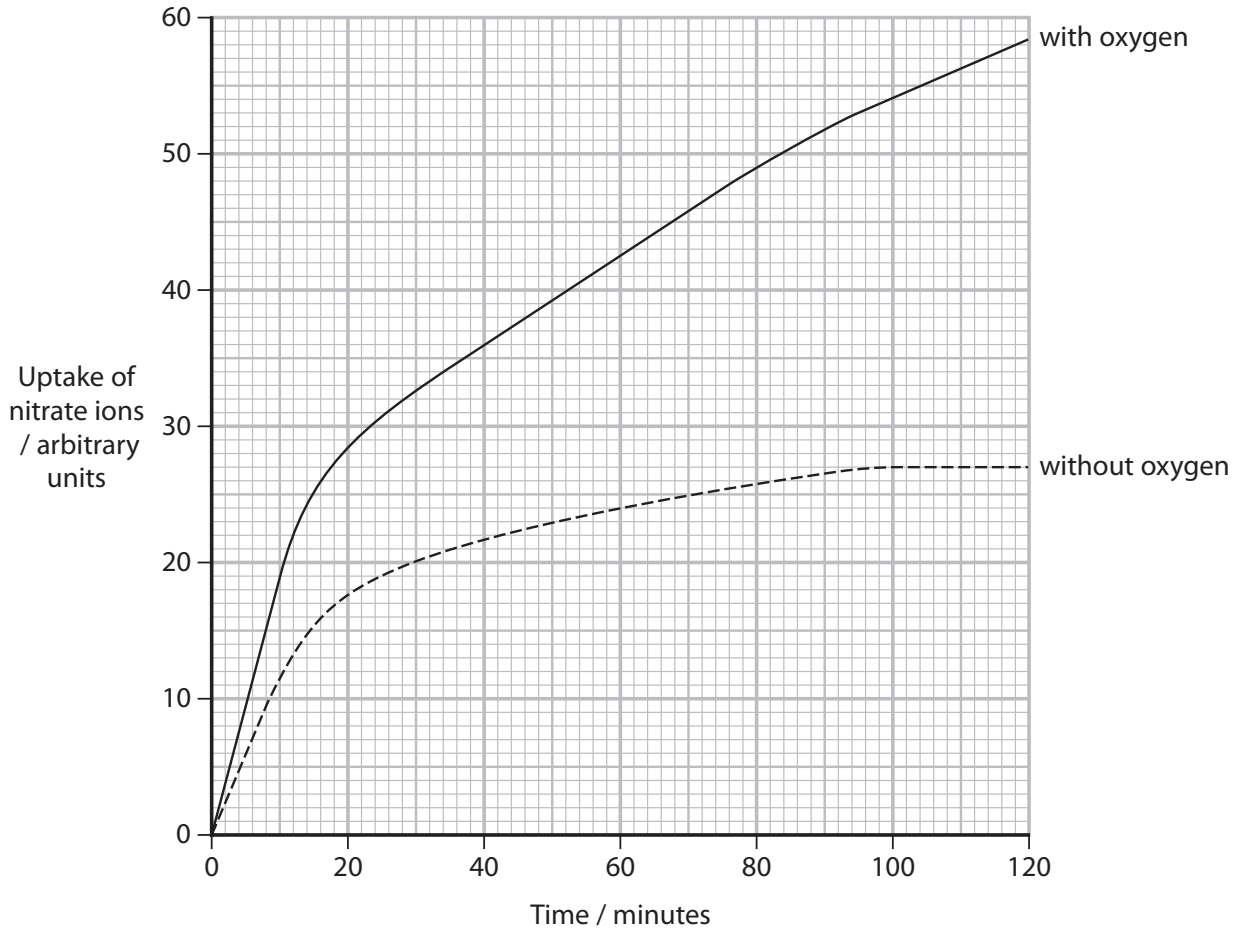
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(b) The graph shows the uptake of nitrate ions by a plant in the presence and absence of oxygen.



Analyse the data to describe **two** conclusions that can be made about the uptake of nitrate ions by this plant.

(2)

1 .....

.....

.....

2 .....

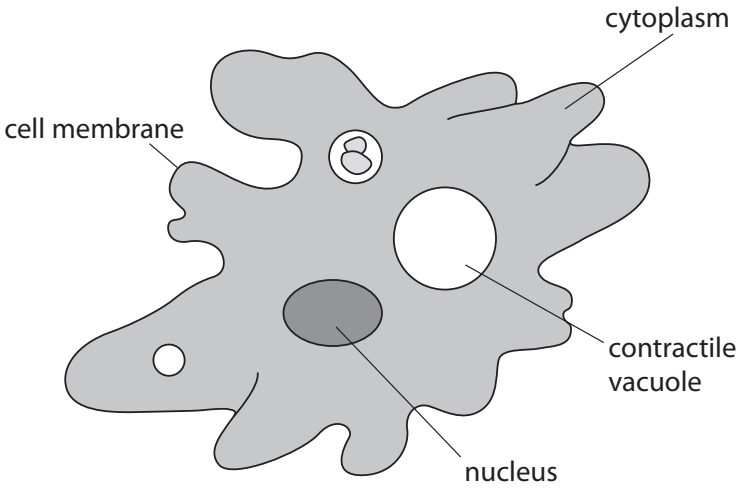
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2 *Amoeba proteus* is a single-celled organism that lives in pond water.

Amoeba has a structure called a contractile vacuole that removes excess water from the cell.

Water that moves into the cytoplasm is transported into the contractile vacuole. When full, the contractile vacuole moves to the surface of the cell and fuses with the cell membrane. This allows the water it contains to be removed from the cell.

The diagram shows *Amoeba* with a contractile vacuole.



(a) *Amoeba* belongs to the domain

(1)

☒ **A** Eukaryota

☒ **B** Bacteria

☒ **C** Archaea

☒ **D** Animalia

(b) The actual diameter of the contractile vacuole shown in this diagram is 20 μm.

Calculate the magnification of this *Amoeba*.

(2)

Answer .....

(c) (i) The water leaves the contractile vacuole by

(1)

- ☒ **A** endocytosis
- ☒ **B** exocytosis
- ☒ **C** osmosis
- ☒ **D** facilitated diffusion

(ii) A student investigated the effect of mineral ions in pond water on the rate at which the contractile vacuole emptied.

The student placed different specimens of *Amoeba* in different concentrations of mineral ion solution on microscope slides.

The student recorded the rate at which the contractile vacuole emptied.

The results are shown in the table.

Concentration of mineral ions / arbitrary units	Number of times contractile vacuole emptied per minute
5	14
10	6
15	5
20	3
25	2

Analyse the data to explain the change in the rate at which the contractile vacuole emptied.

(2)

1 A student investigated the water potential of potato cells.

The student used this method.

- six potato cubes of the same shape and size were cut from the same potato
- each cube was weighed
- each cube was then placed into a different concentration of sucrose solution
- each cube was removed from the sucrose solution after one hour
- each cube was then reweighed and the percentage change in mass was calculated

The table below shows the results of the investigation.

Concentration of sucrose solution / mol dm^{-3}	Percentage change in mass (%)
0.0	+18.0
0.2	+5.0
0.4	–8.0
0.6	–16.0
0.8	–23.5
1.0	–24.0

(a) The student was given a 1.0 mol dm^{-3} sucrose solution.

State how the student used this solution to make a 0.8 mol dm^{-3} sucrose solution.

(1)

(b) Sketch a graph you could use to identify the water potential of potato cells.

(2)

(c) The method used by the student could be improved to obtain a more accurate value for the water potential of these potato cells.

Justify **three** improvements that could be made.

(3)

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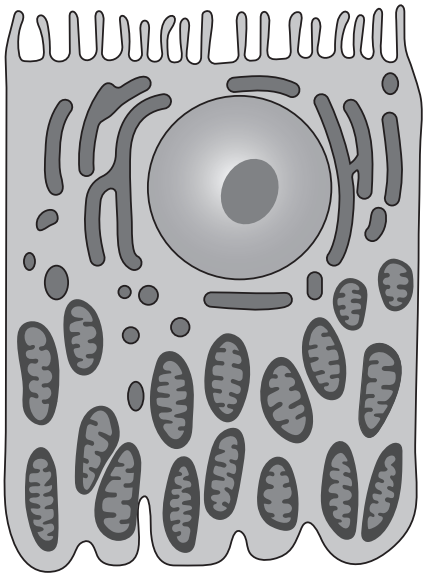
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3 (a) The diagram shows a cell from the proximal convoluted tubule of the nephron.



Explain how the features shown in the diagram enable this cell to carry out its function.

(4)

(b) (i) Which of the following statements about facilitated diffusion are correct?

(1)

1. substances move through membrane proteins
2. substances move against a concentration gradient
3. substances move down a concentration gradient
4. substances move between phospholipids

☒ **A** 1 and 2

☒ **B** 1 and 3

☒ **C** 2 and 3

☒ **D** 2 and 4

(ii) The collecting duct is also part of the nephron.

Which of the following are the effects of increased release of antidiuretic hormone (ADH)?

(1)

☒ **A** decreased permeability of the collecting duct to water, producing more concentrated urine

☒ **B** decreased permeability of the collecting duct to water, producing more dilute urine

☒ **C** increased permeability of the collecting duct to water, producing more concentrated urine

☒ **D** increased permeability of the collecting duct to water, producing more dilute urine

(Total for Question 3 = 6 marks)

1 Plants take up inorganic ions from the soil.

These ions include calcium, phosphate and potassium.

(a) (i) Name the molecule that contains calcium ions in the cell walls of a plant.

(1)

.....

(ii) How many of the following statements are correct?

(1)

- phosphate ions are used to make DNA and RNA
- phosphate ions are used in the structure of the cell membrane
- the element potassium is part of a peptide bond

☒ **A** none

☒ **B** one only

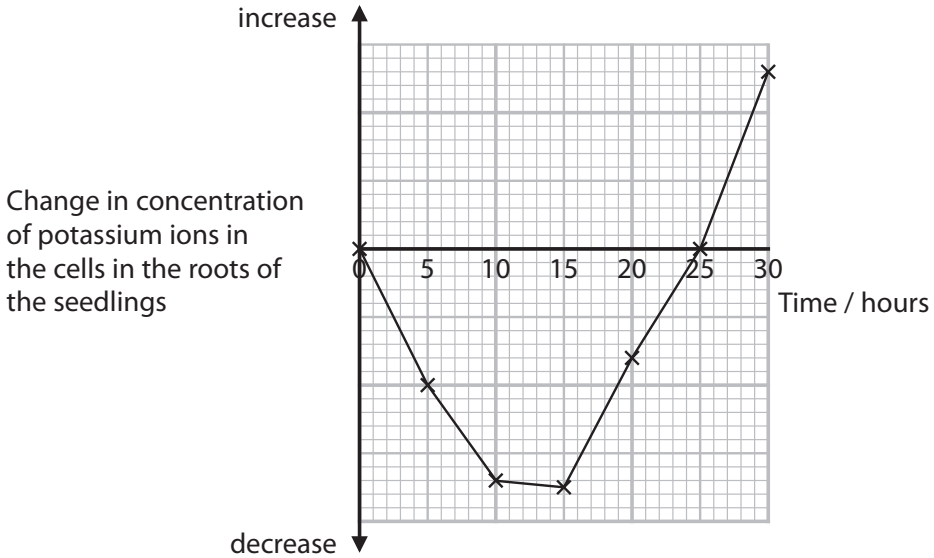
☒ **C** two only

☒ **D** three

(b) The uptake of potassium ions by plant seedlings in anaerobic and aerobic conditions was investigated.

The seedlings were grown in a mineral ion solution containing a low concentration of potassium ions for 30 hours. The conditions were anaerobic for the first 15 hours and aerobic for the second 15 hours.

The graph shows the results of this investigation.

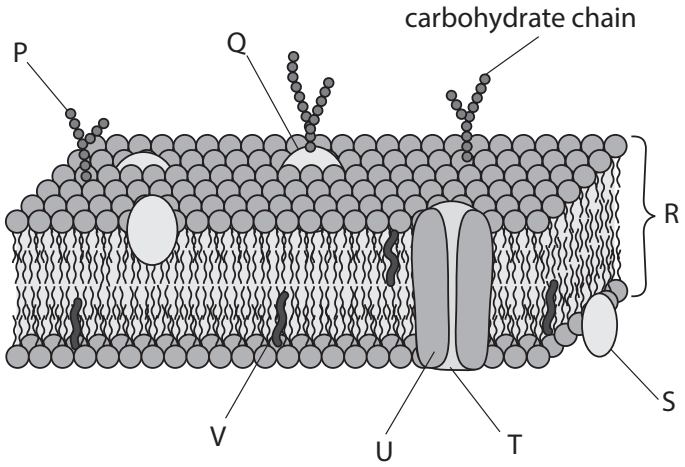


Explain the changes in the concentration of potassium ions in the cells in the roots of the seedlings during this investigation.

(4)

1 The cell surface membrane controls transport into and out of the cell.

(a) The diagram shows a cell surface membrane with some structures labelled.



(i) Which of the following labelled structures is cholesterol?

(1)

- ☒ **A** P
- ☒ **B** Q
- ☒ **C** S
- ☒ **D** V

(ii) Which of the following labelled structures is an integral protein?

(1)

- ☒ **A** Q
- ☒ **B** R
- ☒ **C** S
- ☒ **D** U

(iii) Which structure allows water molecules into the cell?

(1)

- ☒ **A** P
- ☒ **B** Q
- ☒ **C** T
- ☒ **D** V

(b) Explain how the properties of oxygen and of sodium ions determine how they enter a cell.

(4)

Oxygen

Sodium ions

10 (a) Devise an experiment, which uses changes in mass, to compare the water potential of carrot tissue with the water potential of potato tissue.

(5)

(b) The photograph shows *Salicornia*, a plant growing on salt marshes close to the sea. *Salicornia* colonises bare mud containing seawater.



A student sampled *Salicornia* plants at the river mouth by the sea and at different distances upstream. Samples of the water in the mud were also taken.

The salt concentration of the plants and the water in the mud were measured.

The results are shown in the table.

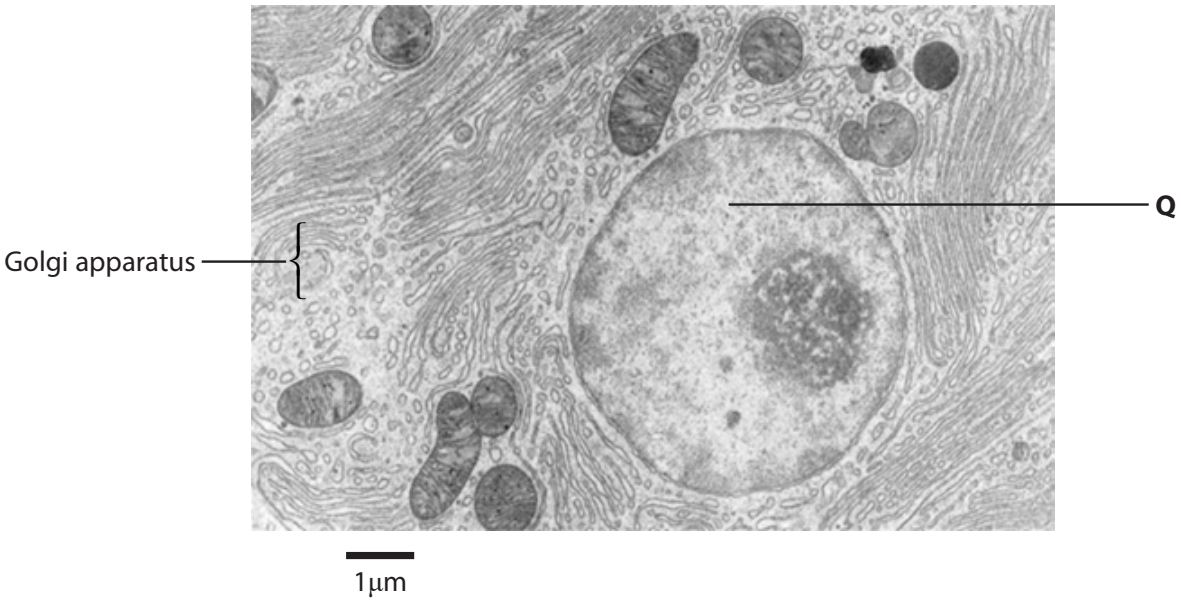
Distance upstream from sea / km	Salt concentration / arbitrary units	
	***Salicornia* plants**	**Water in the mud**
0.0	60.0	2.8
1.6	60.0	1.1
4.8	55.0	0.6
8.0	75.0	0.2

Analyse the data to explain how *Salicornia* is adapted to life in salt marshes.

(3)

6 The pancreas is an organ that secretes digestive enzymes.

The electron micrograph shows part of a secretory cell from a human pancreas.



(a) Name organelle **Q**.

(1)

.....

(b) Calculate the maximum diameter of organelle **Q**.

(2)

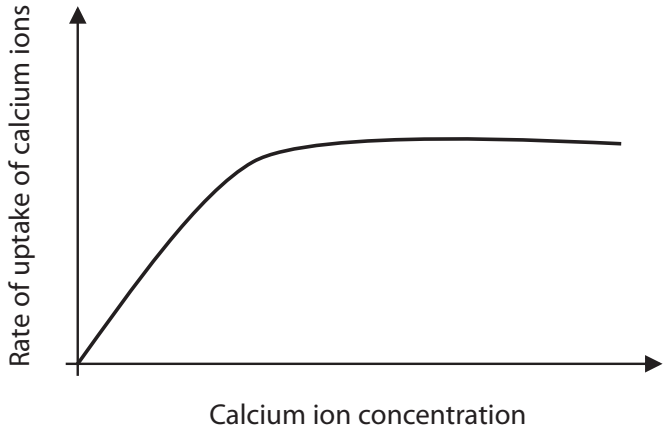
Answer .....

(c) Describe the role of the Golgi apparatus in producing secreted enzymes.

(3)

(d) Calcium ions are needed for the secretion of enzymes from pancreatic cells.

The graph shows the effect of increasing calcium ion concentration on the uptake of calcium ions by pancreatic cells.



Explain the effects of calcium ion concentration on the rate of uptake of calcium ions through the pancreatic cell membrane.

(3)

2 Water potential in plant cells can be represented by the equation

Water potential = turgor pressure + osmotic potential

$$\psi = P + \pi$$

(a) Plant tissue is placed in distilled water.

(i) Which of the following will occur?

(1)

☒ **A** more water will leave the tissue than enter

☒ **B** the cells will become turgid

☒ **C** the tissue will become flaccid

☒ **D** the cells will burst

(ii) When the plant tissue is placed in distilled water the value of

(1)

☒ **A** P will decrease

☒ **B** π will decrease

☒ **C** P will increase

☒ **D** ψ will not change

(iii) Which row of the table correctly identifies the values of P and π if the value of ψ is 0 kPa?

(1)

	P / kPa	π / kPa
☒ **A**	0	0
☒ **B**	–4.6	4.6
☒ **C**	4.6	–4.6
☒ **D**	4.6	0

(iv) Which liquid has the lowest water potential (ψ)?

(1)

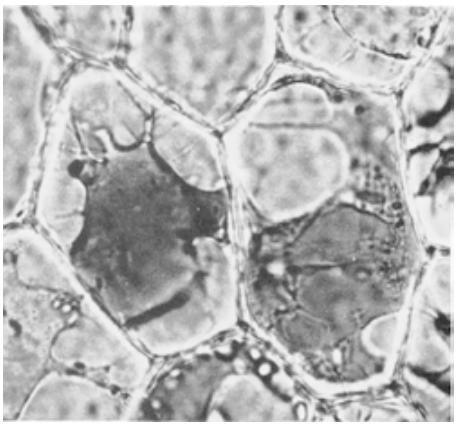
☒ **A** distilled water

☒ **B** 1.0 mol dm^{-3} sodium chloride solution

☒ **C** 0.1 mol dm^{-3} sodium chloride solution

☒ **D** 0.1 mol dm^{-3} potassium chloride solution

(b) If plant cells are placed in a solution with a lower water potential, the cell membranes will shrink away from the cell wall. The cells are described as plasmolysed.



The point at which 50% of the cells are plasmolysed can be used to estimate the osmotic potential of the cells.

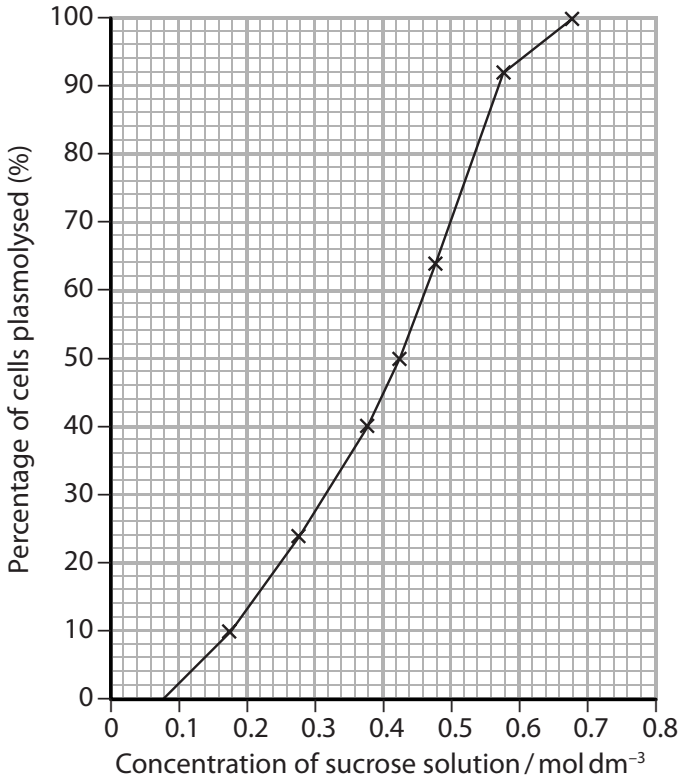
An experiment was carried out to determine the osmotic potential of onion cells.

Onion cells were placed in a range of sucrose concentrations and left for 10 minutes at 25 °C.

A sample of 50 cells was observed for each solution.

The percentage of plasmolysed cells was recorded.

The results are shown in the graph.



The table shows the osmotic potential of a range of sucrose solutions.

Concentration of sucrose solution / mol dm^{-3}	Osmotic potential / kPa
0.30	–860
0.35	–970
0.40	–1120
0.45	–1280
0.50	–1450
0.60	–1800

(i) Analyse the data in the graph and in the table to explain how the osmotic potential of these onion cells could be determined.

(3)

(ii) Explain why the plant tissue was left in sucrose solution for 10 minutes before the cells were observed.

(2)

4 (a) Photographs **P** and **Q** are electron micrographs of mitochondria.

Each photograph was taken using a different electron microscope.

Photograph **P**



Sourced from: http://book.bionumbers.org/how-big-are-mitochondria/

Photograph **Q**



Source: Cellupedia

(i) What is the structure labelled **S**?

(1)

- ☒ **A** crista
- ☒ **B** matrix
- ☒ **C** stroma
- ☒ **D** thylakoid

(ii) Explain the difference in appearance of the parts labelled **C** using the two different electron microscopes.

(2)

*(b) The table shows the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

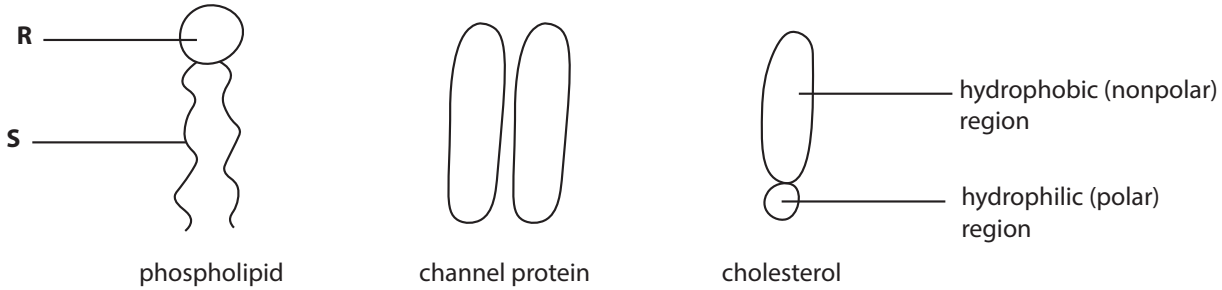
Membrane of mitochondrion	Protein : lipid ratio
inner	3:2
outer	1:1

Explain the difference in the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

(6)

4 The permeability of the cell surface membrane to a particular molecule depends on a number of factors, including the properties of the membrane and the properties of the molecule moving through it.

(a) The diagram shows some of the components of the cell surface membrane.



phospholipid channel protein cholesterol

(i) Which row in the table describes parts R and S of the phospholipid?

(1)

		Part R	Part S
☒	**A**	hydrophilic fatty acid	hydrophobic phosphate
☒	**B**	hydrophilic phosphate	hydrophobic fatty acid
☒	**C**	hydrophobic fatty acid	hydrophilic phosphate
☒	**D**	hydrophobic phosphate	hydrophilic fatty acid

(ii) Draw part of a cell surface membrane that has twelve phospholipids, one channel protein and one cholesterol molecule.

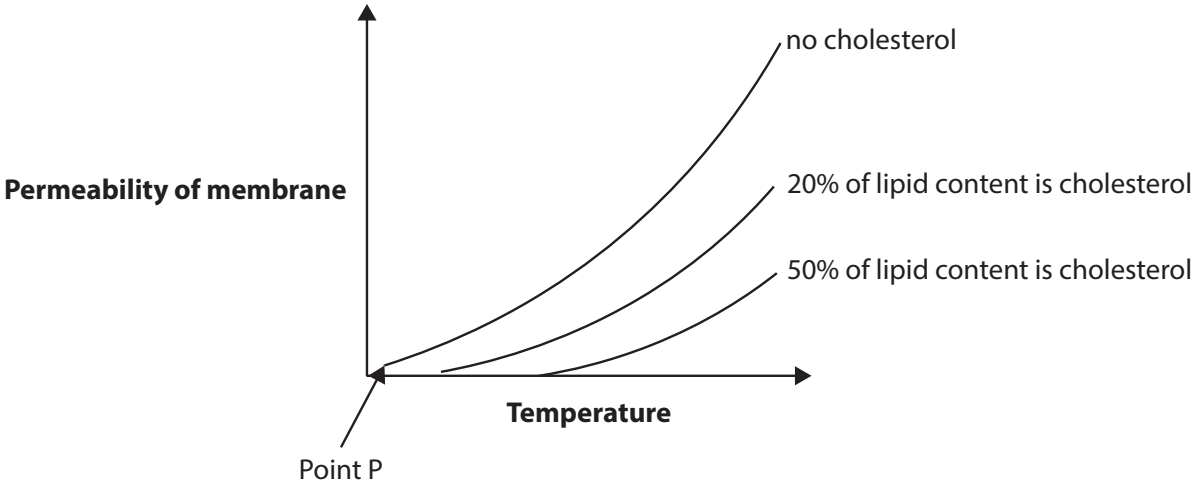
Use the components shown in the diagram.

(2)

(iii) Describe the role of channel proteins in cell transport.

(2)

(b) The graph shows the effect on the permeability of membranes of temperature and the proportion of cholesterol in the membrane.



(i) Analyse the data to give **two** conclusions that can be made from this graph.

(2)

(ii) Explain the effect of temperature on membrane permeability at point P.

(2)

1 Cholera is a disease caused by a bacterial infection that affects the absorption of water in the small intestine.

(a) The photograph shows part of one epithelial cell from the wall of the small intestine.



This cell is adapted to absorb substances by active transport.

State what is meant by the term **active transport**.

(2)

(b) The bacteria that cause cholera release a toxin.

This toxin affects the CFTR protein found in the membrane of intestinal epithelium cells.

The toxin causes the CFTR protein to pump more chloride ions out of these cells into the intestine. This causes a lot of water to be lost in the faeces.

Explain how the toxin causes this water loss.

(3)

(c) The CFTR protein is also found in the membrane of epithelial cells in the lungs.

Cystic fibrosis is a recessive genetic condition caused by mutations of the allele for the CFTR protein.

This can result in the production of thick, highly viscous mucus in the bronchioles and bronchi.

Explain why the blood of people with cystic fibrosis has a low oxygen concentration.

(2)

(d) There is a high frequency of mutated CFTR alleles in some human populations.

In an experiment, three groups of genetically modified mice were infected with cholera bacteria.

The relative volume of water in their faeces was measured.

The results are shown in the table.

Group	Relative volume of water in faeces
Mice with two normal CFTR alleles	1.0
Mice with one normal and one mutated CFTR allele	0.5
Mice with two mutated CFTR alleles	0.1

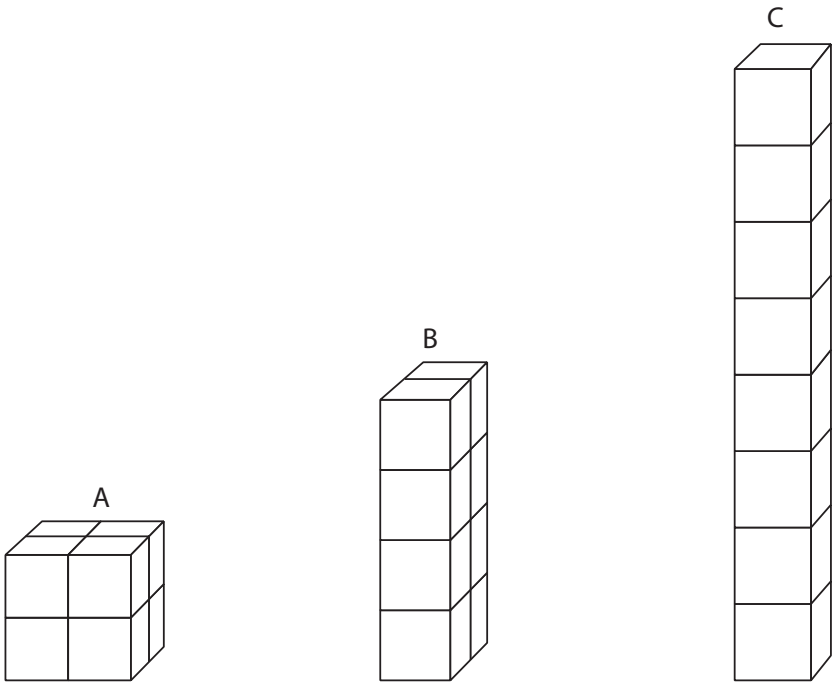
Use the information in the table to explain why the mutated CFTR allele has a high frequency in some human populations.

(3)

(Total for Question 1 = 10 marks)

7 A student investigated the effect of the shape of a potato chip on the rate of absorption of water.

Different shaped chips, A, B and C, were used.



(a) Calculate the surface area to volume ratio of potato chip B.

(3)

Answer .....

(b) These three chips will absorb water at different rates.

Predict the order in which the chips will absorb water, from the lowest rate to the highest rate.

(1)

.....

*(c) Devise an investigation to determine the effect of shape on the rate of absorption of water by potato chips.

(6)

6 The lipid content of the cell membranes of prokaryotic organisms changes in response to changes in the environmental temperature.

(a) Phospholipids form a bilayer in the cell membranes of bacteria.

Describe the structure of a phospholipid.

(2)

(b) The cell membranes of most organisms belonging to the domain Archaea are lipid monolayers.

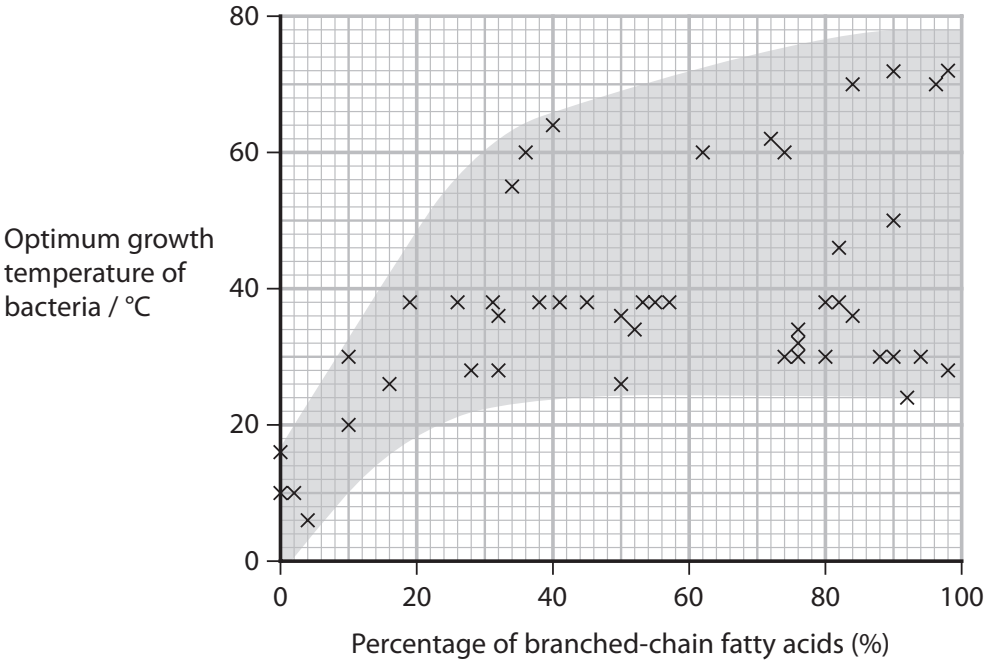
The lipid that forms this monolayer is a bipolar lipid.

Explain why a bipolar lipid is a suitable molecule to form the cell membrane.

(2)

(c) The percentage of branched-chain fatty acids in membranes of bacteria that have different optimum growth temperatures was investigated.

The graph shows the results of this investigation.



(i) Calculate the mean percentage of branched-chain fatty acids in bacteria whose optimum growth temperature is $<20\,°C$.

(1)

Answer ..... %

(ii) Analyse the data to describe **two** conclusions that can be drawn from this investigation.

(2)

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.....

(d) A change in temperature can affect the permeability and fluidity of the membrane.

Explain why it is important that the lipid composition of the membrane of prokaryotic organisms changes if the temperature changes.

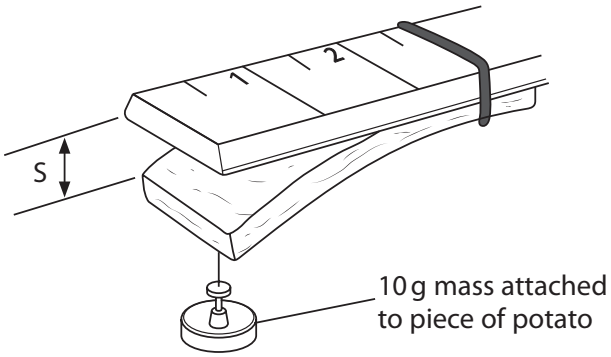
(3)

6 A student investigated the effect of changes in turgor on plant tissue.

Equal sized pieces of potato were cut and attached to a ruler.

These pieces were immersed in different concentrations of sucrose solution and left for one hour.

The pieces were then removed from the solution and the turgor was determined as shown in the diagram.



The distance (S) that each piece sagged from the ruler was measured.

The table shows the results of this investigation.

Concentration of sucrose solution / mol dm^{-3}	Mean distance S / mm
0.00	0.0
0.20	0.5
0.30	4.0
0.35	5.5
0.40	8.0
0.45	9.5
0.50	10.0
0.60	10.5

(a) (i) Plot a suitable graph to display the results of this investigation.

(3)



(ii) Calculate the mean change in the distance S in mm as the sucrose concentration changes from 0.2 to 0.4 mol dm^{-3}.

(2)

Answer ..... mm per mol dm^{-3}

(iii) Analyse the data to explain the relationship between the concentration of sucrose and turgor in the pieces of potato.

(4)

(b) Criticise the method used to determine turgor in this investigation.

(2)

5 Substances can move into or out of cells by a variety of methods.

(a) (i) A small ion is in high concentration outside a cell.

By which method is the ion most likely to enter the cell?

(1)

- ☒ **A** active transport
- ☒ **B** diffusion
- ☒ **C** facilitated diffusion
- ☒ **D** osmosis

(ii) Which of the following are required for active transport?

(1)

1 ATP

2 carrier proteins

3 cell membrane

- ☒ **A** 1 only
- ☒ **B** 1 and 2 only
- ☒ **C** 1 and 3 only
- ☒ **D** 1, 2 and 3

(iii) Which is a description of exocytosis?

(1)

- ☒ **A** a form of active transport in which large particles move into cells
- ☒ **B** a form of active transport in which large particles move out of cells
- ☒ **C** a form of passive transport in which large particles move into cells
- ☒ **D** a form of passive transport in which large particles move out of cells

(b) The properties of cell membranes were investigated using samples of tissue from a beetroot.

The following procedure was used:

- equal sized discs of beetroot were cut, washed and placed in boiling tubes containing 5 cm^3 of distilled water
- one of these boiling tubes was placed in a water bath at 20 °C for 30 minutes
- the discs of beetroot were then removed from the boiling tube
- a colorimeter was then used to measure the absorbance of the liquid in the boiling tube
- this was repeated using water baths at 30 °C, 40 °C, 50 °C, 60 °C and using an ice bath at 5 °C
- each temperature was tested 8 times.

The boiling tubes contained a red pigment that had leaked out of the beetroot discs.

The darker the red colour of the liquid in the boiling tube, the higher the absorbance.

The results of this investigation are shown in the table.

Temperature / °C	Absorbance / a.u.									
	1	2	3	4	5	6	7	8	Mean	Standard deviation
5	0.02	0.03	0.04	0.02	0.04	0.03	0.02	0.01	0.03	0.01
20	0.10	0.08	0.05	0.10	0.07	0.09	0.06	0.07	0.08	
30	0.12	0.09	0.07	0.10	0.08	0.07	0.09	0.10	0.09	0.02
40	0.09	0.10	0.12	0.09	0.12	0.13	0.11	0.09	0.11	0.02
50	0.12	0.17	0.14	0.15	0.20	0.23	0.18	0.19	0.17	0.04
60	0.85	0.97	1.03	0.89	1.10	0.89	0.92	0.87	0.94	0.09

(i) Explain which temperature above 30 °C shows the most variation in absorbance.

(2)

(ii) Calculate the standard deviation for the results at 20 °C.

Use the formula

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

(3)

Answer .....

(iii) Explain the effect of increasing temperature on membrane permeability.

(3)

6 The equation $\psi = P + \pi$ is used to determine the water potential of plant cells.

(a) State what the terms P and π represent.

(2)

P .....

π .....

(b) Students carried out an investigation to determine the osmotic potential and therefore water potential of plant epidermal cells.

Plant cells were placed in salt solutions of different concentrations.

The concentration that has the same osmotic potential as the cell sap causes visible plasmolysis in 50% of the cells. In a plasmolysed cell, the cell contents can be seen to have shrunk away from the cell wall.

When 50% of the cells are plasmolysed, this is referred to as the point of incipient plasmolysis.

The students counted the number of plasmolysed cells in different concentrations of salt solution.

The results are shown in Table 1.

Table 1

Salt concentration / mol dm^{-3}	Number of plasmolysed cells in a sample of 25				Mean percentage plasmolysis (%)
	count 1	count 2	count 3	count 4	
0.0	0	0	0	1	1
0.1	2	3	4	3	
0.2	6	4	7	4	21
0.3	8	10	9	7	34
0.4	11	9	12	8	40
0.5	12	13	15	16	56
0.6	18	17	16	17	68
0.7	22	19	20	21	82
0.9	23	25	22	24	94

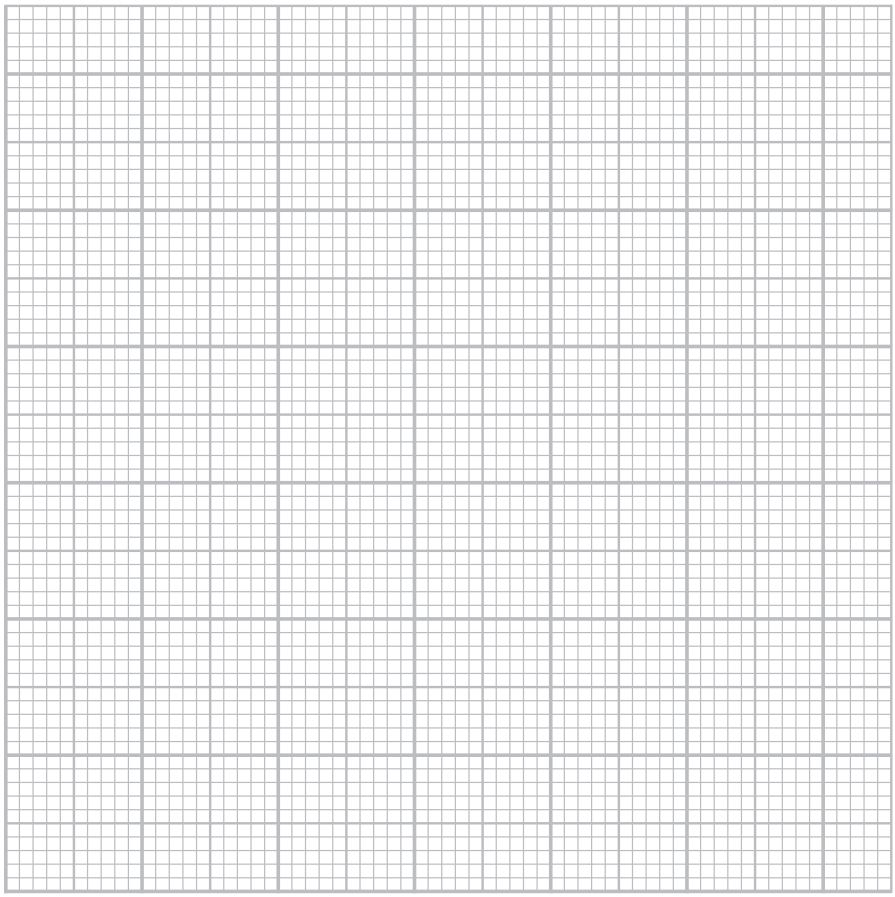
(b) (i) Calculate the mean percentage plasmolysis in the salt concentration of 0.1 mol dm^{-3}.

(1)

Answer .....

(ii) Plot a suitable graph to show the relationship between salt concentration and mean percentage plasmolysis.

(3)



(iii) Determine the concentration of salt solution in which incipient plasmolysis would occur, using your graph.

(1)

Answer ..... mol dm^{-3}

(iv) Table 2 shows the relationship between molarity and osmotic potential of salt solutions.

Table 2

Salt concentration / mol dm^{-3}	Osmotic potential / kPa
0.1	–270
0.2	–550
0.3	–830
0.4	–1130
0.5	–1460
0.6	–1820
0.7	–2200
0.8	–2610
0.9	–3050
1.0	–3560

Determine the water potential of the epidermal cells using table 2 and your answer to (b)(iii).

(2)

Answer .....

(c) Explain how finding the point of incipient plasmolysis allows the students to determine the water potential of the epidermal cells.

(2)

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.....

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7 Cystic fibrosis is a recessive inherited condition where the cells in the lungs produce sticky mucus. This mucus builds up in the airways, causing breathlessness and chest infections.

People with cystic fibrosis often need treatments such as physiotherapy and antibiotics.

(a) The incidence of babies born with cystic fibrosis in Australia is 1 in 2500.

Use the Hardy Weinberg equation, $p^2 + 2pq + q^2 = 1$, to calculate the percentage of Australians who are carriers of cystic fibrosis.

(4)

Answer ..... %

(b) A woman is a carrier of the cystic fibrosis allele. Her partner does not have cystic fibrosis and is not a carrier.

Use a genetic cross to determine the probability of this woman producing a child who is also a carrier.

(4)

Probability .....

(c) Australian scientists observed that people with cystic fibrosis who went surfing had fewer symptoms than people with cystic fibrosis who did not go surfing.

The scientists carried out a trial on 164 people with cystic fibrosis.

These people were placed at random into either the experimental group or the control group.

The experimental group inhaled a fine spray of 7.0% salt solution and the control group inhaled a fine spray of 0.9% salt solution.

The scientists found that the mucus in the experimental group contained more water and became less sticky than the mucus in the control group.

(i) Explain why only the fine spray of 7.0% salt solution resulted in mucus that contained more water.

(2)

(ii) Explain why the control group inhaled a fine spray of 0.9% salt solution, rather than a fine spray of pure water.

(2)

4 Substances move into cells by several processes.

(a) (i) Which of these processes requires energy from respiration?

(1)

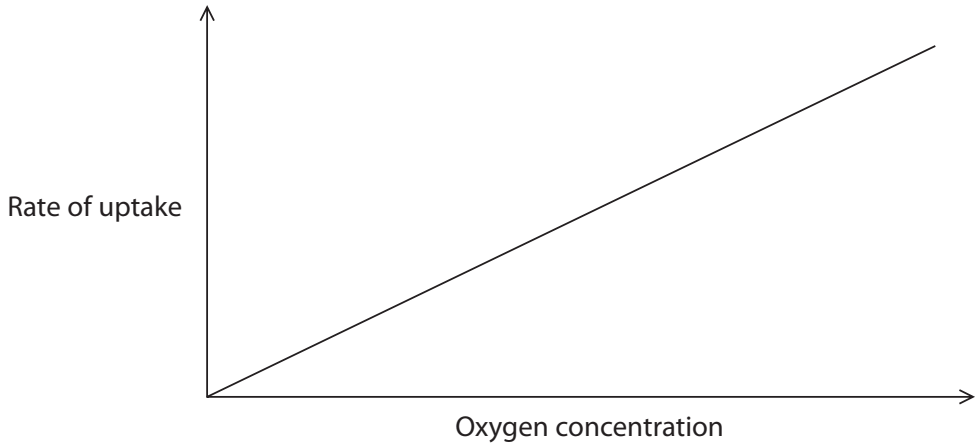
- ☒ **A** diffusion
- ☒ **B** endocytosis
- ☒ **C** facilitated diffusion
- ☒ **D** osmosis

(ii) Which of these processes can occur against a concentration gradient?

(1)

- ☒ **A** active transport
- ☒ **B** diffusion
- ☒ **C** facilitated diffusion
- ☒ **D** osmosis

(iii) The graph shows the effect of increasing oxygen concentration on the rate of uptake of a substance **other** than oxygen.



Which of these processes is shown by the graph?

(1)

- ☒ **A** active transport
- ☒ **B** diffusion
- ☒ **C** facilitated diffusion
- ☒ **D** osmosis

(iv) Which substance can enter a cell by diffusion?

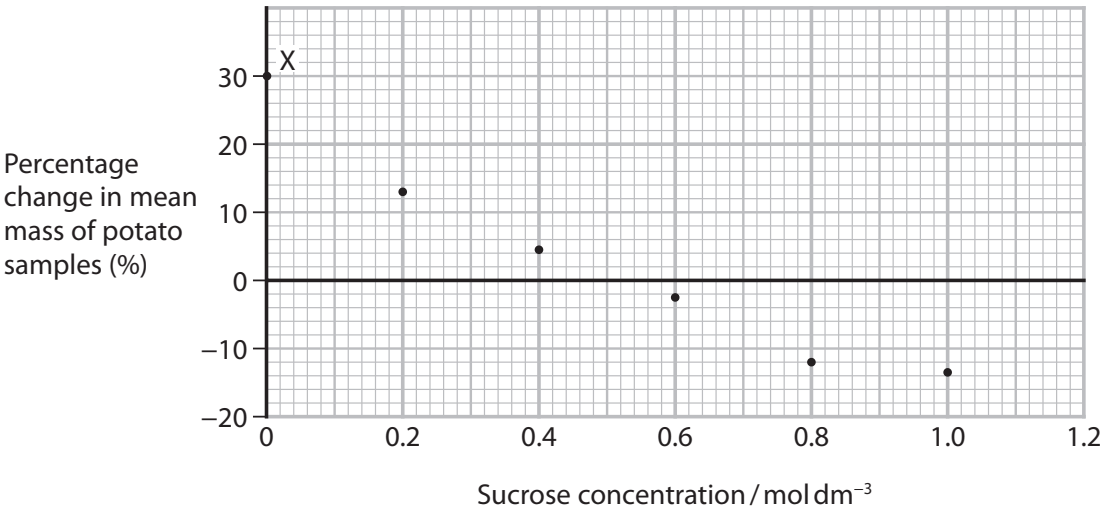
(1)

- ☒ **A** amino acid
- ☒ **B** carbon dioxide
- ☒ **C** glucose
- ☒ **D** protein

(b) When plant cells absorb water, the water potential of the cells changes.

The water potential of potato cells was investigated.

The graph shows the percentage change in mean mass of potato samples after immersion in sucrose solutions of different concentrations.



(i) Draw a suitable line on this graph.

(1)

(ii) Give the sucrose concentration that has the same water potential as the cells in these potato samples.

(1)

Answer ..... mol dm^{-3}

(iii) The water potential (ψ) of plant cells can be calculated using the equation:

$$\psi = P + \pi$$

Explain the changes in the water potential of cell (ψ), turgor pressure (P) and osmotic potential (π), at point X on the graph.

(4)

(iv) Explain why it is more difficult to determine the osmotic potential (π) than the water potential (ψ) of plant cells.

(2)

7 A student investigated the effect of the concentration of sodium chloride solution on blood.

The student set up six test tubes, each with a different concentration of sodium chloride solution.

Five drops of blood were added to each test tube.

The appearance of the solutions was then recorded.

Samples of each solution were observed using a light microscope.

The table shows the results of this investigation.

Concentration of sodium chloride (%)	Appearance of solution after blood was added	Observation with light microscope
3.0	very cloudy	cells seen with shrunken edges
1.0	very cloudy	cells seen
0.9	very cloudy	cells seen
0.7	slightly cloudy	cells seen
0.5	cloudy at first, then went clear	no cells seen
0.3	clear	no cells seen

(a) Analyse the data to comment on the effect of the concentration of sodium chloride solution on blood.

(4)

(b) The student then investigated the effect of using glucose solutions and sucrose solutions, instead of sodium chloride solutions.

The appearance of the solutions was recorded and samples were observed using a light microscope.

When the concentration of glucose solution was below 3%, the solution was clear and no blood cells could be seen. When the concentration of glucose solution was above 3%, the solution was cloudy and blood cells could be seen.

When the concentration of sucrose solution was below 6%, the solution was also clear and no blood cells could be seen. When the concentration of sucrose solution was above 6%, the solution was cloudy and blood cells could be seen.

Explain the differences in the effects of the solutions of glucose and sucrose.

(3)

(c) (i) State the part of the brain responsible for osmoregulation.

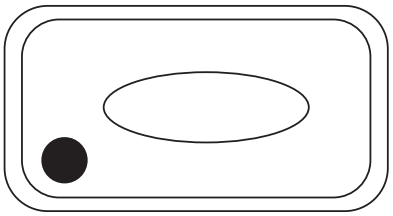
(1)

(ii) Explain how, on a very hot day, the brain ensures that the water potential of the blood remains constant.

(4)

6 Water potential determines the direction of movement of water in and out of cells.

(a) The diagram shows a plant cell.



The turgor pressure (P) of the cell is 400 kPa and the osmotic potential (π) is –500 kPa.

(i) Calculate the water potential (ψ) of this cell.

(1)

Answer ..... kPa

(ii) Explain the direction of net movement of water for this plant cell when it is placed in a sucrose solution with a water potential (ψ) of –400 kPa.

(2)

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(b) A student carried out an investigation to determine the water potential of cells from a potato tuber, using a range of concentrations of sucrose solutions.

Cylinders of potato were cut using a cork borer, and the cylinders were then cut into discs.

The mass of each disc was recorded. One disc was placed in each sucrose solution and left for 12 hours. Each disc was then reweighed.

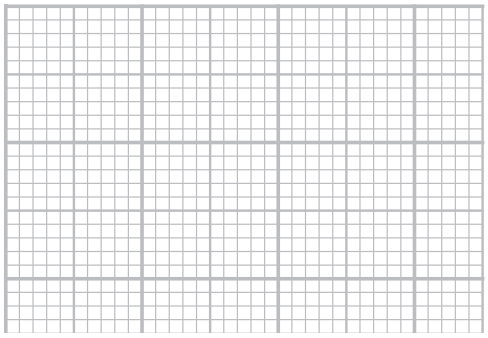
The table shows the data collected.

Concentration of sucrose solution / mol dm^{-3}	0.0	0.1	0.2	0.3	0.4	0.5
Percentage change in mass of potato disc	+14.2	+1.9	−9.8	−22.7	−31.9	−37.1

(i) Plot a suitable graph of these results.

Join the points with straight lines.

(3)



(ii) Determine the concentration of sucrose solution that causes no change in mass, using your graph.

(1)

Answer ..... mol dm^{-3}

(iii) Evaluate whether the method used in this investigation would provide valid results for the water potential of potato cells.

(5)

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3 Beetroot (*Beta vulgaris*) is an edible plant. The photograph shows some beetroot plants.



(Source: © VOISIN / PHANIE / SCIENCE PHOTO LIBRARY)

The root cells contain a red pigment, betalain, in the vacuole.

(a) (i) Draw a typical cell from a root, as seen using a light microscope. Label **three** named membranes.

(2)

(ii) Describe the structure of a membrane in a plant cell.

(2)

(b) A group of students investigated the effect of temperature on membrane permeability using tissue from a beetroot. They used the following method.

1. Tubes containing 20 cm^3 of water were placed in water baths for 15 minutes at 20°C, 30°C, 40°C, 50°C and 60°C.
2. Cylinders were cut from the same beetroot using a standard cork borer, and these were cut into 1 cm lengths.
3. Each piece was rinsed in water and then blotted dry, before being added to a tube in the water bath.
4. After 20 minutes, a sample of the liquid was removed.
5. The absorbance (amount of light absorbed by the red pigment) of each sample was measured using a colorimeter.

The table shows the results.

Temperature /°C	Absorbance					
	Group 1*	Group 2	Group 3	Group 4	Group 5	Mean of groups 2 – 5
20	0.33	0.14	0.07	0.08	0.11	0.10
30	0.57	0.24	0.32	0.33	0.31	0.30
40	0.87	0.53	0.63	0.56	0.51	0.56
50	1.87	1.58	1.63	1.53	1.56	1.58
60	1.93	1.59	1.62	1.49	1.56	1.57

*Group 1 results were excluded from the calculations of the means.

(i) Describe the relationship between temperature and absorbance, as shown by these results.

(2)

(ii) Explain the results of this investigation.

(2)

(c) Group 1 results were excluded from the calculations of the means as they were so different from the other groups.

Identify **four** errors this group may have made which would account for the difference in results.

(4)

5 Differences in water potential affect the direction of movement of water in and out of cells.

(a) The water potential of plant cells can be determined using plasmolysis.

A plant cell is plasmolysed when it loses water and the plasma membrane moves away from the cell wall. This can be observed when the cells are viewed with a light microscope.

A group of students used the following method to find the osmotic potential of cell sap in onion epidermal cells. The osmotic potential is equivalent to the concentration of the sucrose solution when 50% of cells are plasmolysed.

Step 1: A stock sucrose solution of 0.8 mol dm^{-3} was diluted to make a range of concentrations.

Step 2: A thin layer of onion epidermis was placed in 10 cm^3 of sucrose solution in each tube, and left for 20 minutes.

Step 3: Each piece of onion epidermis was placed on a microscope slide covered with a drop of the sucrose solution in which it had been soaking, and a coverslip placed on top.

Step 4: Using a microscope, the total number of cells in the field of view, and the total number that were plasmolysed, were counted.

Step 5: The percentage of plasmolysed cells in each sucrose concentration was calculated.

(i) Describe how you would prepare 10 cm^3 of a solution of sucrose with a concentration of 0.6 mol dm^{-3} from the stock solution.

(2)

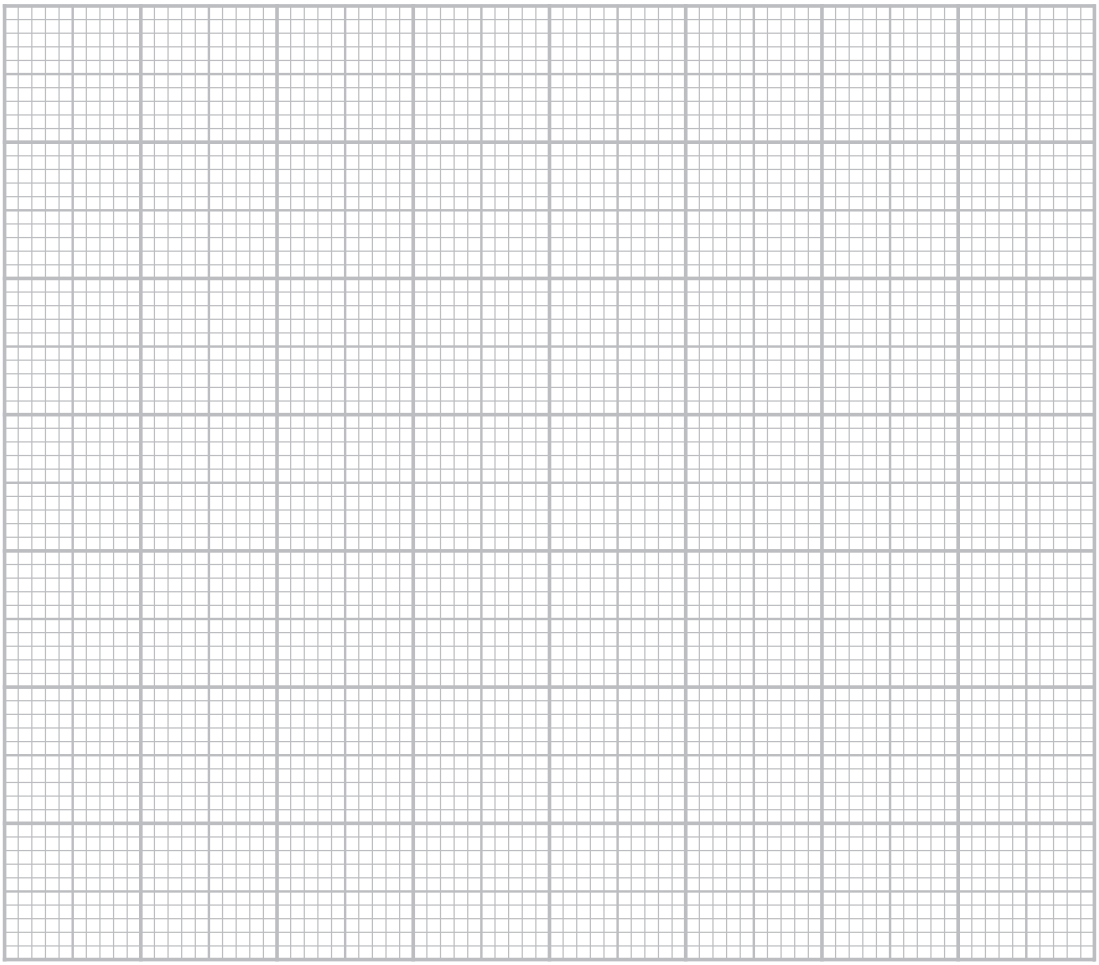
(ii) The table shows the mean results.

Concentration of sucrose solution / mol dm^{-3}	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8
Mean percentage of plasmolysed cells (%)	0.0	1.3	4.0	31.9	59.6	76.3	92.5	99.4	99.8

Plot a suitable graph to display these results.

Join the points with straight lines.

(3)

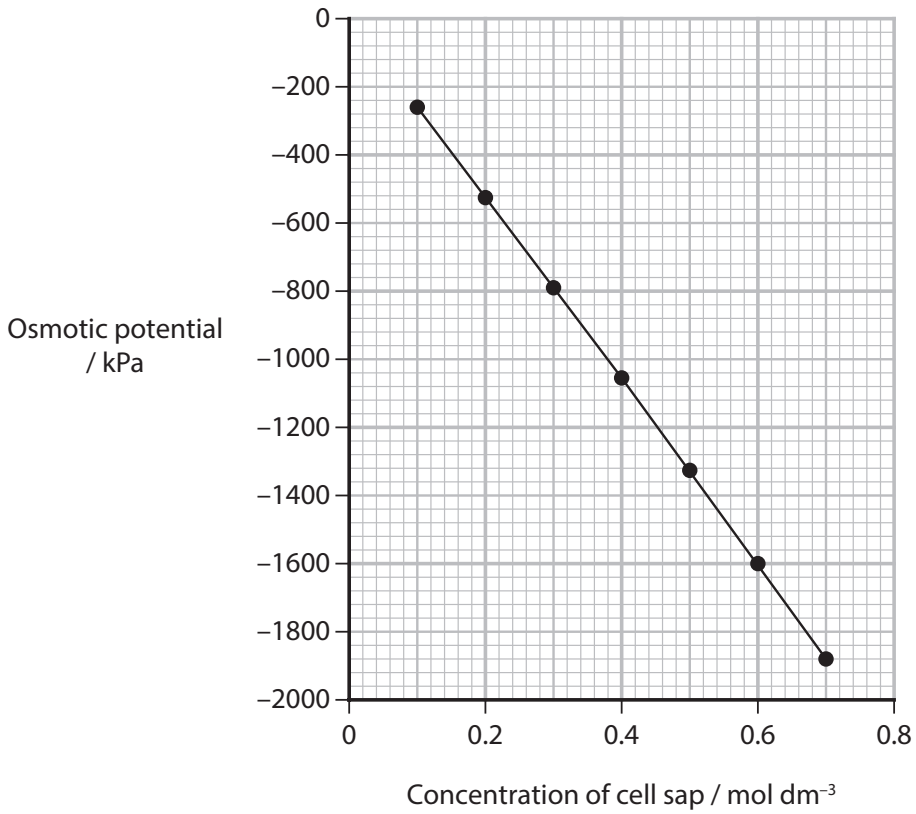


(iii) Determine the concentration of the cell sap of the onion epidermal cells, using your graph.

(1)

Answer ..... mol dm^{-3}

(iv) This conversion graph can be used to convert the concentration of cell sap into osmotic potential.



Determine the osmotic potential of the cell sap of the onion epidermal cells. Use your answer to (b)(iii) and the conversion graph.

(1)

Answer ..... kPa

(v) Write the equation that is used to calculate the water potential of a plant cell.

(1)

.....

.....

(vi) State the water potential of the cell sap of the onion epidermal cells when 50% of the cells are plasmolysed.

(1)

Answer ..... kPa

(b) The students modified the method and repeated the investigation.
The changes are shown in italics.

Step 2: all pieces of onion epidermis were cut *from a single onion*.

Step 2: tubes containing sucrose solution and onion epidermis layers were left *in a thermostatically controlled water bath* for 20 minutes.

Step 4: the total number of cells in the field of view, and the number that were plasmolysed were counted. *This was repeated twice for each of the sucrose concentrations*.

Explain why each of these changes are likely to improve the validity of this investigation.

(3)

8 (a) A student investigated the effect of ethanol on plant cell membranes.

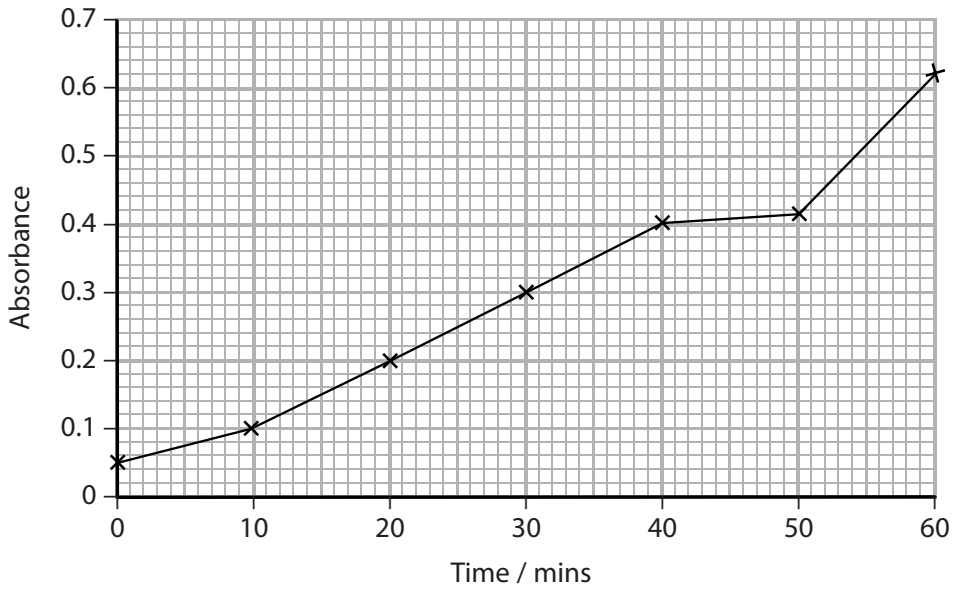
Step 1: The student cut leaf discs from leaves, using a cork borer.

Step 2: These leaf discs were then added to a boiling tube containing 10 cm^3 of 40% ethanol solution. The pigments in the leaf discs dissolved in the ethanol, producing a green solution.

Step 3: The boiling tube was shaken and the amount of red light absorbed by this solution (absorbance) was measured at the start.

Step 4: The absorbance was measured every 10 minutes, for an hour.

The graph shows the results of this investigation.



(i) Explain why red light was used in this investigation.

(2)

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(ii) Explain the absorbance value at 0 minutes.

(2)

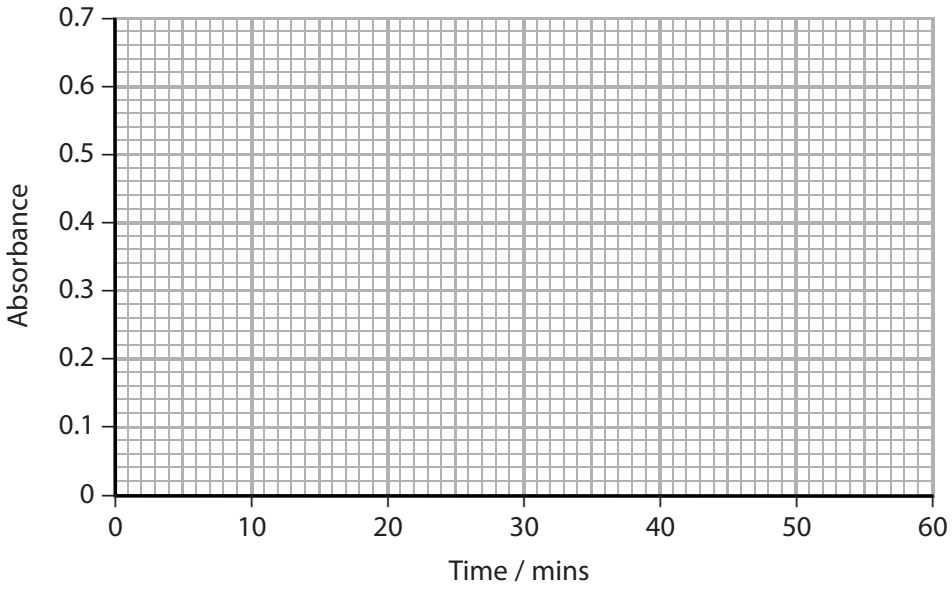
(iii) Explain the effect of ethanol on plant cell membranes.

(2)

(b) The student also carried out a control, using water instead of 40% ethanol.

Draw a line on the graph to show the results for this control.

(2)



(c) The student then investigated the effect of ethanol concentration on leaves from different plant species.

Justify the modifications to the procedure in part (a) that will be required to obtain valid data.

(5)

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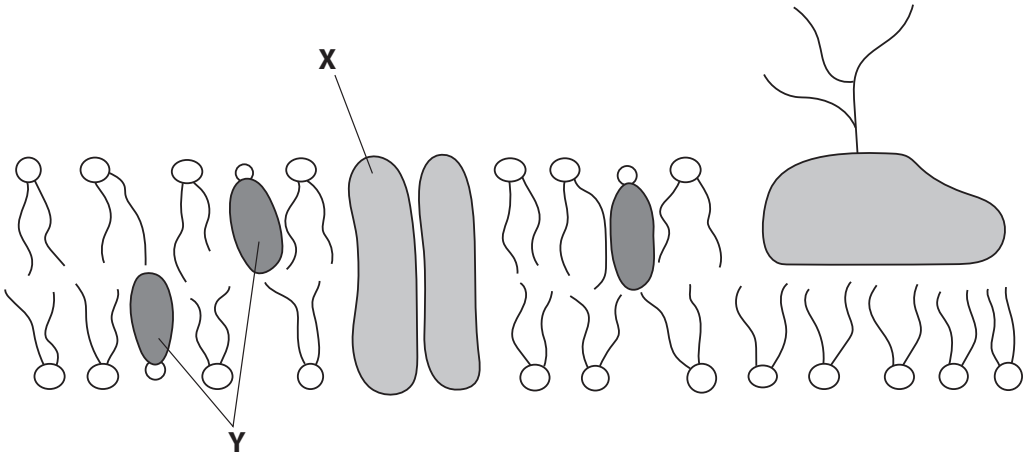
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2 The diagram shows a model of the structure of the cell membrane.



(a) The part labelled X

(1)

- ☒ **A** allows facilitated diffusion to take place
- ☒ **B** is absent in animal cells
- ☒ **C** is made of phospholipid
- ☒ **D** prevents lipid soluble molecules from entering the cell

(b) The part labelled Y

(1)

- ☒ **A** allows active transport to take place
- ☒ **B** allows polar molecules to pass into the cell
- ☒ **C** makes the membrane more fluid
- ☒ **D** makes the membrane permeable to water-soluble molecules

(c) Explain how the properties of molecules affect their transport through the cell membrane.

(3)

(d) The properties of cell membranes were investigated using samples of tissue from a beetroot.

The following procedure was used:

- equal sized discs of beetroot were cut and placed in boiling tubes containing 5 cm^3 of different concentrations of ethanol solution
- these boiling tubes were placed in a water bath at 20 °C for 30 minutes
- the discs of beetroot were then removed from the solutions
- a colorimeter was then used to measure the absorbance of each solution.

The ethanol solutions contained pigment that had leaked out of the beetroot discs. The darker the red colour, the higher the absorbance.

Each concentration of ethanol solution was tested seven times.

The results of this investigation are shown in the table.

Ethanol concentration (%)	Absorbance / a.u.								
	1	2	3	4	5	6	7	Mean	Standard deviation
0	0.30	0.14	0.03	0.58	0.14	0.22	0.03	0.21	0.19
10	0.07	0.30	0.04	0.64	0.30	0.42	0.09	0.27	0.22
20	0.35	0.46	0.08	0.75	0.60	0.65	0.10	0.43	
30	0.39	0.52	0.27	0.82	0.65	0.67	0.45	0.54	0.19
40	0.28	0.60	0.70	0.88	0.72	0.82	0.63	0.66	0.20
50	0.34	0.72	0.73	0.92	0.85	0.89	0.74	0.74	0.19
60	0.25	0.86	0.73	0.93	0.86	0.90	0.78	0.76	0.23
70	0.43	0.93	0.92	0.95	0.88	0.96	0.93	0.86	0.19

(i) Give a reason why the beetroot discs were placed in the same volume of ethanol solution.

(1)

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(ii) Explain why the boiling tubes were kept in a water bath.

(2)

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(iii) Calculate the standard deviation for absorption at the ethanol concentration of 20% using the formula

(2)

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

Answer .....

(iv) State why the standard deviation is a better measure of variation than the range.

(1)

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(v) Explain the effect of increasing ethanol concentration on membrane permeability.

(2)

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7 Plants require mineral ions from the soil for healthy growth.

(a) (i) Describe how mineral (inorganic) ions are taken up by active transport.

(3)

(ii) Describe the function of a named mineral ion that is vital for the growth of plants.

(2)

Mineral ions

Function

(b) The photograph shows *Galium verum* (Lady's bedstraw), a plant that grows in meadows, hedges, road verges and sand dunes.



(Source: © Alfio Scisetti/Alamy Stock Photo)

This plant grows to between 15 cm and 60 cm in height.

A student investigated whether *Galium verum* growing in meadows was taller than *Galium verum* growing on sand dunes.

(i) Give a suitable null hypothesis for this investigation.

(1)

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(ii) Devise a method that can be used to collect valid results to test this null hypothesis.

(5)

(iii) Explain which statistical test would be most suitable to test this null hypothesis.

(2)

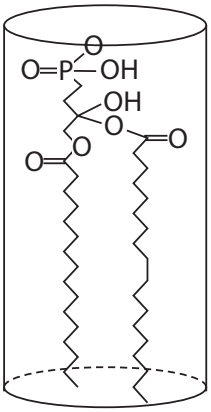
9 The membranes of cells and organelles contain many types of lipids.

(a) Phospholipids are one type of lipid found in cell membranes.

(i) Explain the role of phospholipids in the cell membrane.

(3)

(ii) The diagram shows a phospholipid drawn inside a cylinder.



The cross-sectional area of this cylinder is 0.3 nm^2.

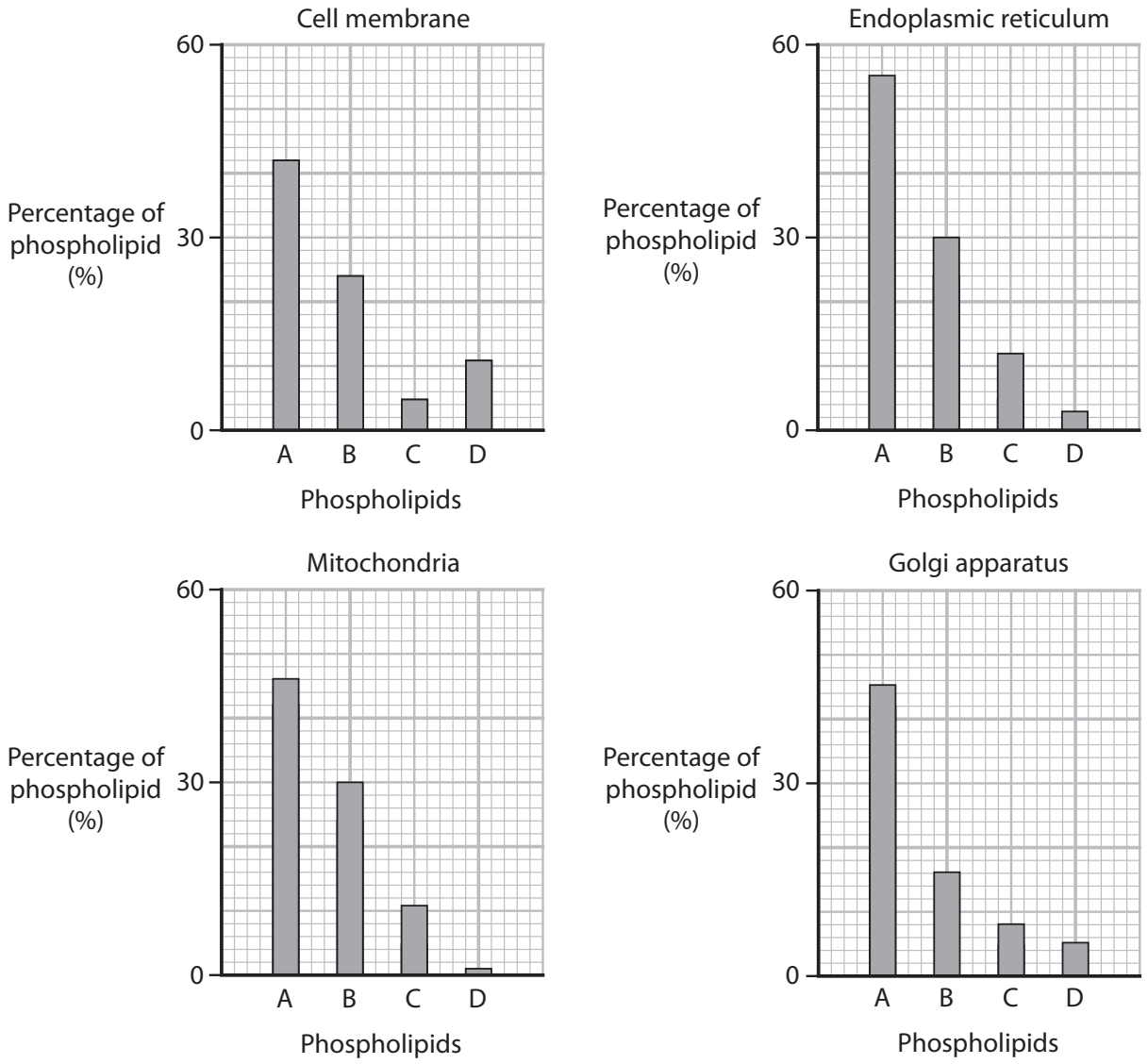
Calculate the number of phospholipid molecules in 1 μm^2 of a phospholipid bilayer.

Give your answer in standard form.

(3)

Answer .....

(b) The graphs show the percentage of four types of phospholipid, A, B, C and D, in the cell membrane and in the membranes of endoplasmic reticulum, mitochondria and Golgi apparatus.



(i) Describe how the structure of one type of phospholipid can be different from the structure of another type of phospholipid.

(2)

(ii) Compare and contrast the phospholipid content of these membranes.

(3)

(iii) The scientists who produced the data did not expect the phospholipid content in the membranes of the endoplasmic reticulum and the Golgi apparatus to be different.

Explain why these scientists did not expect there to be a difference in the phospholipid content in the membranes of these two organelles.

(2)

6 Osmosis is affected by a number of factors, including temperature.

(a) State what is meant by the term **osmosis**.

(2)

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(b) The effect of temperature on the rate of osmosis in potato cylinders was investigated.

- Potato cylinders were cut from the same type of potato using a cork borer.
- Each cylinder was 5 cm long and had a diameter of 1 cm.
- Five cylinders were used at each temperature.
- The cylinders were first blotted dry, weighed and the masses recorded.
- The cylinders were immersed in distilled water at 10 °C for 10 minutes then removed, blotted dry, reweighed and the new masses were recorded.
- This was repeated at temperatures of 15 °C and 20 °C.

(i) The surface area of each potato cylinder is 17.3 cm^2.

Determine the surface area to volume ratio of one of these cylinders.

Use the formula:

$$\text{Volume} = \pi r^2 l$$

Give your answer to **one decimal place**.

(3)

Answer .....

(ii) The table shows the results of this investigation.

Temperature / °C	Initial mass of potato cylinder / g	Final mass of potato cylinder / g	Change in mass / g	Percentage change in mass (%)	Mean percentage change in mass (%)	Standard deviation
10	5.1	5.2	0.1	2.0	2.0	1.4
	5.0	5.0	0.0	0.0		
	5.2	5.3	0.1	1.9		
	5.0	5.2	0.2	4.0		
	4.9	5.0	0.1	2.0		
15	5.1	5.2	0.1	2.0	2.8	
	5.1	5.3	0.2	3.9		
	5.2	5.3	0.1	1.9		
	4.9	5.1	0.2	4.1		
	5.1	5.2	0.1	2.0		
20	4.9	5.1	0.2	4.1	3.6	0.94
	5.0	5.2	0.2	4.0		
	5.2	5.3	0.1	1.9		
	5.1	5.3	0.2	3.9		
	5.0	5.2	0.2	4.0		

Calculate the standard deviation for percentage change in mass for the cylinders at 15 °C.

Use the formula:

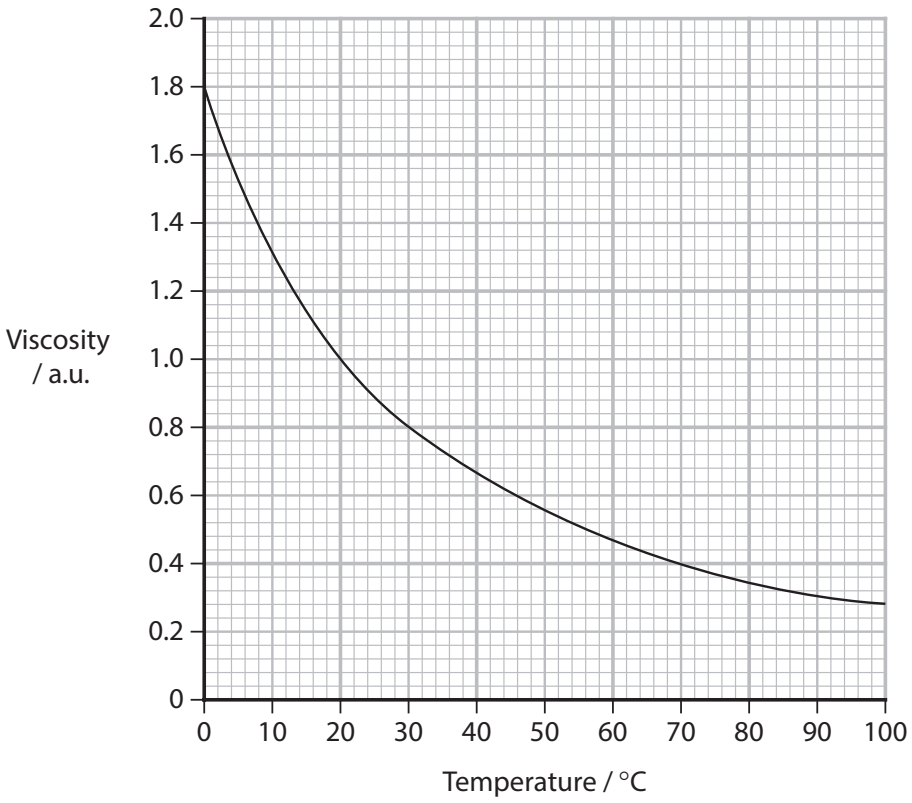
$$s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$$

Give your answer to **two significant figures**.

(3)

Answer .....

(iii) The graph shows the effect of increasing temperature on the viscosity of water. Viscosity is a measure of how quickly liquids flow. A liquid with low viscosity flows more quickly than a liquid with high viscosity.



Analyse the data in the table of results and the graph to explain the effect of temperature on the movement of water into the potato cylinders.

(5)

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)

8 (a) Describe **three** named methods of passive transport by which substances can enter or leave a cell.

(3)

(b) The properties of cell membranes were investigated using samples of tissue from a beetroot.

The following method was used.

Step 1 Equal sized discs of beetroot were cut, washed, and placed in a boiling tube containing 10 cm^3 of ethanol with a concentration of 20%.

Step 2 The boiling tube was placed in a water bath at 20 °C for 30 minutes.

Step 3 The discs of beetroot were then removed from the boiling tube.

Step 4 A colorimeter was then used to measure the absorbance of the liquid in the boiling tube.

Steps 1 to **4** were repeated using ethanol concentrations of 10%, 30%, 40%, 50%, 60% and 0% using distilled water.

Each ethanol concentration was tested 6 times.

The boiling tubes contained a red pigment that had leaked out of the beetroot discs.

The darker the red colour of the liquid in the boiling tube, the higher the absorbance.

The table shows the results of this investigation.

Concentration of ethanol (%)	Absorbance / a.u.							
	1	2	3	4	5	6	Mean	Standard deviation
0 (distilled water)	0.02	0.01	0.02	0.01	0.01	0.02	0.02	0.01
10	0.04	0.02	0.02	0.02	0.03	0.03	0.03	0.01
20	0.06	0.07	0.08	0.11	0.10	0.09	0.09	0.02
30	0.10	0.12	0.12	0.11	0.12	0.13	0.12	0.01
40	0.15	0.14	0.16	0.12	0.15	0.16	0.15	0.02
50	0.19	0.21	0.22	0.18	0.22	0.21	0.21	0.02
60	0.70	0.53	0.64	0.58	0.65	0.78	0.65	

(i) State why the discs were washed in **Step 1**.

(1)

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(ii) Explain the purpose of **Step 2**.

(2)

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(iii) Calculate the standard deviation (s) for the results at 60% ethanol.

Give your answer to **two** decimal places.

(3)

Use the formula:

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

Answer .....

(iv) State which ethanol concentration shows the lowest range of absorbance.

(1)

(v) Explain why standard deviation is a better measure of variation than range.

(2)

(vi) Explain the effect of increasing ethanol concentration on membrane permeability.

(3)

3 Anthocyanin is a purple pigment found in a range of vegetable plants.

The photograph shows some carrots from a variety called Purple Haze.



(a) Describe how you would investigate the effect of temperature on the permeability of the membranes in the root cells of these purple carrots.

(5)

(b) The anthocyanins in purple carrots are used as antioxidants in the food industry.

Purple Haze carrots with a mass of 750g contain 1265.25 mg of anthocyanin.

Calculate the percentage of anthocyanin in these carrots.

Give your answer to two decimal places.

(2)

Answer .....

(c) Purple cauliflower plants also contain anthocyanins.

Cauliflowers can be light purple, dark purple or white.

The photograph shows a dark purple cauliflower.



The colour in cauliflowers is controlled by a single gene with two alleles.

Purple colour is controlled by the allele Pr.

White colour is controlled by the allele pr.

In an investigation, dark purple cauliflowers were crossed with pure bred white cauliflowers.

The F1 generation cauliflowers were all light purple in colour.

(i) State the genotype of the F1 generation.

(1)

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(ii) The F1 generation was then self-fertilised to produce the F2 generation.

The numbers observed (*O*) in the F2 generation were:

31 white cauliflowers, 52 light purple and 20 dark purple cauliflowers.

It was concluded that the purple colour in cauliflowers is controlled by a single gene with two codominant alleles.

State the expected (*E*) number of each of the three phenotypes in the F2 generation.

(2)

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(iii) Calculate the value for Chi squared using these results.

Use the formula for Chi squared:

$$\chi^2 = \sum \frac{(O - E)^2}{E}$$

(3)

Answer .....

(iv) The table shows some critical values for Chi squared.

Degrees of freedom	*p* value				
	0.900	0.500	0.100	0.050	0.010
1	0.016	0.455	2.706	3.841	6.635
2	0.211	1.386	4.605	5.991	9.210
3	0.584	2.366	6.251	7.815	11.345
4	1.064	3.357	7.779	9.488	13.277

Explain why the conclusion that colour in cauliflowers is controlled by a single gene with two codominant alleles is likely to be valid.

(3)

SUB-TOPIC 4(b)

GAS EXCHANGE

20 questions in this sub-topic · 196 marks · lowest tariff first

1 The photograph shows an insect.



Explain how the gas exchange system of an insect is adapted for the efficient uptake of oxygen.

(4)

8 The photograph shows a locust.



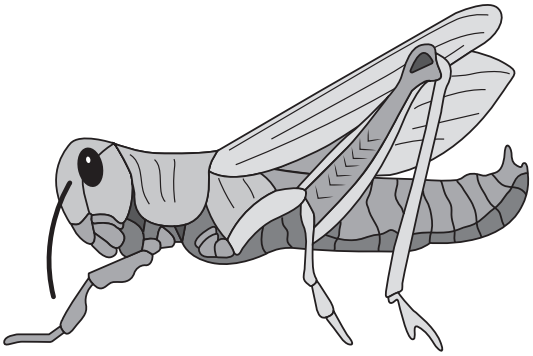
Locusts ventilate their tracheal systems by muscular contractions of their abdomen.

Devise an investigation to determine the effect of carbon dioxide concentration on the rate of ventilation in locusts.

(6)

2 Insects, such as locusts, can be dissected to show their gas exchange system.

(a) (i) The diagram shows a dead locust.



Draw a line on this locust to show where you would cut through the exoskeleton to expose the gas exchange system.

(1)

(ii) State why you would cover the dissected locust with water.

(1)

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(b) The photograph shows part of the dissected gas exchange system, as seen using a microscope.



(Source: © blickwinkel/Alamy Stock Photo)

(i) Name the structures labelled A and B.

(2)

A .....

B .....

(ii) Name the structure that supplies oxygen directly to the muscle tissue.

(1)

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(iii) At the point labelled A, the structure is 0.9 mm in diameter.

Calculate the diameter of the structure at the point labelled X.

Give your answer to **two** decimal places.

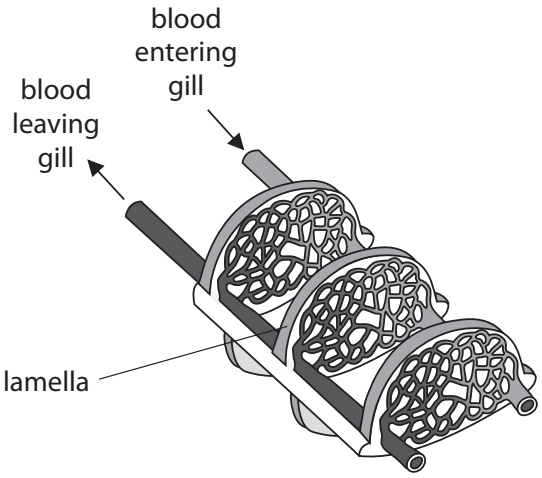
(2)

Answer ..... mm

(Total for Question 2 = 7 marks)

6 Gills are the site of gas exchange in fish.

(a) The diagram shows some of the gill lamellae from a bony fish.

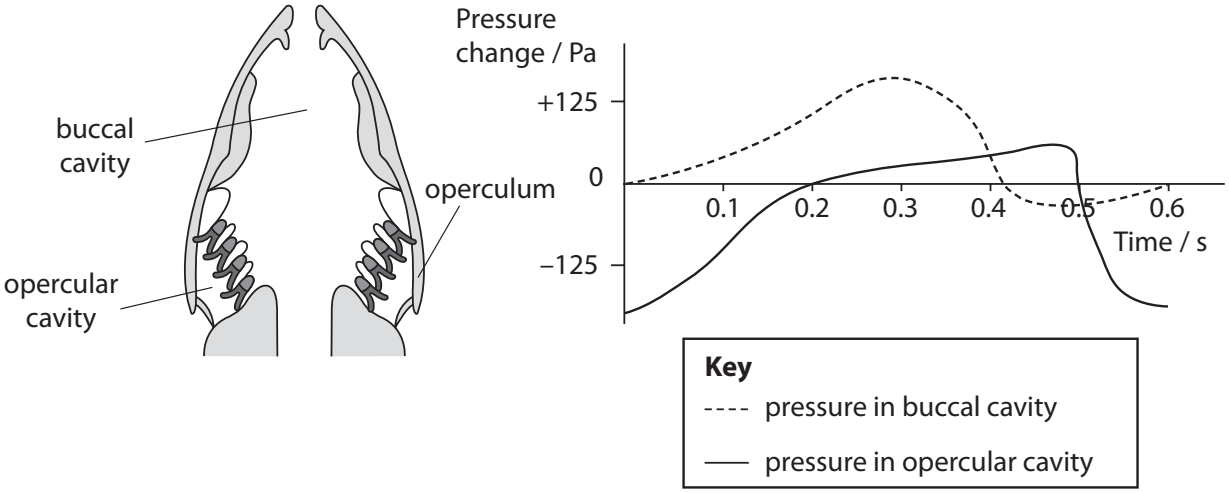


Draw **one** arrow on the diagram to show the direction of water flow across the lamellae.

(1)

(b) The diagram shows a section through the head of a bony fish.

The graph shows the pressure changes in the buccal cavity and opercular cavity during ventilation.



The operculum will be closed between

(1)

- ☒ **A** 0.4 s and 0.5 s
- ☒ **B** 0.0 s and 0.4 s
- ☒ **C** 0.4 s and 0.6 s
- ☒ **D** 0.2 s and 0.4 s

(c) The table shows some information for five species of fish.

Fish species	Activity level	Surface area of gill lamellae / mm^2	Mass of fish / g	Comparison of surface area to mass / $cm^2 g^{-1}$
toadfish	low	46 055	305	1.51
butterfish	medium	120 321	261	4.61
sheepshead	medium	254 048	544	4.67
mullet	high	252 500	250	
mackerel	high	235 040	226	10.40

(i) The comparison of surface area to mass of mullet is

(1)

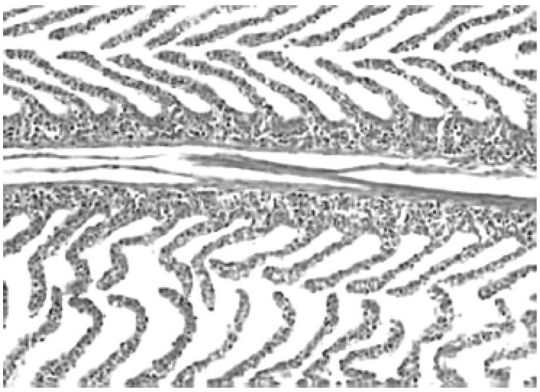
- ☒ **A** 1010 $cm^2 g^{-1}$
- ☒ **B** 10.10 $cm^2 g^{-1}$
- ☒ **C** 1.01 $cm^2 g^{-1}$
- ☒ **D** 0.99 $cm^2 g^{-1}$

(ii) Analyse the data to explain the difference in the activity levels of these fish species.

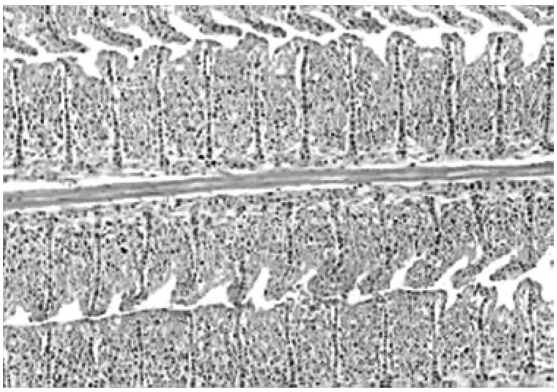
(3)

(d) Water polluted with heavy metal ions can cause the death of fish.

The photographs show cross-sections of the lamellae from a fish caught in unpolluted water and from a fish caught in water polluted with heavy metal ions.



Gill lamellae from a fish in unpolluted water



Gill lamellae from a fish in water polluted with heavy metal ions

Use the photographs to explain why fish die in water polluted with heavy metal ions.

(2)

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(Total for Question 6 = 8 marks)

7 A model can be used to show the effect of surface area on the efficiency of diffusion in the lungs.

The lungs are modelled as two spheres, each with a diameter of 180 mm.

(a) (i) Calculate the surface area in m^2 of a sphere with a diameter of 180 mm, using the formula

$$\text{Surface area} = 4\pi r^2$$

(2)

Answer ..... m^2

(ii) The volume of this sphere is 3.054 dm^3.

Calculate the surface area to volume ratio for this sphere.

(1)

Answer .....

(b) The lungs do not consist of two large spheres. They contain 6000 million small, spherical alveoli.

(i) Explain how having many alveoli increases the efficiency of the diffusion in the lungs.

(2)

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(ii) Explain how other features of alveoli enable efficient diffusion in the lungs.

(3)

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2 Substances move into and out of cells by different mechanisms.

(a) (i) Which of these mechanisms moves substances against a concentration gradient?

(1)

- ☒ **A** active transport
- ☒ **B** diffusion
- ☒ **C** facilitated diffusion
- ☒ **D** osmosis

(ii) Which of these mechanisms enables non-polar molecules to pass through cell membranes?

(1)

- ☒ **A** diffusion
- ☒ **B** facilitated diffusion
- ☒ **C** osmosis
- ☒ **D** transpiration

(b) Which of the following is usually found in a greater concentration in lymph than in blood?

(1)

- ☒ **A** fatty acids
- ☒ **B** glucose
- ☒ **C** haemoglobin
- ☒ **D** oxygen

(c) The size of an animal can affect gas exchange.

As animals increase in size, their

(1)

- ☒ **A** surface area decreases and volume increases
- ☒ **B** surface area to volume ratio decreases
- ☒ **C** surface area to volume ratio increases
- ☒ **D** surface area to volume ratio remains constant

(d) Explain the features of gas exchange surfaces that are common to both insects and mammals.

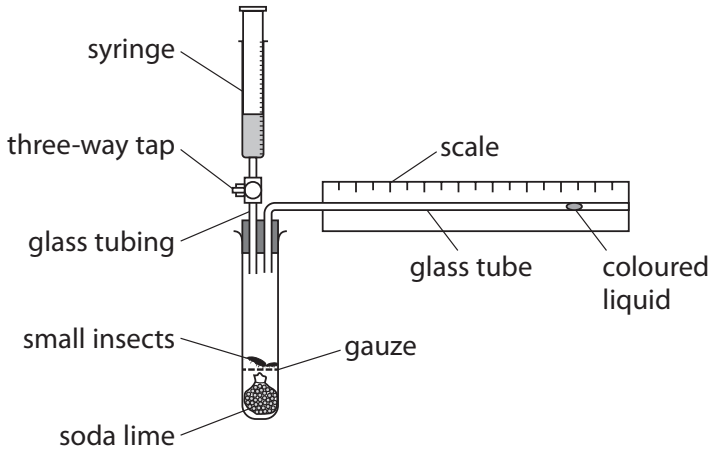
(4)

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)

1 (a) As organisms change size their relative dimensions also change.

Which of the following statements are true?

(1)

As organisms become larger

1. the surface area increases
2. the volume increases
3. the surface area to volume ratio decreases
4. the volume to surface area ratio increases

☒ **A** 1 and 2 only

☒ **B** 1, 2 and 3 only

☒ **C** 1, 2 and 4 only

☒ **D** 1, 2, 3 and 4

(b) Explain why larger organisms need a mass transport system but smaller organisms do not.

(3)

(c) Compare and contrast the gas exchange adaptations in an insect and in a fish.

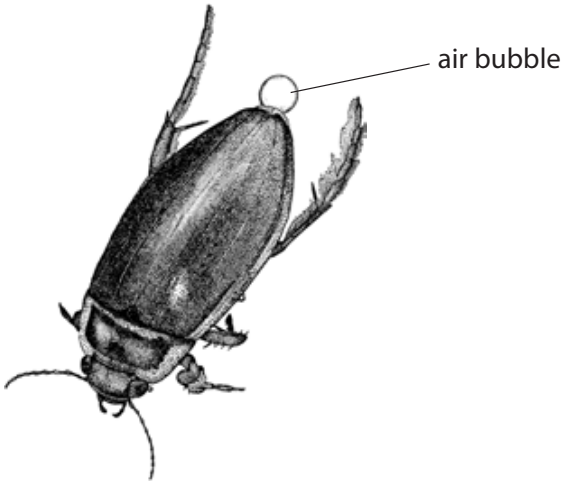
(4)

9 The insect *Dytiscus marginalis* is a beetle that can dive underwater to feed.

Before diving underwater, the beetle traps an air bubble underneath its wings.

The air bubble is connected to its spiracles.

The diagram shows a beetle with an air bubble attached to its body.



(a) State how the oxygen in the air bubble reaches the cells in the beetle.

(1)

(b) When the beetle is underwater, gases can enter or leave the air bubble.

These gas movements affect the size of the bubble.

When the beetle first dives, the concentration of oxygen is higher in the bubble than in the water.

Explain why these facts will affect the time the beetle can stay underwater.

(3)

(c) Warm weather increases the temperature of the water.

This affects the time a beetle can stay underwater.

Devise an investigation to show the effect of water temperature on the time a beetle can stay underwater.

(5)

3 The photograph shows an adult mayfly.



(a) *Rhithrogena germanica* is commonly known as the March brown mayfly.

The classification hierarchy for this mayfly is: Animalia
Arthropoda
Insecta
Ephemeropteroidea
Heptageniidae
Rhithrogena germanica

(i) State the genus of this mayfly.

(1)

.....

(ii) This mayfly belongs to the phylum Arthropoda.

Which is the order for this mayfly?

(1)

☒ **A** Animalia

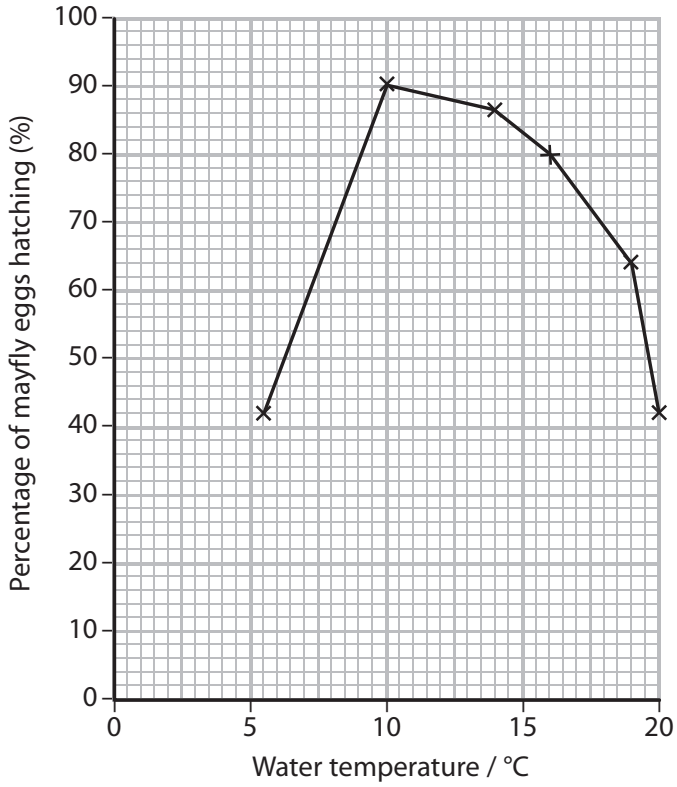
☒ **B** Ephemeropteroidea

☒ **C** Heptageniidae

☒ **D** Insecta

(b) Mayflies lay their eggs in water.

The graph shows the effect of water temperature on the percentage of mayfly eggs that hatch.



Explain the effect of temperature on the percentage of mayfly eggs that hatch.

(4)

(c) Mayfly eggs hatch into immature insects called nymphs. The nymphs live in the water and develop to form adult mayflies.

The photograph shows a mayfly nymph.



Compare and contrast the structure of the gas exchange system of the mayfly nymph with the adult mayfly.

(3)

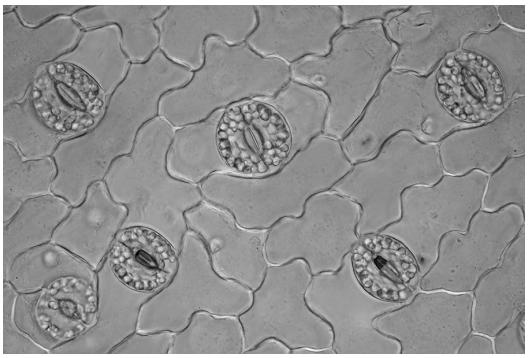
2 Plants and animals have specialised tissues that are adapted for gas exchange.

(a) Which of the following allow gases to enter woody plant stems?

(1)

- ☒ **A** lenticels
- ☒ **B** stomata
- ☒ **C** waxy cuticle
- ☒ **D** xylem

(b) The photograph shows stomata from part of the lower leaf surface of the plantain lily.



(Source: © MAREK MIS/SCIENCE PHOTO LIBRARY)

Magnification ×370

(i) Calculate the number of stomata per cm^2 on this part of the leaf surface.

Give your answer to the nearest whole number.

(3)

Answer .....

(ii) Calculate the estimated number of stomata found on the lower surface of a leaf that has a total area of 130 cm^2.

Use your answer from b(i) in your calculation.

(1)

Answer .....

(iii) Give a reason why the estimated number of stomata on the lower surface of the leaf may not be accurate.

(1)

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(iv) Explain why it is important for plants to be able to open and close their stomata.

(3)

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4 Asthma is a condition that causes bronchi (airways) in the lungs to narrow.

Salbutamol is a drug that is often used to treat asthma.

Salbutamol causes muscles to relax to widen the bronchi.

Salbutamol acts by binding to the adrenaline receptors of cells.

(a) Gas exchange in the lungs occurs at the alveoli.

Explain how alveoli are adapted to maximise gas exchange.

(3)

(b) Which of these statements are correct about the action of adrenaline?

1. adrenaline stimulates the release of second messengers inside cells
2. adrenaline binds directly to transcription factors
3. adrenaline causes the activation of enzymes inside the cells

(1)

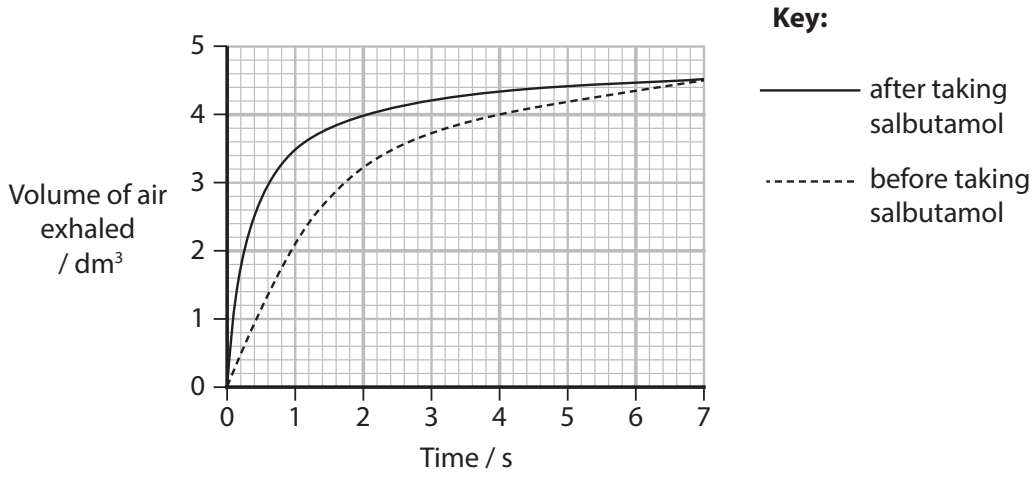
☒ **A** 1 and 2 only

☒ **B** 1 and 3 only

☒ **C** 1, 2 and 3

☒ **D** 2 and 3 only

(c) The graph shows the volumes of air breathed out by a person with asthma before taking salbutamol and after taking salbutamol.



(i) Determine the rate of exhalation of air at **one second** after taking salbutamol.

Use a tangent to the curve.

(2)

Answer ..... dm³ per second

(ii) Explain why taking salbutamol increases the concentration of oxygen in the blood compared with not taking salbutamol.

(3)

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5 A student planned to keep two species of fish in an aquarium.

One species of fish should be kept at a minimum temperature of 25 °C. The other species requires a minimum concentration of oxygen of 7.5 mg dm^{-3} water.

(a) The student investigated the effect of water temperature on the solubility of oxygen in water.

The table shows the results of this investigation.

Water temperature / °C	Solubility of oxygen in water / mg dm^{-3}
0	14.2
10	11.5
20	12.0
30	7.7
40	7.8
50	5.9
60	5.3

The student used a statistical test on these data.

(i) Which is the correct statistical test to use on these data?

(1)

☒ **A** Chi squared test

☒ **B** correlation coefficient

☒ **C** standard deviation

☒ **D** Student's t test

(ii) The student analysed the data using the formula:

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

The student calculated $\sum d^2$ to be 108.

Use the formula to calculate r_s.

(3)

Answer .....

(iii) Explain how the student should use the r_s value calculated in (a)(ii) to find the strength of the relationship between these two variables.

(2)

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(b) Explain why the student chose to keep these two species of fish in an aquarium at 30°C.

(4)

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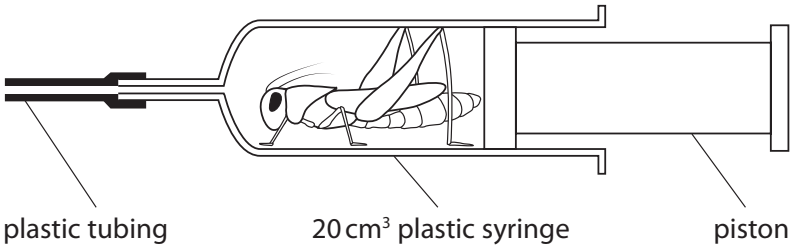
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6 The effect of gas composition on the breathing rate of locusts was investigated.

The method used was:

Step 1 A locust was placed in a 20 cm^3 clear plastic syringe, as shown in the diagram. The piston was inserted so it gently held the locust in place so that the locust had no room to move.



Step 2 The number of pumping movements of the abdomen which occurred in 30 seconds was counted. This was repeated three more times.

Step 3 Gases of different compositions were added to the syringe through the plastic tubing.

Step 4 For each different composition of gases, the number of pumping movements of the abdomen which occurred in 30 seconds was counted.

Step 5 Between each composition of gases used, the piston was moved in and out ten times to replace the exhaled air with laboratory air.

Step 6 The locust was then left for 5 minutes before the next composition of gases was added.

(a) (i) State the purpose of **Step 5**.

(1)

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(ii) State the purpose of **Step 6**.

(1)

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(b) The table shows the results of the investigation.

Gas composition (%)		Number of movements in 30 seconds				Mean	Range	SD
oxygen	carbon dioxide							
21	0.1	26	22	31	29	27	9	3.9
16	4.1	41	44	46	49	45	8	3.4
100	0.0	5	12	6	8	8	7	3.1
94	6.0	48	42	46	49	46	7	3.1
88	12.0	44	46	50	53	48	9	
83	17.0	54	51	53	49	52	5	2.2

(i) Calculate the standard deviation for the number of movements in 30 seconds when the gas has a composition of 88% oxygen and 12% carbon dioxide.

Use the formula

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

(3)

Answer .....

(ii) Explain the relationship between the range and the standard deviation.

(2)

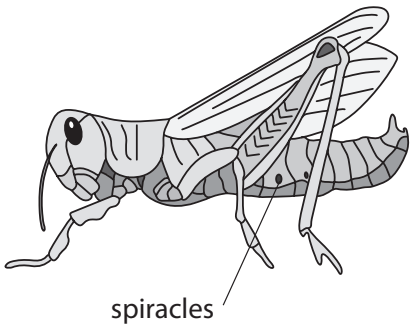
(c) Analyse the data to comment on the effect gas composition has on the breathing rate of this locust.

(4)

2 Insects such as locusts do not breathe through the mouth.

The gas exchange system of a locust includes air sacs, tracheae and tracheoles.

The diagram shows a locust before dissection.



(a) Describe how you would dissect a locust to ensure that the gas exchange system is clearly visible.

(3)

(b) A student investigated the effect of different gases on the breathing rate of a locust.

The student blew exhaled air over a locust in a syringe and recorded its breathing rate.

The locust was immediately given pure oxygen and the breathing rate was recorded.

The table shows the results of this investigation.

Treatment	Breathing rate / breaths min^{-1}
Exhaled air	56
Pure oxygen	3

The student concluded that carbon dioxide increased the breathing rate of the locust.

Comment on how the limitations of this method affect the validity of this conclusion.

(5)

(c) Explain the role of air sacs in the gas exchange system of locusts.

(2)

(d) Locusts have a complex gas exchange system because they are multicellular organisms.

Explain why single-celled organisms do not have a gas exchange system.

(2)

9 Acute respiratory distress syndrome (ARDS) is a condition that can occur in babies.

In ARDS, cells in the alveoli do not produce enough of a substance called surfactant.

The alveoli cannot expand sufficiently when the baby inhales.

The diagram shows the alveoli of a baby with ARDS and the alveoli of an unaffected baby.



Alveoli of a baby with ARDS



Alveoli of an unaffected baby

(a) The surfactant in the alveoli reduces the surface tension of water.

(i) Which bond is responsible for the cohesive forces between water molecules that contribute to the surface tension of water?

(1)

☒ **A** covalent

☒ **B** ionic

☒ **C** hydrogen

☒ **D** hydrophobic

(ii) Surfactant contains phospholipid molecules.

How many of the following components are found in phospholipids?

(1)

1 amino acids

2 fatty acids

3 glycerol

4 phosphate

☒ **A** one

☒ **B** two

☒ **C** three

☒ **D** four

(b) The efficiency of the lungs is calculated using the formula for the Carrico index.

$$\text{Carrico index} = \frac{\text{partial pressure of oxygen in arterial blood}}{\text{proportion of oxygen in inhaled air}}$$

The table shows the Carrico index for an unaffected baby and a baby with ARDS.

Baby	Carrico index / kPa
Unaffected baby	67
Baby with ARDS	38

(i) Calculate the partial pressure of oxygen in arterial blood for the unaffected baby, if the proportion of oxygen in inhaled air is 0.21.

(1)

Answer ..... kPa

(ii) Explain why the Carrico index for the baby with ARDS is lower than the Carrico index for the unaffected baby.

(4)

*(c) Scientists investigated the effect of two synthetic surfactants, A and B, for treating ARDS.

Four groups of rabbits with ARDS were used.

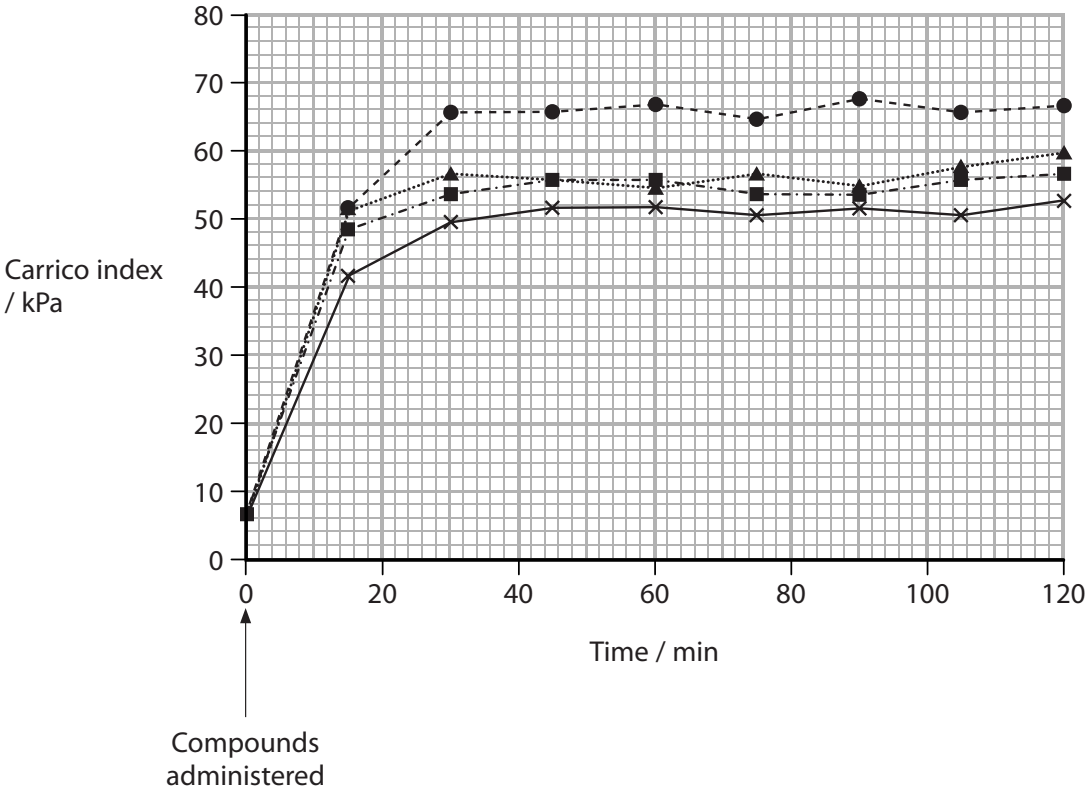
Each group of rabbits was given a different treatment.

- One group received compound A.
- One group received compound B.
- One group received both compound A and compound B.
- One group received a natural surfactant control.

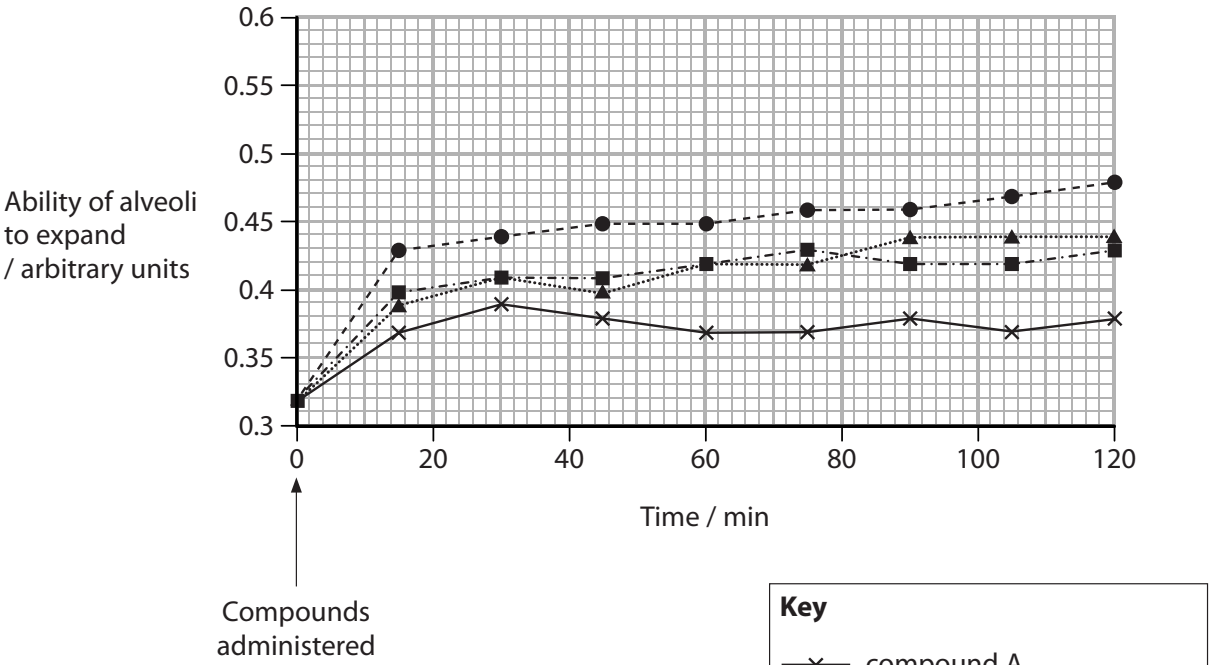
The mean Carrico index of each group of rabbits and the ability of the alveoli to expand were determined every 15 minutes.

Graph 1 and Graph 2 show the results of this investigation.

Graph 1 Effect of compounds A and B on the Carrico index



Graph 2 Effect of compounds on the ability of alveoli to expand



Analyse the data to explain the potential use of these two compounds to treat ARDS in human babies.

(6)

8 Gas exchange systems in a mammal and in an insect are different.

(a) Explain why larger species of animal need specialised gas exchange surfaces.

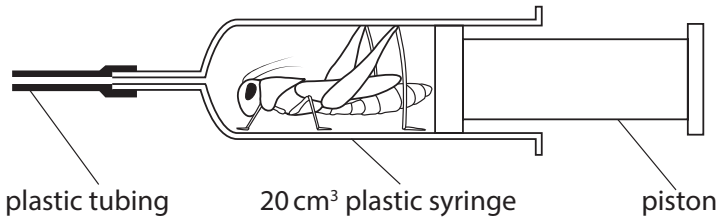
(3)

(b) Compare and contrast the gas exchange systems in insects and in mammals.

(3)

(c) The effect of gas composition on the ventilation rate of a locust was investigated using the following method.

Step 1 A locust was placed in a 20 cm^3 clear plastic syringe, as shown in the diagram. The piston was inserted gently to hold the locust in place.



Step 2 Different mixtures of gases were added to the syringe through the plastic tubing.

Step 3 For each mixture of gases, the number of pumping movements of the locust's abdomen was counted for one minute. This was repeated two more times.

Step 4 Between each mixture of gases used, the piston was moved in and out ten times to replace the mixture with laboratory air.

Step 5 The locust was then left for five minutes before the next mixture of gases was added.

(i) State the independent variable in this investigation.

(1)

.....

(ii) The table shows the results of this investigation.

Gas mixture		Ventilation rate / movements per minute			Mean ventilation rate / movements per minute
Oxygen (%)	Carbon dioxide (%)				
100.0	0.0	10	24	12	15.3
21.0	0.1	52	44	62	52.7
16.4	4.1	106	98	102	102.0
94.0	6.0	96	84	92	90.7
88.0	12.0	82	92	102	92.0
83.0	17.0	108	98	99	101.7

Analyse the data to comment on the effect of the different gas mixtures on the ventilation rate of the locust.

(4)

(iii) Describe how the method could be modified to investigate the effect of temperature on the ventilation rate of a locust.

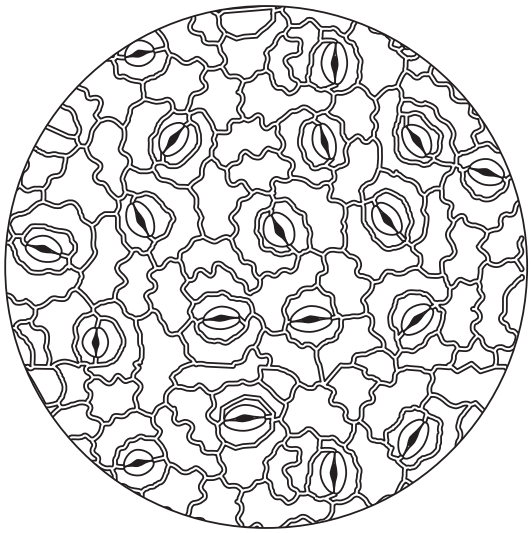
(2)

6 A student investigated the effect of light intensity on the development of stomata in coffee plant leaves.

The following method was used:

- young coffee seedlings were separated into two groups
- one group was grown in bright light and the other group was grown in dim light
- leaves were selected from each group and their surfaces were painted with nail varnish
- the nail varnish was allowed to dry and then peeled off the leaf surface
- each nail varnish peel was observed using a light microscope.

The diagram shows an example of the field of view seen by the student when using the high power lens.



(a) Describe how a microscope should be used to observe the stomata using the high power lens.

(3)

(b) The diameter of the field of view is 0.4 mm.

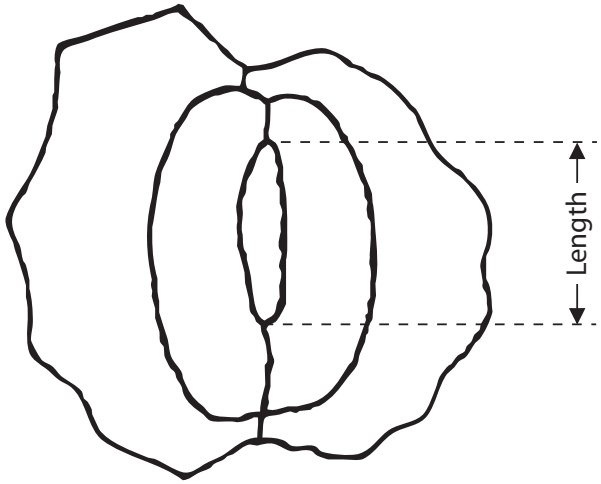
Calculate the number of stomata per mm^2 on the leaf surface.

The area of a circle is πr^2, where π is 3.142.

(2)

Answer ..... mm^{-2}

(c) The diagram shows one of the stomata drawn by the student.



The actual length of this stoma is 20 µm.

Calculate the magnification of this drawing.

(2)

Answer .....

(d) The results of this investigation are shown in the table.

Leaf sample	Number of stomata mm^{-2}	
	Leaves in bright light	Leaves in dim light
1	184	143
2	190	138
3	182	140
4	185	132
5	192	136
Mean ($\bar{x}$) and SD	186.6 ± 4.2	137.8

(i) Calculate the SD for the leaves in dim light.

Use the formula

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

(2)

Answer .....

(ii) Describe how these nail varnish peel samples should be taken to allow a valid comparison between the mean numbers of stomata.

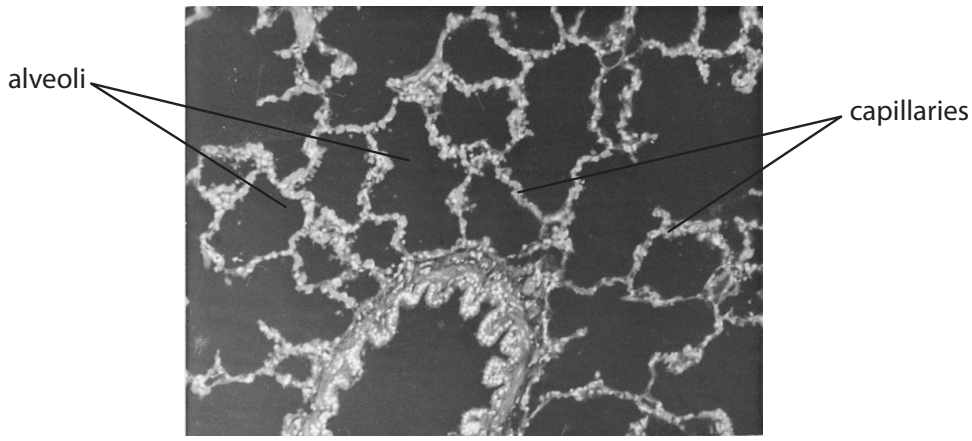
(2)

(iii) Analyse the data to explain how fewer stomata might affect the growth of coffee plants.

(3)

7 Living organisms have a range of gas exchange systems.

(a) The photograph shows human lung tissue, as seen using a light microscope.



© BIOPHOTO ASSOCIATES/SCIENCE PHOTO LIBRARY

(i) The typical diameter of an adult alveolus is 200 µm.

There are 300 million alveoli in each lung.

Calculate the total surface area of a pair of adult lungs, using the formula:

$$\text{surface area of one alveolus} = 4\pi r^2$$

Give your answer in m^2.

(3)

Answer ..... m^2

(ii) Explain the importance of a large surface area in a gas exchange system.

(2)

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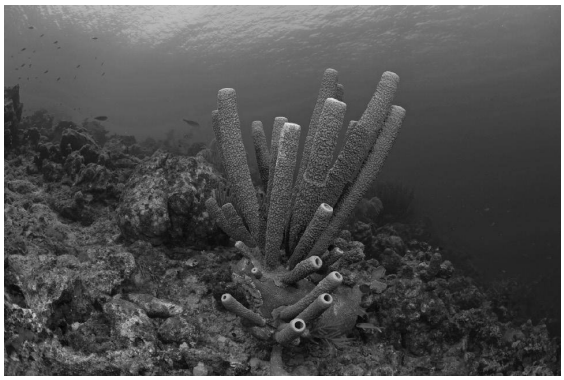
(iii) Fluid passes out of the capillaries into the spaces around the alveoli.

Some of this fluid passes into the alveoli.

Explain the importance of having fluid inside the alveoli.

(2)

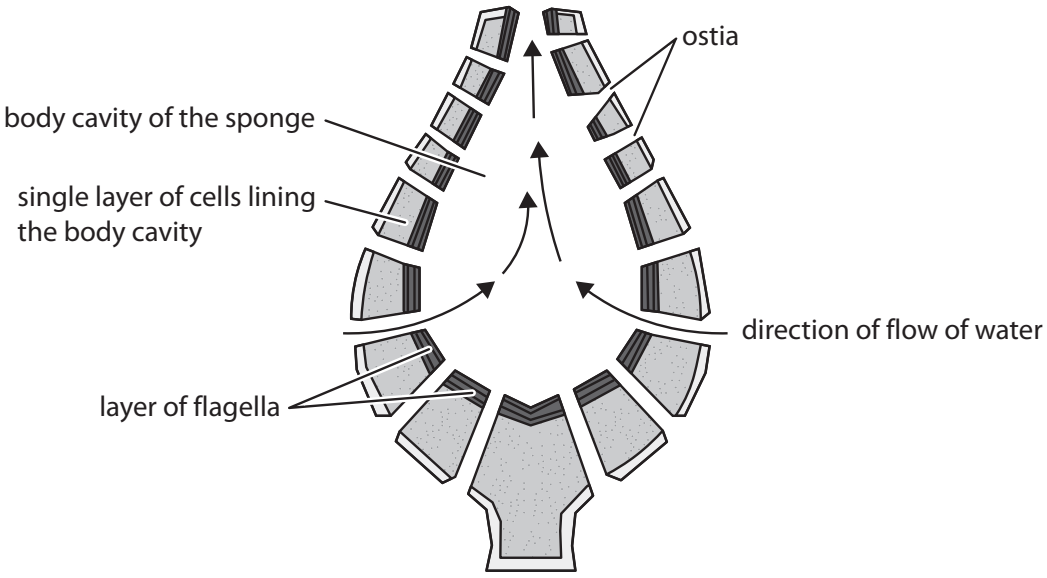
(b) The photograph shows a marine sponge.



© Helmut Corneli/Alamy Stock Photo

Sponges are aquatic animals that are covered in pores called ostia.

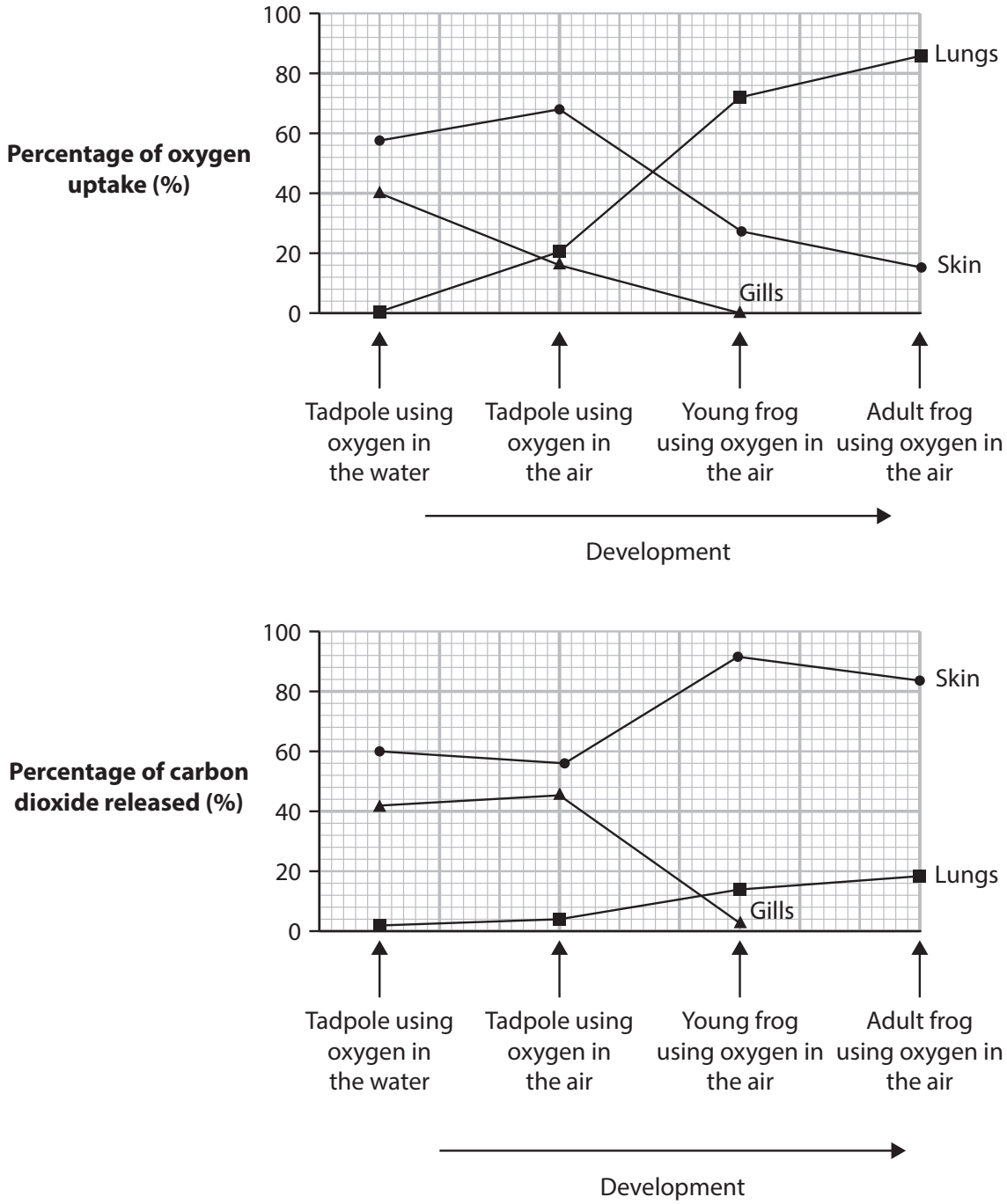
The diagram shows a section through a sponge.



Analyse the information in the diagram to explain how this sponge is adapted for gas exchange.

(3)

(c) The graphs show changes in gas exchange as a tadpole develops into an adult frog.



Analyse the data to explain the role of the gills, lungs and skin in gas exchange as a tadpole develops into a frog.

(4)

9 Plants and animals are adapted for gas exchange.

(a) (i) Which row of the table describes gas exchange in the root of a plant?

(1)

		Net movement of carbon dioxide	Net movement of oxygen
☒	**A**	in only	out only
☒	**B**	out only	in only
☒	**C**	in and out	in and out
☒	**D**	neither in nor out	neither in nor out

(ii) Which is the gas exchange surface in the stem of a woody plant?

(1)

☒ **A** lenticel

☒ **B** pit

☒ **C** plasmodesmata

☒ **D** stomata

(b) Spiracles are small openings in the exoskeletons of insects that allow air to enter the respiratory system.

Water can evaporate out of the spiracles when they are open. The insect can close the spiracles to reduce water loss.

In an investigation, the water loss from insects in air with different humidities was measured.

The insects were kept in air with 80% humidity and then moved into air with a lower humidity. Water loss was then measured.

The investigation was repeated in air high in carbon dioxide to keep the spiracles open.

The table shows the results of this investigation.

Percentage humidity (%)	Water loss from insects / mg hr^{-1}	
	Insects in air	Insects in air high in carbon dioxide
0	0.10	0.90
20	0.13	0.68
40	0.15	0.50
60	0.13	0.35
80	0.07	0.07

(i) State how the water loss could have been measured in this investigation.

(1)

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(ii) Calculate the percentage increase in water loss from the insects kept in air at 0% humidity compared with those kept at 80% humidity.

Give your answer to two decimal places.

(1)

Answer ..... %

(iii) Explain why the insects were kept in air with 80% humidity at the start of this investigation.

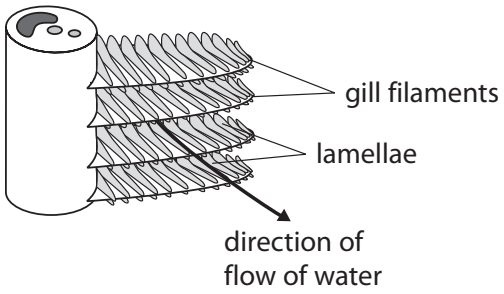
(2)

(iv) Explain the results of this investigation.

(3)

(c) The gas exchange surfaces of fish are the gills.

The diagram shows part of the structure of a gill.



Fish can be divided into two groups: species of fish that are active and species of fish that are inactive.

The table shows some information about some species of fish and their gills.

Species of fish	Mass of fish / g	Total number of gill filaments	Number of lamellae on each side of filament per mm	Surface area of gills / cm^2 per g of fish	Diffusion distance between water and blood / µm
Active species					
Trachurus	26	1665	39	7.8	2.2
Lucioperca	70	1811	15	18.0	no data
Salmo	394	1606	19	2.0	6.4
Katsuwonus	3258	6066	32	13.5	0.6
Thunnus	26600	6480	24	8.9	no data
Inactive species					
Callionymus	39	478	16	2.1	no data
Ictalurus	239	no data	10	1.2	no data
Opsanus	251	660	11	1.9	5.0
Tinca	268	1764	22	1.8	2.5

(i) Lamellae are present on both sides of the gill filaments.

The mean length of a gill filament is 25 mm.

Calculate the total number of lamellae on the gill filaments of *Thunnus*.

Express your answer in standard form.

(1)

Answer .....

*(ii) Analyse the data to explain the relationships between the activity of these fish and the structure of their gills.

(6)

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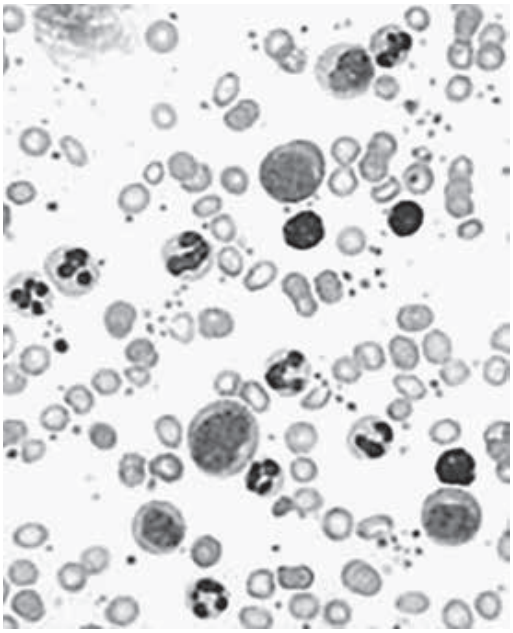
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SUB-TOPIC 4(c)

CIRCULATION, THE HEART AND BLOOD

52 questions in this sub-topic · 509 marks · lowest tariff first

1 (a) The photograph shows a blood smear.



Which row of the table gives the correct number of each type of white blood cell in this photograph?

(1)

	Number of lymphocytes	Number of monocytes	Number of neutrophils
☒ **A**	3	5	8
☒ **B**	3	8	5
☒ **C**	5	3	8
☒ **D**	8	5	3

(b) Which row of the table gives the correct role of each of the blood components?

(1)

	Erythrocytes	Leucocytes	Platelets
☒ **A**	defence	transport	defence
☒ **B**	defence	defence	transport
☒ **C**	transport	defence	defence
☒ **D**	transport	transport	defence

(c) Blood taken from a patient had an unusually high proportion of eosinophils.

Explain why this patient had an unusually high proportion of eosinophils.

(2)

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1 Blood is pumped around the body in blood vessels to supply cells with nutrients and oxygen.

(a) Which box in each row of the table shows where endothelial cells and valves are found?

(2)

Features of blood vessels	Type of blood vessel			
	both capillaries and veins	capillaries only	veins only	neither capillaries nor veins
Endothelial cells	☒	☒	☒	☒
Valves	☒	☒	☒	☒

(b) Nutrients and oxygen pass into cells from tissue fluid.

Explain how tissue fluid is formed.

(2)

1 The venom from some species of snake contains enzymes that affect the blood clotting process.

(a) (i) Which is a correct statement about enzymes?

(1)

- ☒ **A** enzymes decrease the activation energy of metabolic reactions and decrease reaction time
- ☒ **B** enzymes decrease the activation energy of metabolic reactions and increase reaction time
- ☒ **C** enzymes increase the activation energy of metabolic reactions and decrease reaction time
- ☒ **D** enzymes increase the activation energy of metabolic reactions and increase reaction time

(ii) Which components of the blood clotting process are active enzymes?

(1)

- ☒ **A** fibrin and thrombin
- ☒ **B** fibrinogen and thrombin
- ☒ **C** fibrinogen and thromboplastin
- ☒ **D** thrombin and thromboplastin

(b) Factor Xa is a clotting factor present in human blood.

The table shows the effect of different masses of Factor Xa and snake venom on the time taken for blood to clot.

Mass added / μg	Time taken for blood to clot / s	
	Factor Xa added	Snake venom added
0.002	150	104
0.004	44	50
0.020	40	38
0.040	39	37

Describe the effect of snake venom on the time taken for the blood to clot.

(2)

(c) State the role of platelets in the blood clotting process.

(1)

2 The table shows two differences between blood plasma and tissue fluid.

Blood plasma	Tissue fluid
Has a higher protein content	Has a lower protein content
Contains more dissolved oxygen	Contains less dissolved oxygen

(a) State how tissue fluid is formed.

(1)

(b) Explain the differences between blood plasma and tissue fluids shown in the table.

(2)

(c) Some of the tissue fluid is not reabsorbed into the blood capillary.

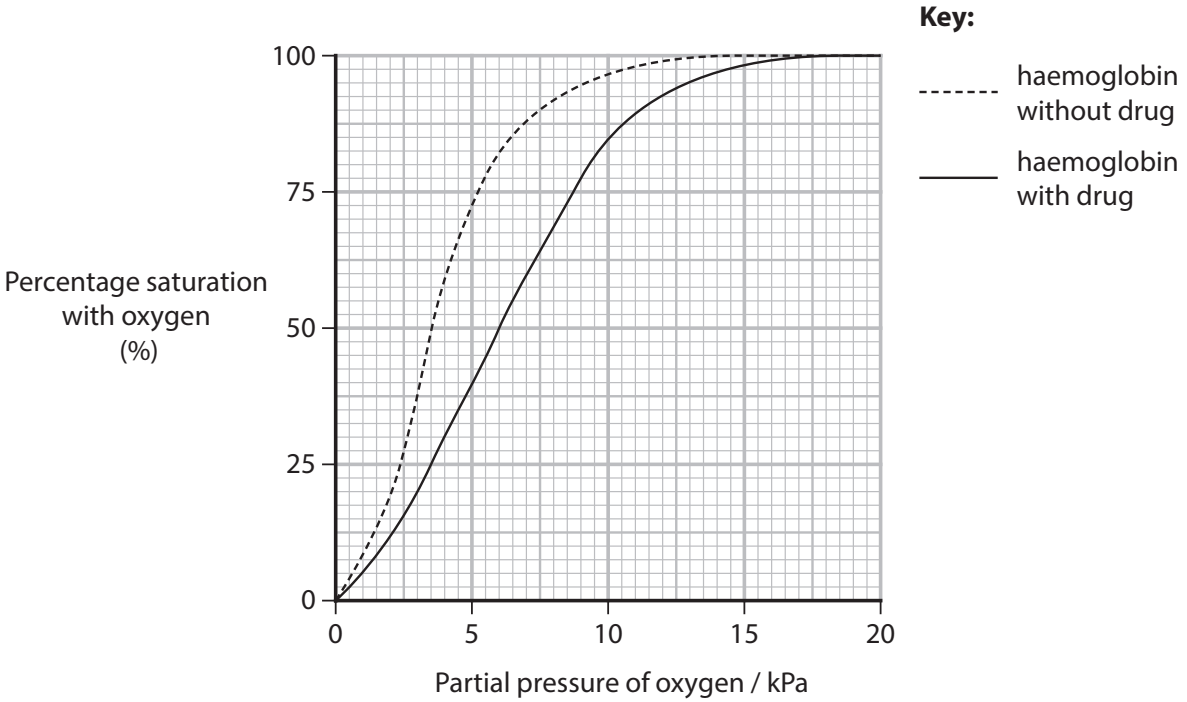
Describe what happens to the tissue fluid that is not reabsorbed into the blood capillary.

(2)

6 Tissue hypoxia is a medical condition that occurs if body tissues cannot get sufficient oxygen from the blood.

Scientists have developed a drug that may help people suffering from tissue hypoxia.

The graph shows the oxygen dissociation curves for haemoglobin from a patient treated with the hypoxia drug and a patient not treated with the drug.



(a) Explain the shape of the haemoglobin dissociation curve without the drug.

(3)

(b) The partial pressure of oxygen in the alveoli is approximately 14 kPa.

Explain why giving a patient the drug is a more effective method of treating tissue hypoxia than increasing the partial pressure of oxygen in the inhaled air.

(3)

5 Blood contains a variety of cells, plasma and clotting factors.

Smoking can increase the risk of blood clot formation.

An investigation was carried out to determine the effects of smoking on the contents of blood plasma.

In the first part of the investigation, blood samples were taken from male smokers and non-smokers aged between 35 and 50. All males were matched for health status, body mass and diet.

The concentration of fibrinogen in their blood plasma was measured.

The results are shown in the table.

Number of cigarettes per day	Sample size	Mean blood plasma concentration of fibrinogen / mg 100 cm^{-3}	Standard deviation
0	30	241.8	± 3.0
1 to 10	10	329.0	± 7.4
11 to 20	22	361.0	± 4.7
> 20	8	376.9	± 6.6

In the second part of the investigation, blood samples were taken from men aged between 35 and 50 just after waking.

Another blood sample was taken just after the men had smoked their first cigarette.

The concentration of thrombin present in both blood samples was measured.

The concentration of thrombin present in the blood of the non-smokers was also measured.

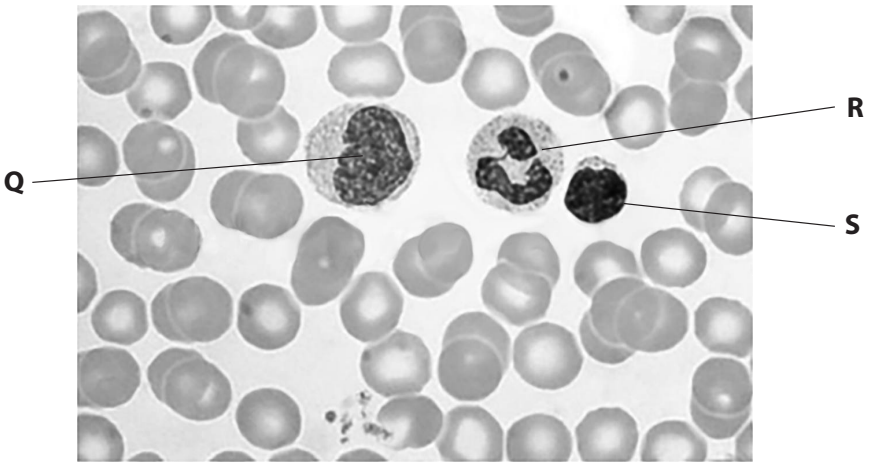
The results are shown in the table.

Group	Sample size	Mean thrombin concentration / arbitrary units	Standard deviation
Non-smokers after waking	9	56	± 1
Smokers after waking	10	121	± 47
Smokers after first cigarette	10	365	± 76

(a) Analyse the data to explain why smoking can increase the risk of blood clot formation.

(4)

(b) The diagram below shows some of the cells found in blood.



(i) Which row of the table correctly identifies the cells labelled **Q**, **R** and **S** ?

(1)

		Q	R	S
☒	**A**	erythrocyte	monocyte	neutrophil
☒	**B**	neutrophil	lymphocyte	monocyte
☒	**C**	monocyte	neutrophil	erythrocyte
☒	**D**	monocyte	neutrophil	lymphocyte

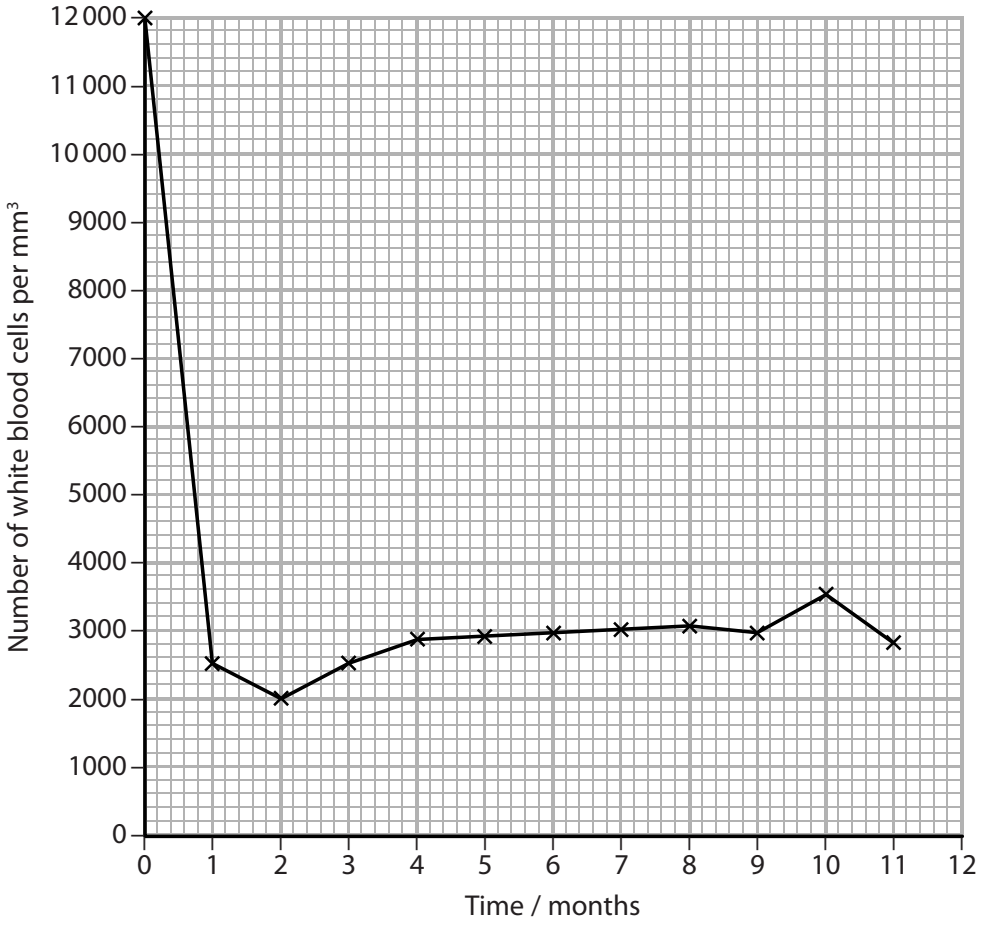
(ii) Describe the function of a neutrophil in defence.

(2)

(Total for Question 5 = 7 marks)

4 Cancer treatment using chemotherapy can affect the number of white blood cells in the body.

The graph shows the number of white blood cells in a patient during chemotherapy.



(a) (i) Which of the following shows the white blood cell count in the blood of this patient at the start of treatment?

(1)

- ☒ **A** 12×10^3 per dm^3
- ☒ **B** 12×10^6 per dm^3
- ☒ **C** 12×10^9 per dm^3
- ☒ **D** 12×10^{12} per dm^3

(ii) Calculate the percentage change in the white blood cell count by the end of the first month of chemotherapy.

(2)

Answer .....

(b) Cancer treatment can cause pancytopenia.

Pancytopenia is a condition in which the numbers of white blood cells, red blood cells and platelets in the body are reduced.

Explain how two of the symptoms of pancytopenia could be treated.

(4)

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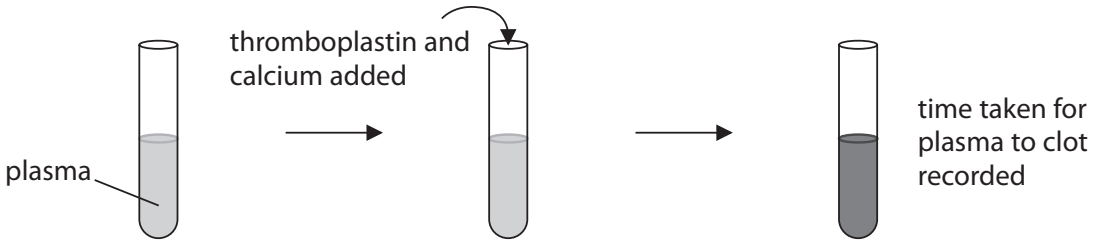
7 A farmer used anticoagulant bait to kill rats on his farm.

The anticoagulant prevents the activity of vitamin K that is needed for the synthesis of prothrombin.

The farmer's dog became ill with excessive bleeding in the gums.

A vet carried out a prothrombin test that measures the clotting time of blood plasma.

The diagram shows the test procedure with blood plasma from a healthy dog.



(a) (i) Give the reason why thromboplastin and calcium ions were added to the plasma samples.

(1)

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(ii) The clotting time for the plasma from the farmer's dog was 73 seconds. The clotting time for the plasma from the healthy dog was 12 seconds.

Explain the difference in these clotting times.

(3)

(b) Give one way in which the vet could treat the farmer's dog to reduce the symptom of excessive bleeding in the gums.

(1)

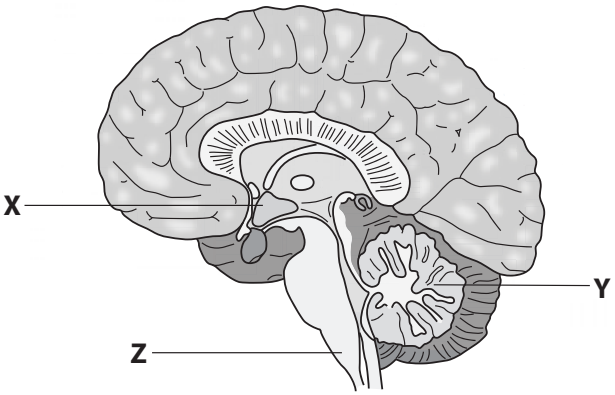
(c) The vet noticed that blood had collected in the lower part of the lungs of the farmer's dog.

Explain how this would affect the farmer's dog.

(2)

2 The brain is involved in many homeostatic mechanisms.

(a) The diagram shows a vertical section through a human brain.



Which row of the table correctly matches the regions **X**, **Y** and **Z** with their functions?

(1)

		Control of breathing rate	Control of balance	Temperature regulation
☒	**A**	X	Y	Z
☒	**B**	Y	Z	X
☒	**C**	Z	X	Y
☒	**D**	Z	Y	X

(b) An action potential results from the depolarisation of the membrane of a neurone.

Which row of the table shows the correct state of the ion channels during this depolarisation?

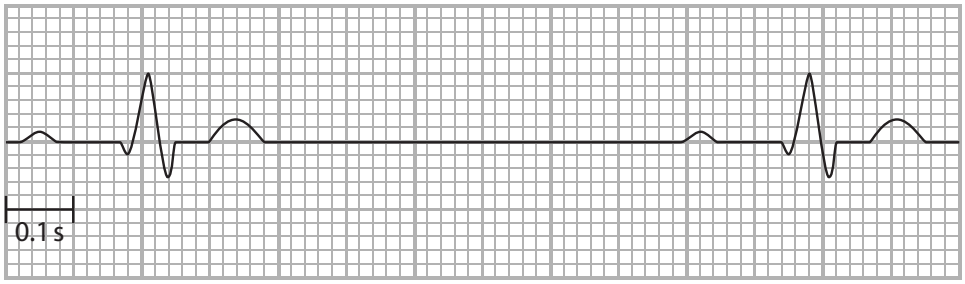
(1)

		Na^+ channels	K^+ channels
☒	**A**	closed	closed
☒	**B**	closed	open
☒	**C**	open	closed
☒	**D**	open	open

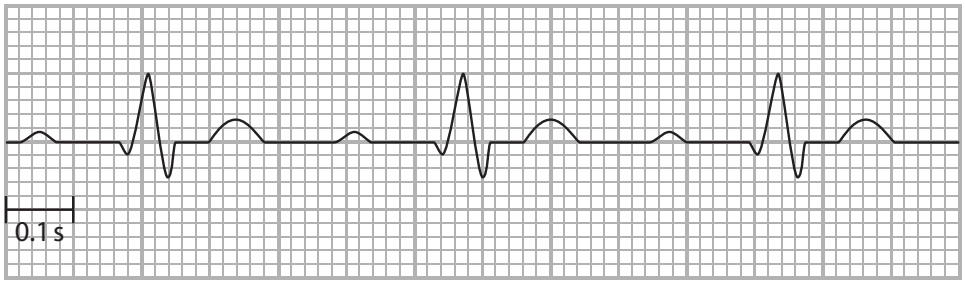
(c) The autonomic nervous system plays a role in regulating heart rate.

The diagram shows an ECG trace from a student before and during exercise.

before exercise



during exercise



(i) Calculate the heart rate of this student during exercise.

(1)

Answer .....

(ii) Describe how exercise results in an increased heart rate.

(4)

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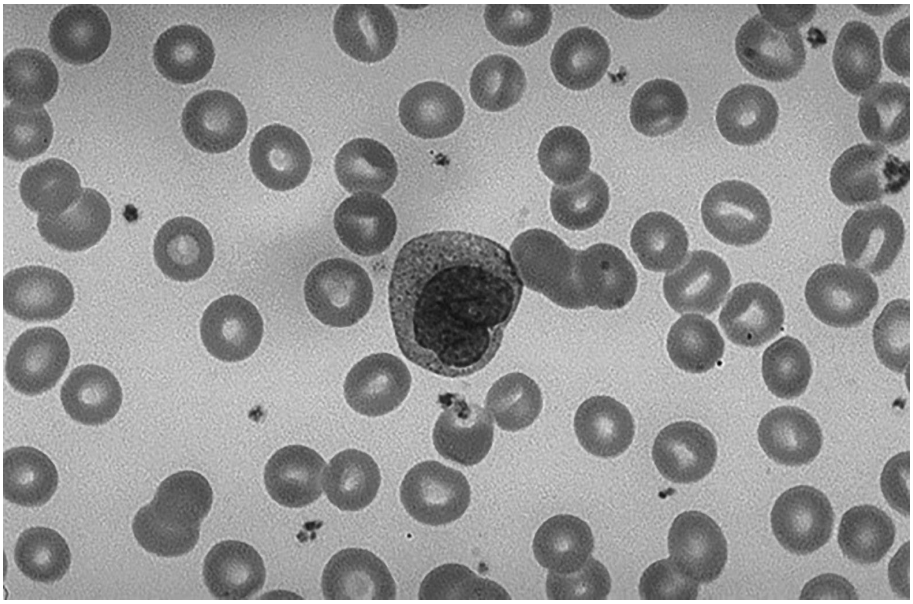
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1 The photograph shows blood cells as seen using a light microscope.



Source: Library.med.utah.edu

(a) Explain how the structures of erythrocytes and monocytes are related to their functions.

(3)

(b) Blood is able to clot and prevent further blood loss from a cut.

Give **one** other function of blood clotting.

(1)

(c) Doctors can measure the effectiveness of the clotting process using the prothrombin time test (PTT).

This test measures how long it takes for a sample of blood to clot.

Two groups of adults had their PTT recorded.

One group had liver disease and the other group was a healthy control.

The results are shown in the table.

Group	Mean PTT / seconds	Standard deviation / seconds
with liver disease	20.1	0.3
control	13.5	0.1

Analyse the data to deduce whether PTT is a useful indicator of liver disease.

(3)

5 Some animals have a single circulatory system and others have a double circulatory system.

(a) Compare and contrast single and double circulatory systems.

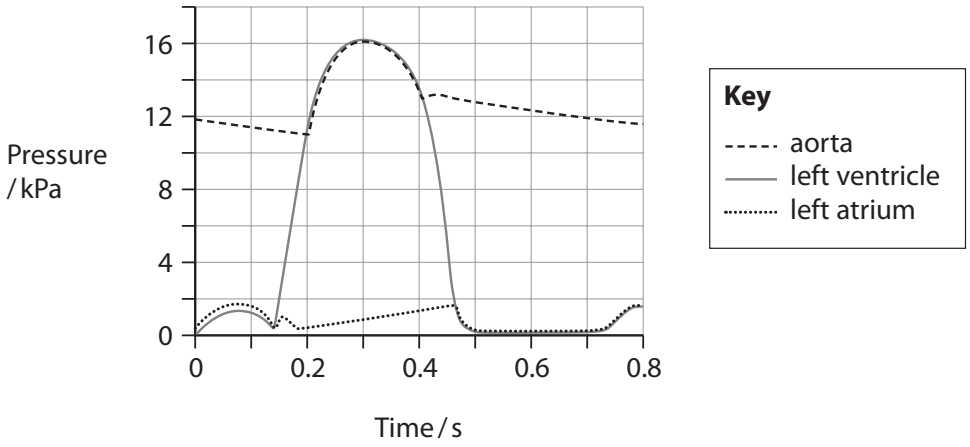
(3)

(b) During exercise, the heart rate of a human increases and then takes time to return to resting rate after the exercise ends.

Devise an investigation to determine whether the sex of a person significantly affects the time taken for the heart rate to return to resting rate after exercise.

(4)

1 (a) The graph shows the pressure changes in the left side of the heart during one contraction.



(i) At what time does the atrioventricular (bicuspid) valve close?

(1)

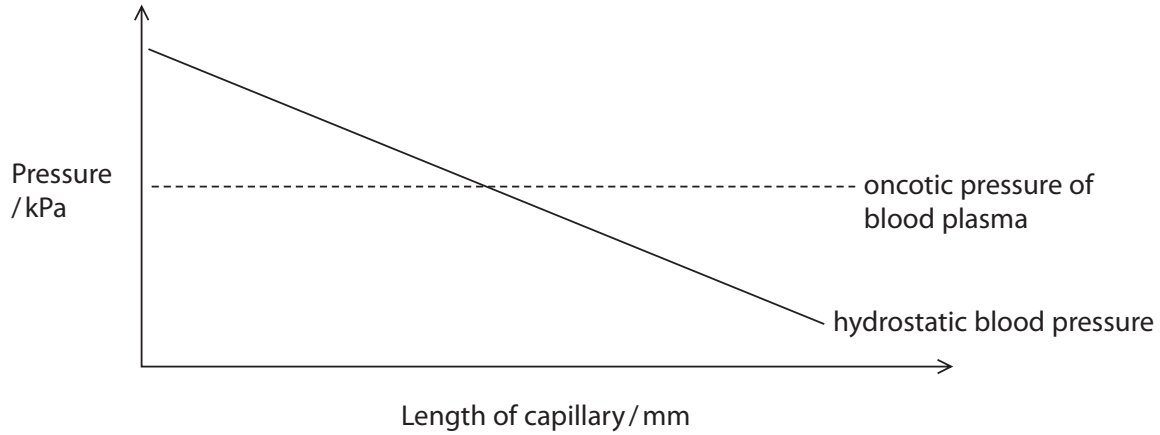
- ☒ **A** 0.14 s
- ☒ **B** 0.20 s
- ☒ **C** 0.45 s
- ☒ **D** 0.40 s

(ii) Which is the sequence of structures that an impulse passes through during one heart contraction?

(1)

- ☒ **A** atrioventricular node, bundle of His, sinoatrial node
- ☒ **B** atrioventricular node, sinoatrial node, bundle of His
- ☒ **C** sinoatrial node, bundle of His, atrioventricular node
- ☒ **D** sinoatrial node, atrioventricular node, bundle of His

(b) The graph shows the hydrostatic pressure and oncotic pressure of the blood along a capillary.



(i) Explain how tissue fluid is formed by the capillary. Use the information in the graph to help your answer.

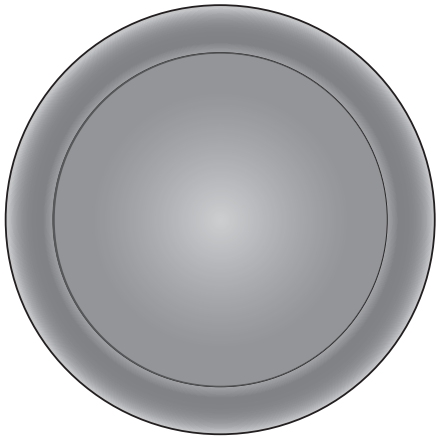
(3)

(ii) Kwashiorkor is a condition caused by a lack of dietary protein. One symptom is accumulation of tissue fluid.

Explain why children suffering from kwashiorkor often suffer from an excess of tissue fluid. Use the graph to support your answer.

(2)

1 The diagram shows a magnified human red blood cell.



(a) The actual diameter of this cell is 7.20 μm.

Calculate the magnification of this diagram.

(2)

Answer .....

(b) A regular sphere with a diameter of 7.20 μm has a surface area of 162.86 μm^2.

(i) Calculate the volume of a sphere with a diameter of 7.20 μm.

Use the formula $V = \frac{4}{3} \pi r^3$

(2)

Answer ..... μm^3

(ii) Explain how a red blood cell with the same diameter as this sphere enables it to carry out its functions in transporting gases in the blood.

(3)

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3 When a blood vessel is damaged a clot is formed.

(a) Give **one** function of blood clotting when a blood vessel is damaged.

(1)

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(b) (i) Which of the following factors are likely to lead to increased plaque formation and atherosclerosis?

(1)

1. increased levels of high-density lipoproteins
2. smoking tobacco
3. too little exercise
4. type 2 diabetes

☒ **A** 1 only

☒ **B** 1, 2 and 3 only

☒ **C** 1, 2, 3 and 4

☒ **D** 2, 3 and 4 only

(ii) Which of the following describes atherosclerosis?

(1)

☒ **A** develops in arteries because blood flow is slower

☒ **B** develops in arteries because blood pressure is higher

☒ **C** develops in veins because blood flow is slower

☒ **D** develops in veins because blood pressure is lower

(c) A deep vein thrombosis (DVT) is a blood clot in the legs.

The blood clot may travel into the lungs and block the flow of blood.

Airline passengers on long-distance flights are advised to carry out exercises such as stretching and flexing their leg muscles to reduce the risk of DVT.

Aspirin is a drug that can be used to prevent platelets binding to the inside of blood vessels.

The use of aspirin for the prevention of DVT in air travel is not based on evidence.

Passengers who are at low risk of DVT are not advised to take aspirin because of the small risk of serious side effects such as bleeding.

Analyse this information to explain the advice airline passengers are given.

(4)

4 The mammalian circulatory system transports materials to and from cells.

(a) (i) State how the double circulatory system of mammals ensures a higher hydrostatic blood pressure than a single circulatory system.

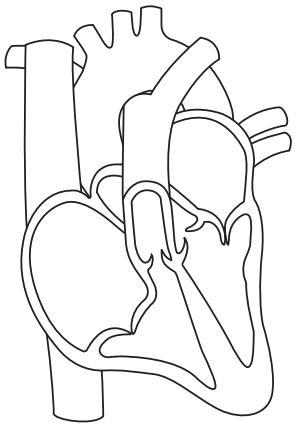
(1)

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(ii) The diagram shows a section through a mammalian heart during part of the cardiac cycle.



Which of the following statements is true for this stage in the cardiac cycle?

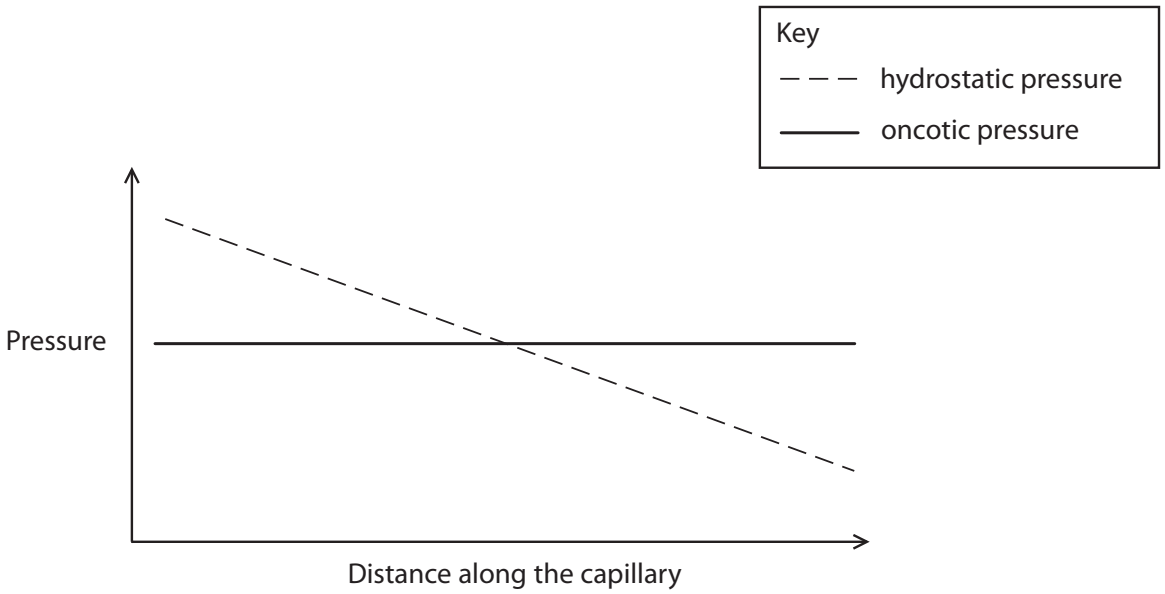
(1)

- ☒ **A** the pressure in the aorta is higher than the pressure in the left ventricle
- ☒ **B** the atrioventricular valves are open and the semilunar valves are closed
- ☒ **C** the pressure in the left ventricle is higher than the pressure in the left atrium
- ☒ **D** the atrioventricular node is about to send an impulse along the bundle of His

(b) Lymphoedema is a condition that causes severe swelling of body tissues due to the accumulation of tissue fluid.

This occurs when lymphatic ducts are blocked.

The diagram shows how the hydrostatic blood pressure and oncotic plasma pressure vary along the length of a capillary.



(i) With reference to the diagram, explain how tissue fluid is produced and reabsorbed by the capillaries.

(4)

(ii) Lymphatic ducts remove proteins that are secreted by cells.

Explain how a blockage of a lymphatic duct could lead to lymphoedema.

(2)

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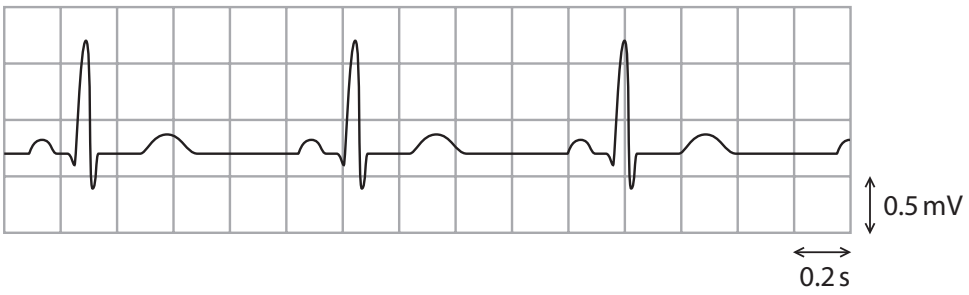
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1 A person visited his doctor for a health check.

The doctor obtained an ECG trace to show the electrical activity of the person's heart.

The diagram shows part of this trace.



(a) The trace shows the P waves, T waves and QRS complexes.

Which of the following shows the electrical activity during ventricular systole?

(1)

☒ **A** P wave only

☒ **B** P and T wave

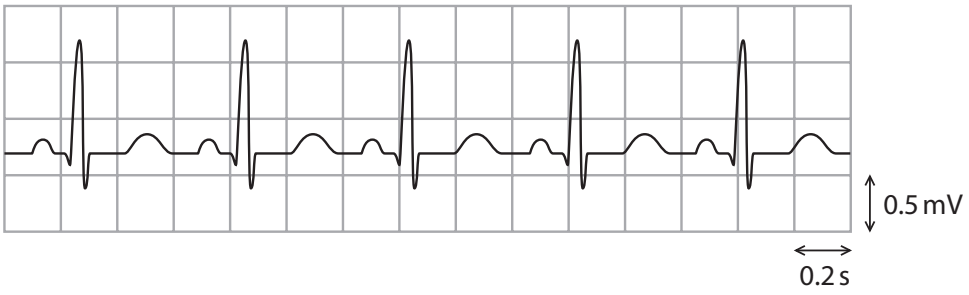
☒ **C** T wave only

☒ **D** QRS complex

(b) Twelve months later, the same person visited his doctor with symptoms of stress.

The doctor obtained another ECG trace.

The diagram shows part of this trace.



The doctor diagnosed that the person was suffering from stress.

Analyse the data in both ECG traces to comment on this diagnosis.

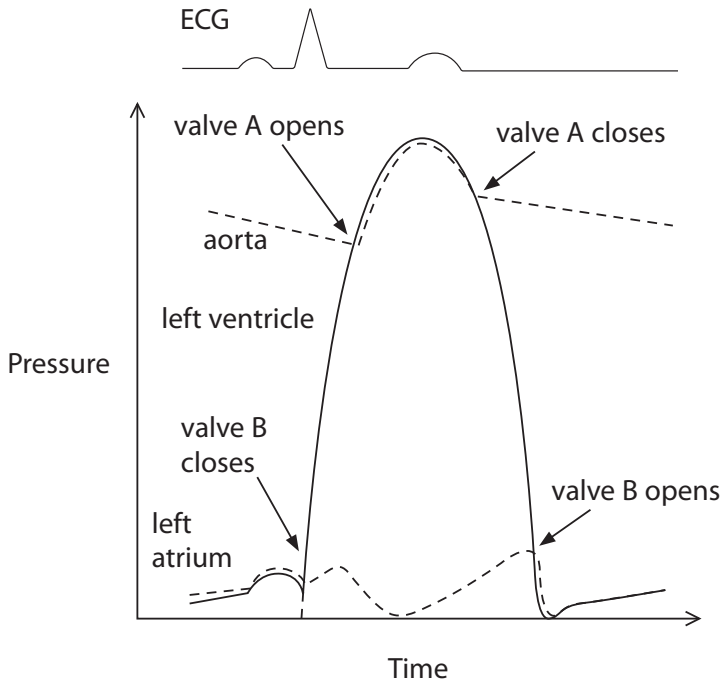
(3)

(c) Stress increases blood pressure, which can damage blood vessels.

Explain why stress is a health risk.

(4)

1 The diagram shows an ECG trace and pressure changes in the aorta and in the left side of the heart.



(a) Valve A is the

(1)

- ☒ **A** atrioventricular
- ☒ **B** mitral
- ☒ **C** semi-lunar
- ☒ **D** bicuspid

(b) Which wave on the ECG trace occurs when the pressure in the left ventricle is highest?

(1)

- ☒ **A** P
- ☒ **B** Q
- ☒ **C** R
- ☒ **D** T

(c) Which of these structures functions as the heart's pacemaker?

(1)

- ☒ **A** the atrioventricular node (AVN)
- ☒ **B** the bundle of His
- ☒ **C** the septum
- ☒ **D** the sinoatrial node (SAN)

(d) The heart muscle is described as myogenic.

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

(1)

(ii) An artificial pacemaker may be fitted to a patient's heart to control the cardiac cycle.

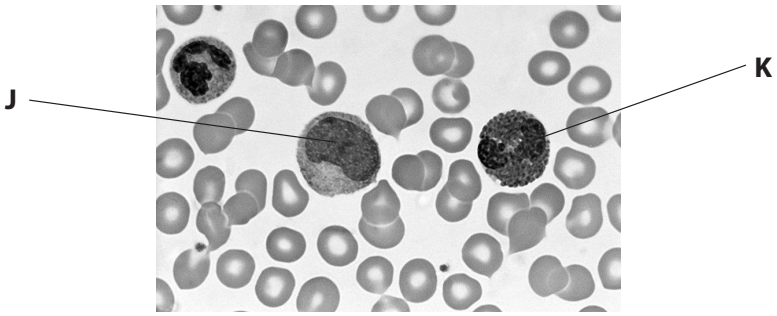
Early pacemaker models did not change the heart rate.

Newer pacemaker models can change the heart rate depending on circumstances.

Comment on the advantages of these newer pacemaker models.

(4)

4 The photograph shows a blood smear from a healthy person, as seen using a light microscope.



Source: © biophoto associates/science photo library

(a) (i) Which row of the table identifies the cells labelled **J** and **K**?

(1)

	Cell J	Cell K
☒ **A**	eosinophil	lymphocyte
☒ **B**	lymphocyte	neutrophil
☒ **C**	monocyte	eosinophil
☒ **D**	neutrophil	monocyte

(ii) Which is the approximate ratio of erythrocytes to leucocytes in this blood smear?

(1)

☒ **A** 1:50

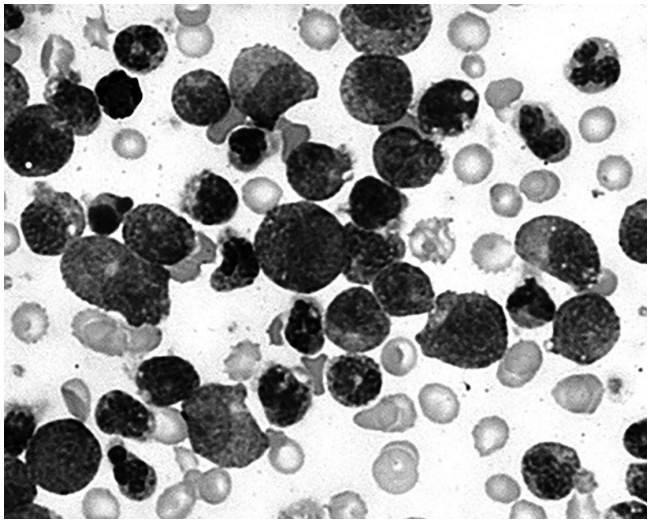
☒ **B** 3:50

☒ **C** 50:1

☒ **D** 50:3

(b) Chronic myelogenous leukaemia (CML) is a blood disorder.

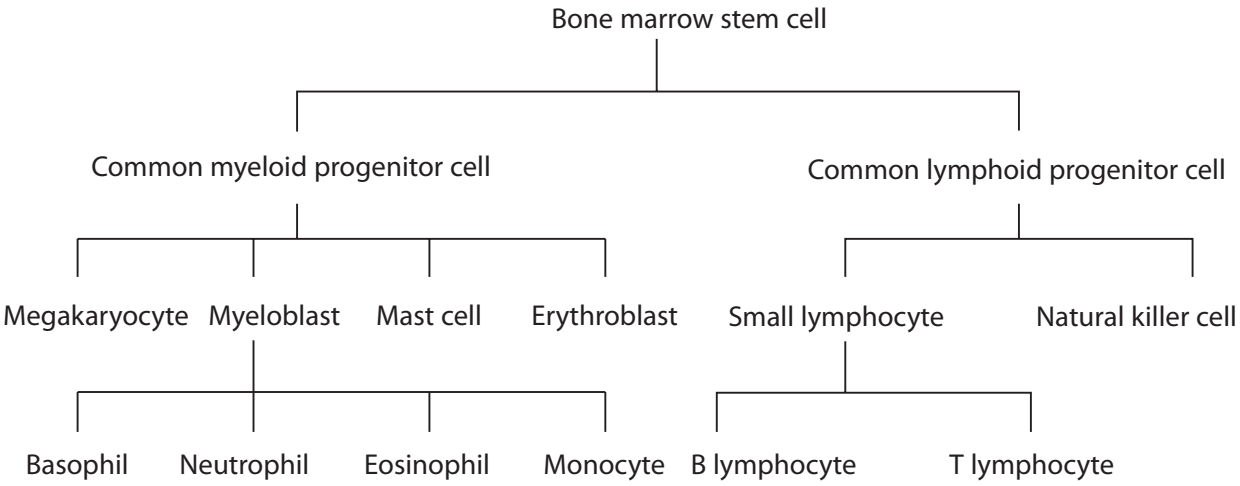
The photograph shows a blood smear from a person with CML, as seen using a light microscope.



Explain why a blood smear can be used to diagnose CML.

(2)

(c) The diagram shows some stages in the production of blood cells from bone marrow stem cells.



Explain how a bone marrow stem cell differentiates into either a common myeloid progenitor cell or a common lymphoid progenitor cell.

(4)

4 Passive smoking is the inhalation of tobacco smoke from another person's cigarettes.

A study was conducted into the effect of passive smoking on the development of babies, during pregnancy, in women who do not smoke.

The study compared the condition of new-born babies from women who had been exposed to passive smoking with babies from women who had not been exposed to passive smoking. All babies were assessed on:

- birth weight
- length
- head circumference
- apgar score after 1 minute
- apgar score after 5 minutes.

Apgar scores are a measure of the baby's condition at 1 minute and 5 minutes after birth. The measure covers appearance, pulse, grimace (reflex), activity and respiration.

Scores of 7 or higher are considered normal.

The results of the study are shown in the table.

	Group			
	Exposed to passive smoking number of mothers = 1085		**Not exposed to passive smoking** number of mothers = 2341	
Measure	**Mean**	**Standard deviation**	**Mean**	**Standard deviation**
Birth weight / kg	3.15	0.46	3.21	0.46
Baby's length / cm	49.62	3.09	49.87	2.48
Head circumference / cm	34.05	1.59	34.14	1.73
Apgar score at 1 min	7.73	0.86	7.75	0.82
Apgar score at 5 min	8.92	0.64	8.91	0.66

(a) Explain why all the women chosen for the study were non-smokers.

(2)

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*(b) Cigarette smoke contains the gas carbon monoxide.

The affinity of haemoglobin for carbon monoxide is 200 times greater than its affinity for oxygen.

When carbon monoxide binds to a haemoglobin molecule, this increases its affinity for oxygen.

This causes the dissociation curve to shift to the left.

Analyse the data to evaluate the effect of passive smoking on the development of babies.

(6)

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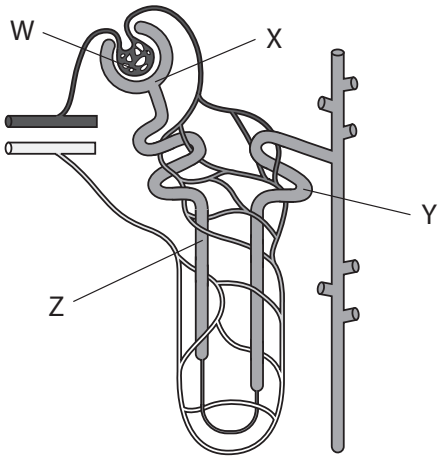
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6 The diagram shows a nephron.



(a) Which labelled parts of this nephron would normally contain glucose?

(1)

- ☒ **A** W only
- ☒ **B** W and X
- ☒ **C** W, X, and Y
- ☒ **D** W, X, Y, and Z

(b) Oedema is an accumulation of tissue fluid. This is due to less tissue fluid being returned to the blood capillaries.

(i) Explain how tissue fluid is returned to capillaries.

(3)

(ii) Furosemides are drugs that are used to reduce oedema. They are diuretics that increase urine production.

Furosemides reduce the active transport of sodium ions by the loop of Henle.

Explain how furosemides cause an increase in urine production.

(4)

2 (a) The photograph shows a section through an artery and a vein, as seen using a light microscope.



(Source: © BIOPHOTO ASSOCIATES/SCIENCE PHOTO LIBRARY)

(i) The actual diameter of the artery measured from X to Y is 1.2mm.

Calculate the magnification of this photograph.

(1)

Answer .....

(ii) Explain how **two** features of that artery distinguish it from the vein shown in the photograph.

(2)

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(b) The following are stages in blood clotting:

- M – platelets form a plug and release clotting factors
- N – fibrin network traps red blood cells and platelets
- P – prothrombin activator converts prothrombin into thrombin
- Q – thrombin converts fibrinogen into fibrin.

Which is the correct sequence of these stages in the formation of a blood clot?

(1)

- ☒ **A** M Q P N
- ☒ **B** M N Q P
- ☒ **C** N M Q P
- ☒ **D** M P Q N

(c) Blood clots can form in arteries and in veins.

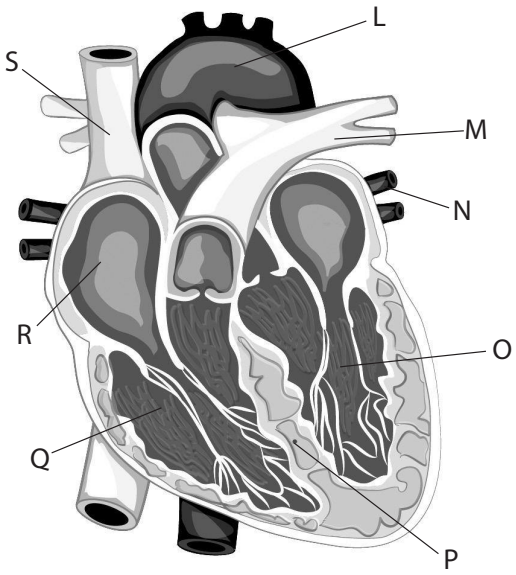
(i) Give **one** reason why the development of blood clots in an artery is more dangerous than the development of blood clots in a vein.

(1)

(ii) Explain how **three** lifestyle factors can lead to an increase in the risk of developing atherosclerosis.

(3)

3 Diagram 1 shows a human heart with some structures labelled.



(Source: © okili77/Shutterstock)

Diagram 1

(a) (i) Which blood vessel carries oxygenated blood to the heart from the lungs?

(1)

- ☒ **A** L
- ☒ **B** M
- ☒ **C** N
- ☒ **D** S

(ii) Which labelled structure has the highest pressure during the cardiac cycle?

(1)

- ☒ **A** M
- ☒ **B** O
- ☒ **C** Q
- ☒ **D** R

(iii) Which labelled structure is the septum?

(1)

- ☒ **A** O
- ☒ **B** P
- ☒ **C** Q
- ☒ **D** R

(b) Bony fish have a heart with one atrium and one ventricle.

Diagram 2 shows the structure of a heart from a bony fish with some structures labelled.

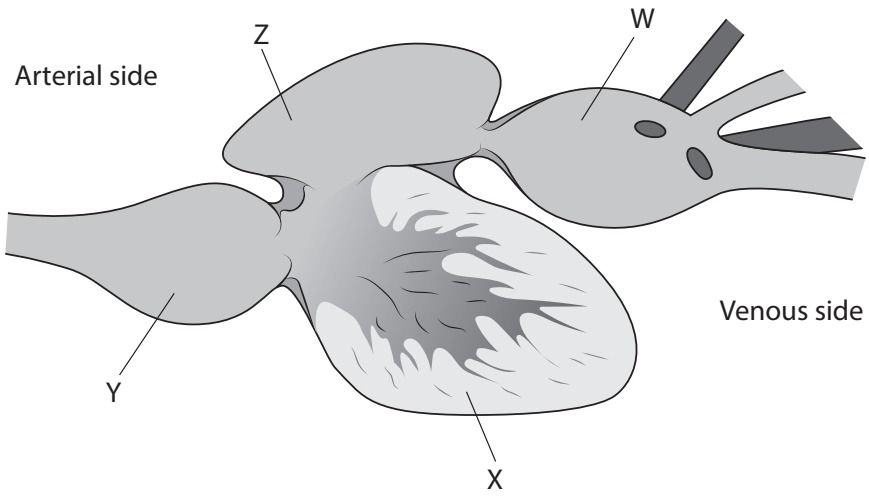


Diagram 2

(i) Which of the following structures is the atrium?

(1)

- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(ii) Draw arrows on diagram 2 to show the direction of blood flow through this heart.

(1)

(iii) Explain how the heart and circulatory system of a bony fish differ from those of a mammal.

(3)

4 Scientists are developing ways of using stem cells to replace heart cells that have been damaged as a result of heart disease.

(a) The table shows the results of a survey of the incidence of heart disease.

Age / years	Incidence of heart disease per 1000 population	
	In women	In men
18 to 44	3	5
45 to 64	118	138
65 to 74	220	305
75 and older	358	422

Analyse the data to explain the factors affecting the incidence of heart disease.

(2)

(b) Explain why heart cells are damaged as a result of heart disease.

(2)

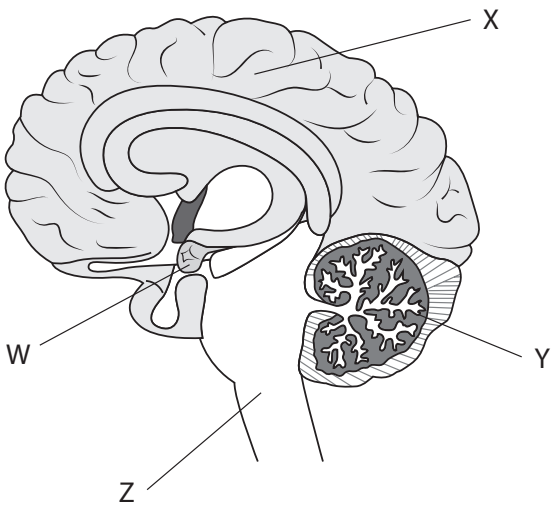
(c) Both embryonic stem cells and induced pluripotent stem cells (iPS cells) can be used to create new heart cells.

Compare and contrast the properties and uses of embryonic stem cells with those of iPS cells.

(5)

4 The autonomic nervous system controls the heart rate.

(a) The diagram shows a human brain.



(i) Which region of the brain controls the heart rate?

(1)

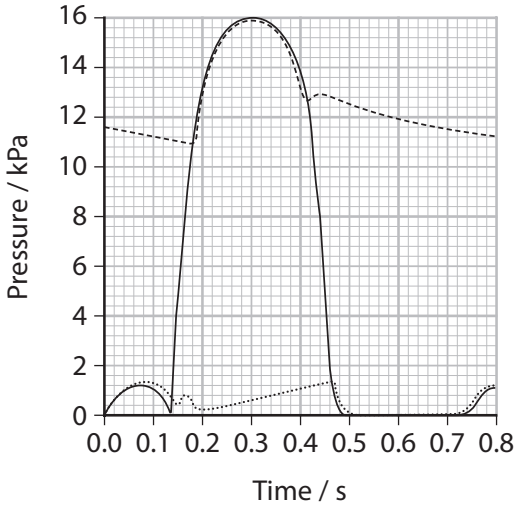
- ☒ **A** W
- ☒ **B** X
- ☒ **C** Y
- ☒ **D** Z

(ii) Which one of the following would lead to an increase in heart rate?

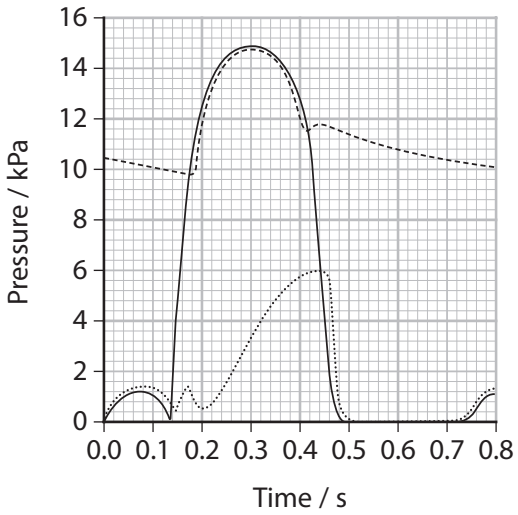
(1)

- ☒ **A** release of acetylcholine by the sympathetic nervous system
- ☒ **B** release of acetylcholine by the parasympathetic nervous system
- ☒ **C** release of noradrenaline by the sympathetic nervous system
- ☒ **D** release of noradrenaline by the parasympathetic nervous system

(b) The graphs show the pressure changes that occur in a healthy heart and the pressure changes that occur in a heart with an atrioventricular valve that leaks.



Healthy heart



Heart with an atrioventricular valve that leaks

Key

—— left ventricle
----- aorta
····· left atrium

(i) An atrioventricular valve in the healthy heart has a surface area of 3.5 cm^2.

Determine the force that is applied to this atrioventricular valve when it closes.

Use the formula

$$\text{Pressure in kPa} = \frac{\text{Force in newtons}}{\text{Area in m}^2}$$

(3)

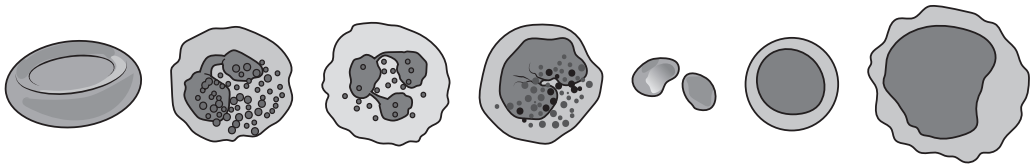
Answer ..... newtons

(ii) Explain why people with an atrioventricular valve that leaks find exercise difficult.

(4)

5 Blood cells carry out a wide variety of roles in the body.

The diagram shows some of the components present in a sample of blood.



P Q R S T U V

(a) (i) Which of these components is involved in blood clotting?

(1)

- ☒ **A** Q
- ☒ **B** R
- ☒ **C** S
- ☒ **D** T

(ii) Which of these pairs of components is involved in the immune response?

(1)

- ☒ **A** P and Q
- ☒ **B** S and T
- ☒ **C** T and U
- ☒ **D** U and V

(iii) Which of these components is a lymphocyte?

(1)

- ☒ **A** P
- ☒ **B** R
- ☒ **C** T
- ☒ **D** U

*(b) The relative number of each type of blood cell can be used to diagnose blood conditions.

Tables 1 and 2 show data for the blood conditions, A, B, C and D.

The tables also show the normal number of blood cells.

Table 1

Condition	Number of lymphocytes per dm^3
A	below 1.5×10^9
Normal range	1.5×10^9 to 4.5×10^9
B	above 4.8×10^9

Table 2

Condition	Number of neutrophils per dm^3
C	below 1.0×10^9
Normal range	2.0×10^9 to 7.5×10^9
D	above 8.0×10^9

Table 3 gives some of the possible symptoms and medical advice for patients with each condition.

Table 3

Condition	Possible symptoms	Medical advice
A	infections that do not get better	have a seasonal flu vaccine avoid uncooked foods
B	swelling of lymph nodes	if condition persists check for no underlying condition such as leukaemia
C	increased susceptibility to infection in severe cases, bacteria that are normally present in the mouth can cause serious infections	cancer treatments such as chemotherapy often cause this condition
D	can occur as a normal response to infection	if condition persists check for no underlying condition such as leukaemia

Analyse the data in Tables 1, 2 and 3 to explain the consequences for patients with these conditions.

(6)

3 Stroke volume is the volume of blood that leaves the left ventricle of the heart in each beat.

Cardiac output is the volume of blood that leaves the left ventricle each minute.

The table shows the relationship between heart rate, stroke volume and cardiac output in a person.

Heart rate / beats min^{-1}	Stroke volume / cm^3	Cardiac output / dm^3 min^{-1}
60	110	6.6
100	120	12.0
120	120	14.4
160	120	
175	120	21.0

(a) Calculate the cardiac output for the heart with a stroke volume of 120 cm^3 and a heart rate of 160 beats min^{-1}.

(1)

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

(b) Analyse the data to explain the relationship between heart rate and cardiac output.

(2)

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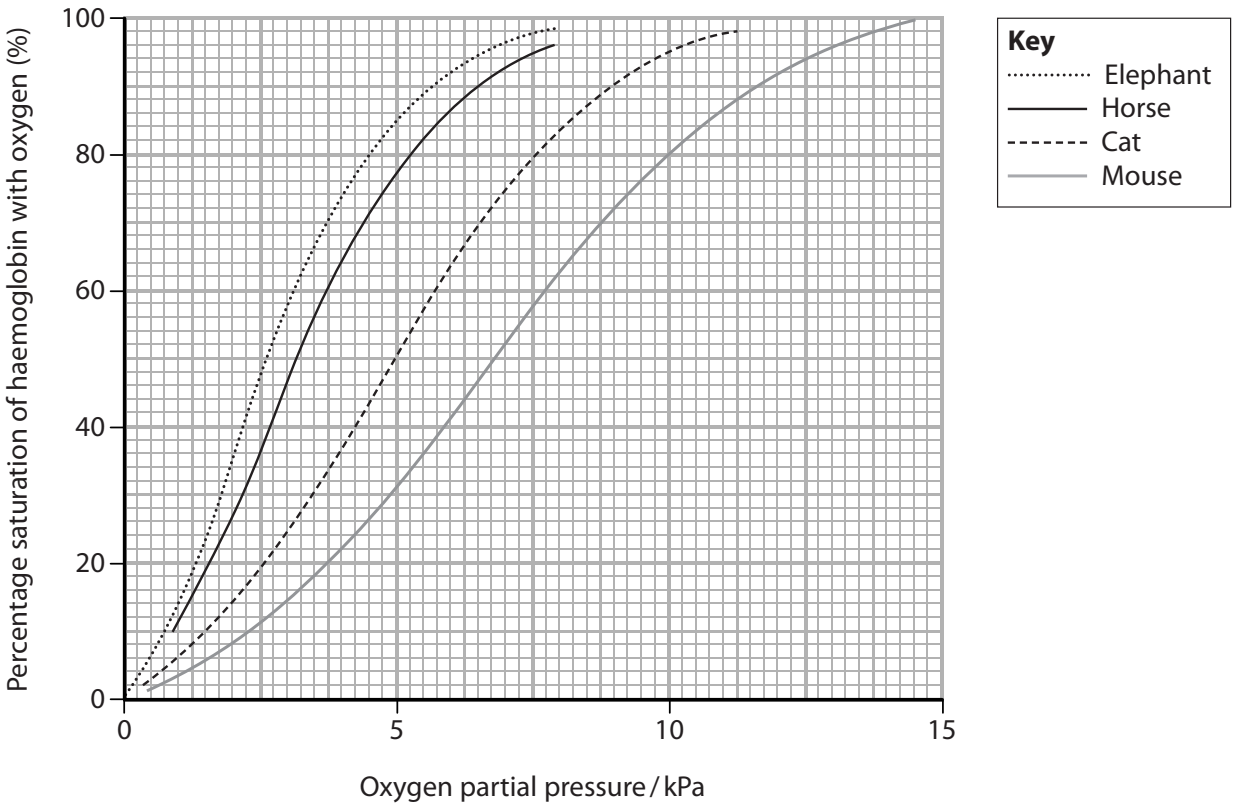
(c) (i) Explain how electrical events during the cardiac cycle can lead to an increase in stroke volume.

(3)

(ii) Explain why Olympic athletes who train for long distance events often have low resting heart rates.

(4)

4 The graph shows the oxygen dissociation curves of haemoglobin from four species of mammal.



(a) Explain the shape of the haemoglobin dissociation curve.

(3)

(b) Calculate how much more oxygen is released as the partial pressure falls from 10 kPa to 5 kPa in the mouse than in the cat.

(3)

Answer .....

(c) Explain why the dissociation curve for mouse haemoglobin is to the right-hand side of the dissociation curve for elephant haemoglobin.

(3)

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(d) Some species of horse live at high altitudes where the partial pressure of oxygen is very low.

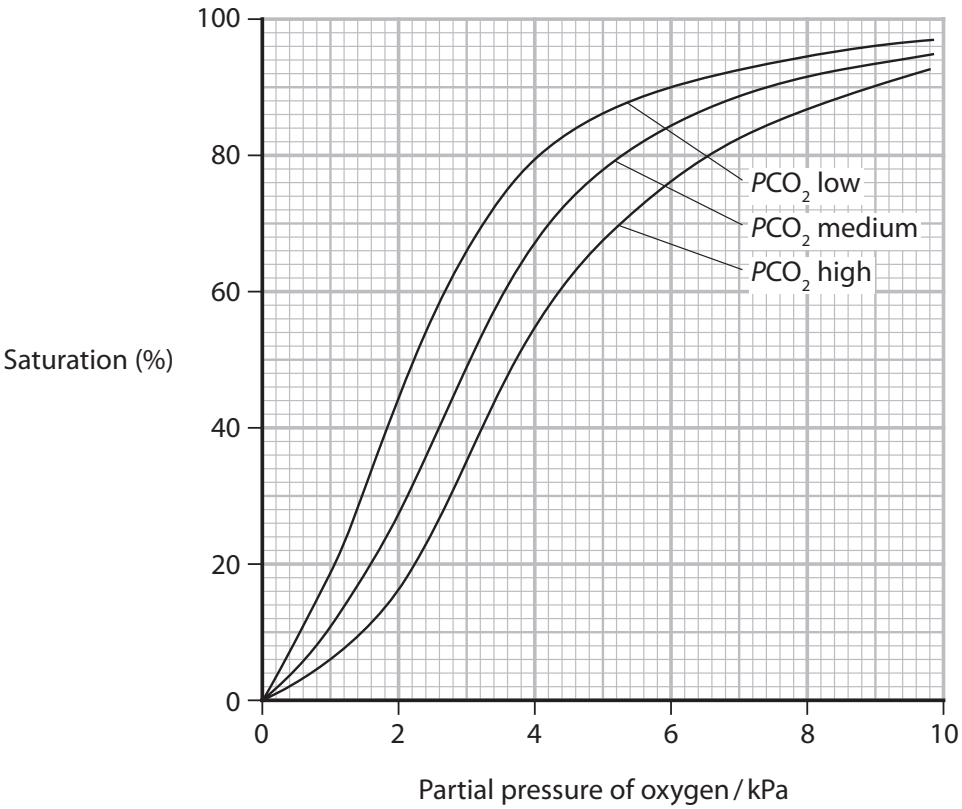
Draw a curve on the graph to show the oxygen dissociation curve of these horses.

(1)

(Total for Question 4 = 10 marks)

7 Haemoglobin transports oxygen within the blood.

The graph shows the relationship between the partial pressure of oxygen and the saturation of haemoglobin with oxygen at three partial pressures of carbon dioxide.



(a) (i) The curve moves to the right when more carbon dioxide is present.

This move to the right is due to the

(1)

- ☒ **A** Bohr effect
- ☒ **B** chloride shift
- ☒ **C** dissociation curve
- ☒ **D** oxygen debt

(ii) Explain why the curves are S-shaped.

(2)

(iii) Calculate the difference between the percentage change in saturation of haemoglobin with oxygen as the partial pressure of oxygen changes from 8 kPa to 2 kPa for low carbon dioxide compared with high carbon dioxide.

(2)

Difference ..... %

(iv) Analyse the data to explain the advantage to the mammal of the curve moving to the right.

(3)

(b) Mammals that live at high altitudes are in an environment with a lower partial pressure of oxygen.

Explain the position of the haemoglobin dissociation curve for mammals that live at high altitude.

(2)

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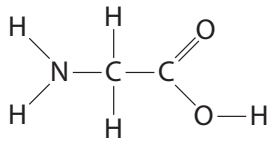
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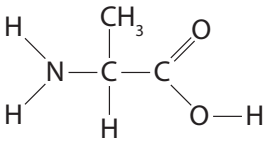
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3 The diagram shows two amino acids found in the primary sequence of collagen.



glycine



alanine

(a) (i) Which is the R-group for alanine?

(1)

- ☒ **A** CH_3
- ☒ **B** COOH
- ☒ **C** H
- ☒ **D** NH_2

(ii) Draw the products of a condensation reaction between glycine and alanine.

(2)

(iii) Describe the structure of collagen.

(3)

(b) Ehlers-Danlos syndrome is a human condition caused by a mutation in a collagen gene.

This causes changes to the elasticity and strength of arteries.

Mice were genetically modified to have this mutation.

The elastic constant and force required to break arteries from genetically modified mice and unmodified mice were measured.

The elastic constant is calculated by using the formula:

$$\text{elastic constant} = \frac{\text{force applied}}{\text{increase in length of artery}}$$

The results are shown in the table.

Artery	Elastic constant / N mm^{-1}	Force required to break artery / N
unmodified mice	0.26	2.0
genetically modified mice	0.12	1.6

(i) Calculate the force required to produce an increase in length of 0.5 cm for an artery taken from an unmodified mouse.

(1)

Answer .....

(ii) People with Ehlers-Danlos syndrome are at risk of developing aneurysms.

An aneurysm is an area of artery wall that weakens and can burst.

Explain why people with Ehlers-Danlos syndrome have a high risk of aneurysms.

(3)

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5 Haemoglobin and myoglobin are both pigments involved in the transport and storage of oxygen.

(a) Compare and contrast the structures and roles of haemoglobin and myoglobin.

(4)

*(b) Some species of mammal are able to dive underwater for long periods of time.

Table 1 shows information about the concentration of myoglobin in the muscle, the maximum duration of an underwater dive and the mean body mass of different mammal species.

Table 1

Mammal species	Mean myoglobin concentration / mg g^{-1}	Mean body mass / kg	Maximum dive time / seconds
American water shrew	11.0	0.016	24
Grey seal	54.0	240	1920
Harbour seal	61.0	112	1935
Human	6.45	62	150
Rat	1.43	0.40	20

Table 2 describes the habitats for each of these species.

Table 2

Species	Habitat
American water shrew	Semi-aquatic
Grey seal	Aquatic
Harbour seal	Aquatic
Human	Terrestrial
Rat	Terrestrial or semi-aquatic

Analyse the data to comment on the factors affecting dive time in these mammals.

(6)

5 The photograph shows a vicuna, *Lama vicugna*.



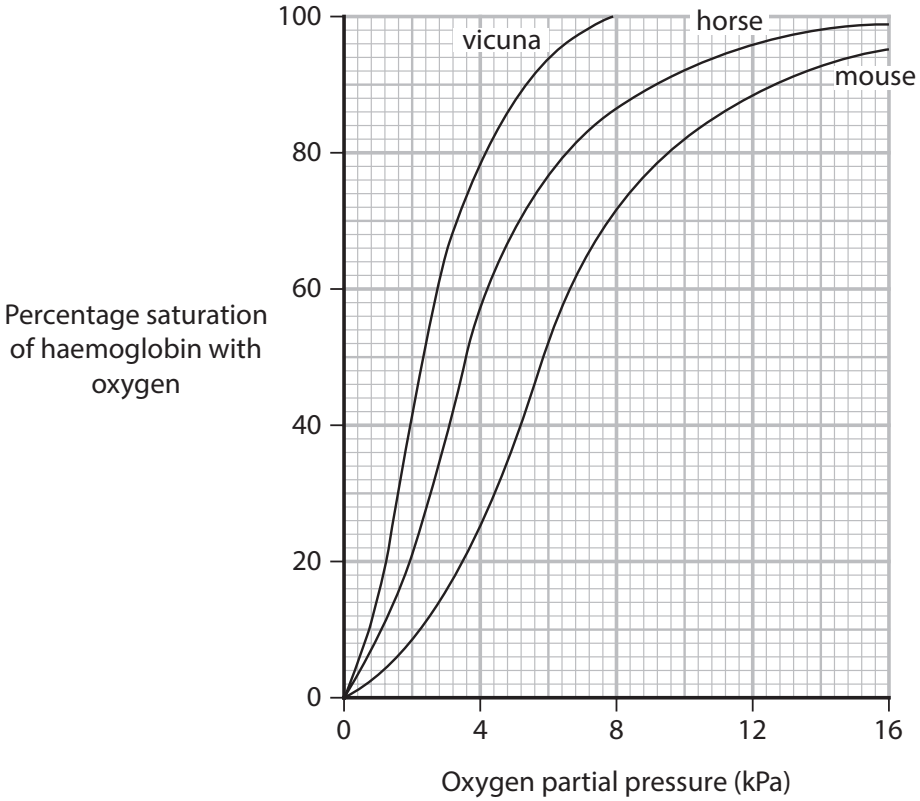
(Source: © Stefano Buttafoco/Shutterstock)

Vicunas live in high mountainous regions of South America. At high altitudes, the atmospheric pressure is low.

(a) State the genus to which this animal belongs.

(1)

(b) The graph shows the oxygen dissociation curve of haemoglobin from this animal, from a horse and from a mouse.



(i) Explain why the dissociation curves for all three animals are S-shaped.

(2)

(ii) Calculate the difference in the percentage saturation of haemoglobin for the vicuna at a partial pressure of 6 kPa and a partial pressure of 2 kPa.

(1)

Answer .....

(iii) Explain the differences in the dissociation curves of the vicuna and the horse.

(2)

(c) Llamas are closely related to vicunas but are larger and are used as pack animals to transport materials. They have an oxygen dissociation curve that is similar to that of a vicuna.

Explain the advantage of using llamas to transport heavy loads at high altitude rather than using horses.

(3)

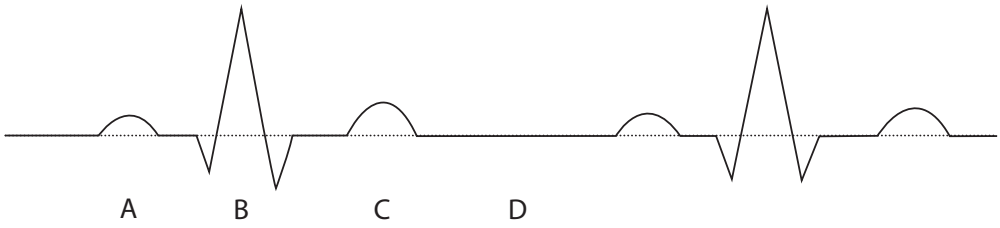
(d) Give a reason why the dissociation curve for the mouse is located to the right of the dissociation curve for the horse.

(1)

(Total for Question 5 = 10 marks)

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)

(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

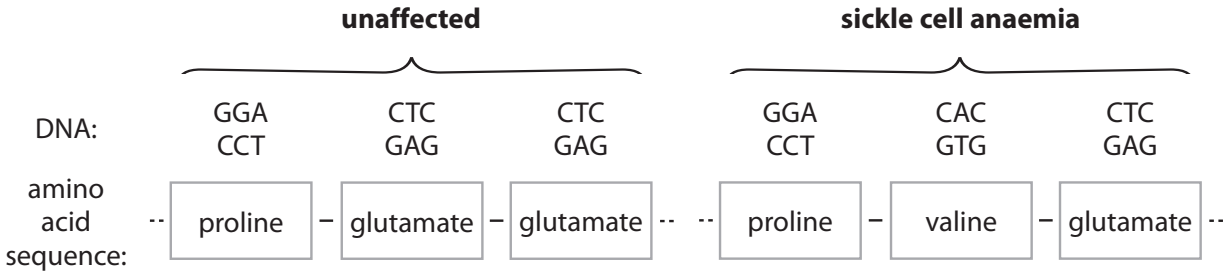
(ii) The anti-anxiety drug has a similar shape to noradrenaline.

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

(4)

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

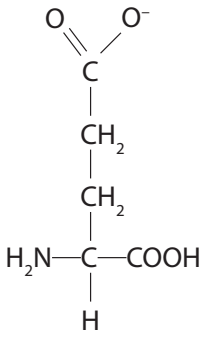
(ii) Which type of mutation has occurred to produce the allele for sickle cell anaemia?

(1)

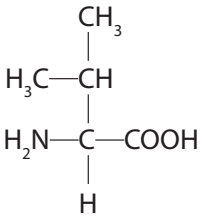
- ☒ **A** insertion
- ☒ **B** deletion
- ☒ **C** substitution
- ☒ **D** translocation

(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



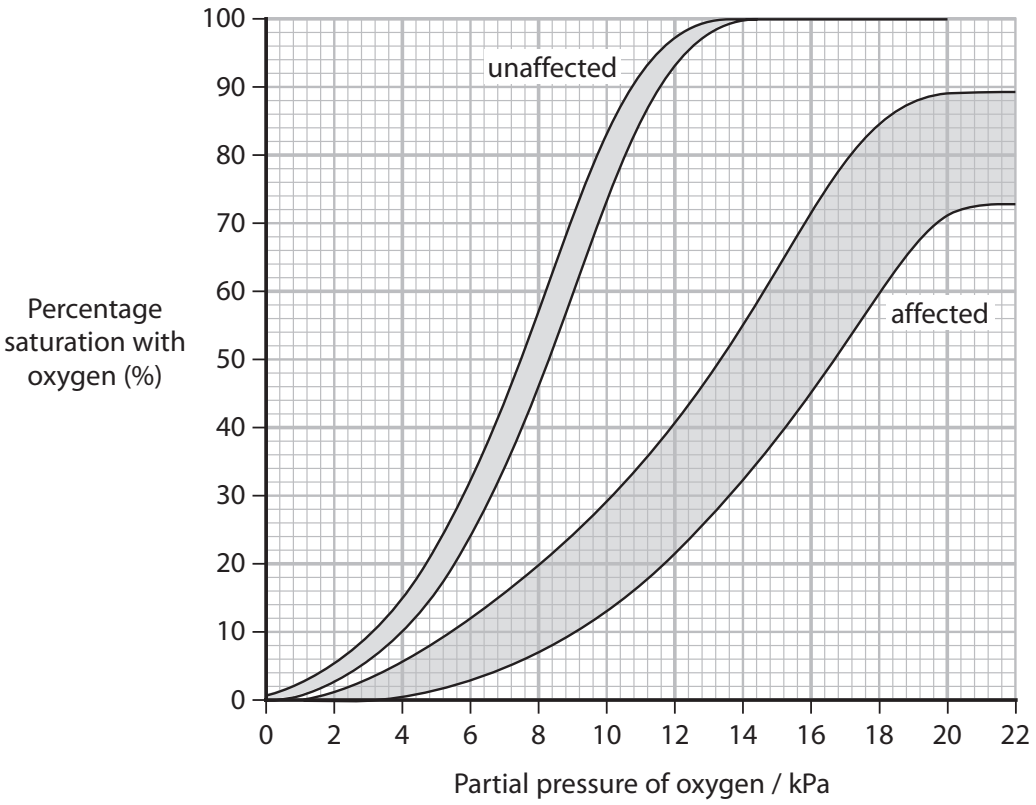
valine

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

(2)

(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)

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

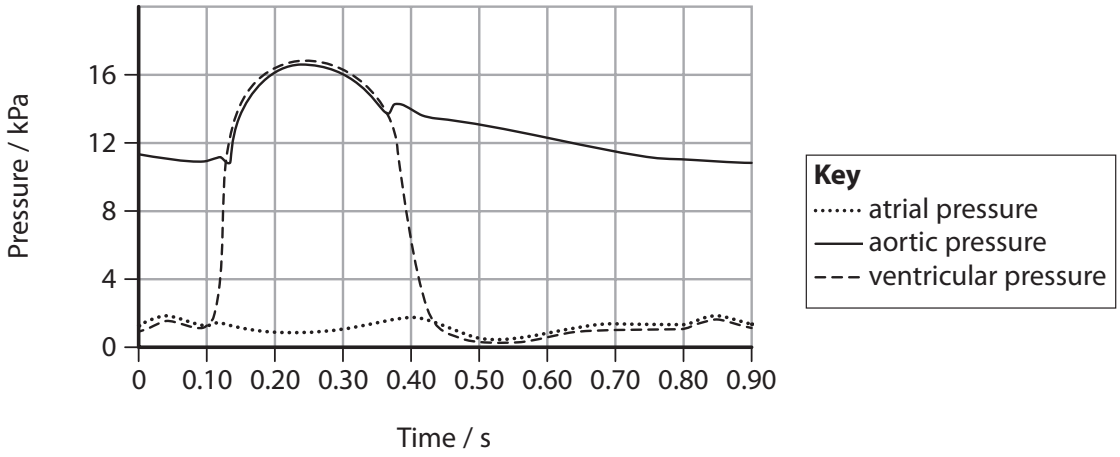
State how the graph suggests that other genes affect the phenotype of people affected by sickle cell anaemia.

(1)

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

(3)

5 The graph shows the pressure changes in the left side of the heart during one cardiac cycle.



(a) (i) Calculate the heart rate.

(1)

Answer .....

(ii) During which time period does blood leave the left ventricle?

(1)

- ☒ **A** 0.10 s to 0.13 s
- ☒ **B** 0.10 s to 0.37 s
- ☒ **C** 0.13 s to 0.37 s
- ☒ **D** 0.13 s to 0.43 s

(iii) At which time does the valve between the atrium and the ventricle close?

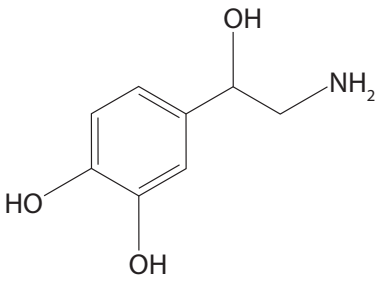
(1)

- ☒ **A** 0.10 s
- ☒ **B** 0.13 s
- ☒ **C** 0.37 s
- ☒ **D** 0.43 s

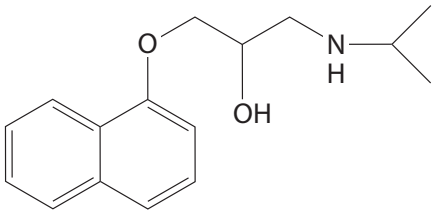
(b) Describe how myogenic stimulation brings about contraction of the atria and the ventricles.

(5)

(c) The diagram shows two chemicals that affect the human heart rate.



Noradrenaline



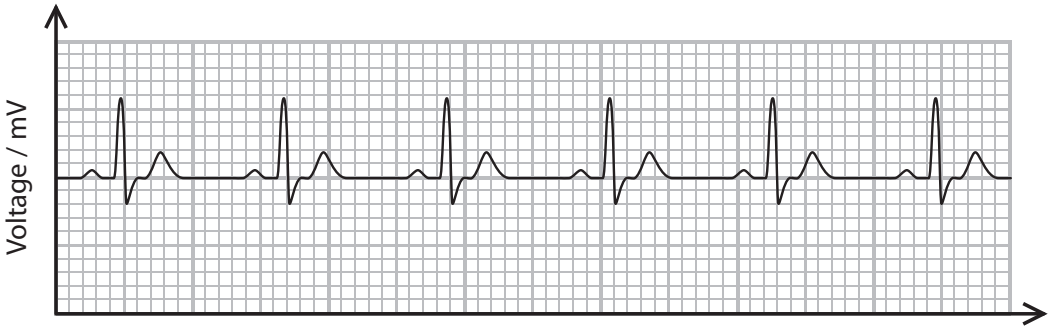
Beta blocker

Beta blockers are drugs used to regulate the heart rate of some patients.

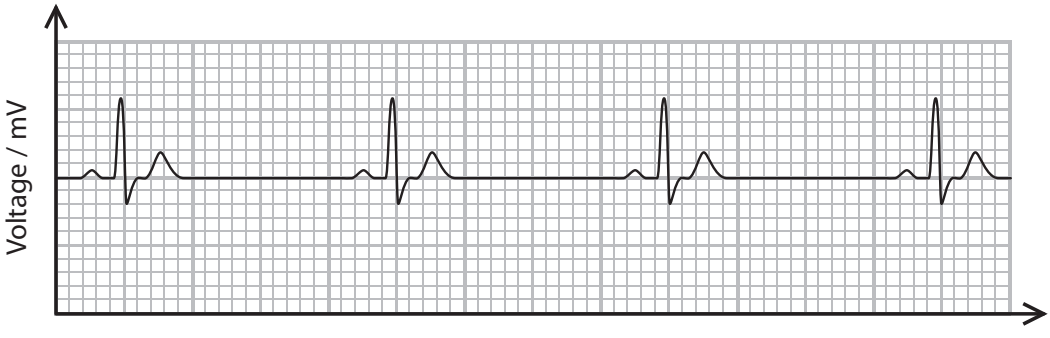
The effect of beta blockers on the heart rate during exercise was investigated.

The ECG traces show the heart rate of a person exercising before and after taking a beta blocker.

Exercise with no beta blocker



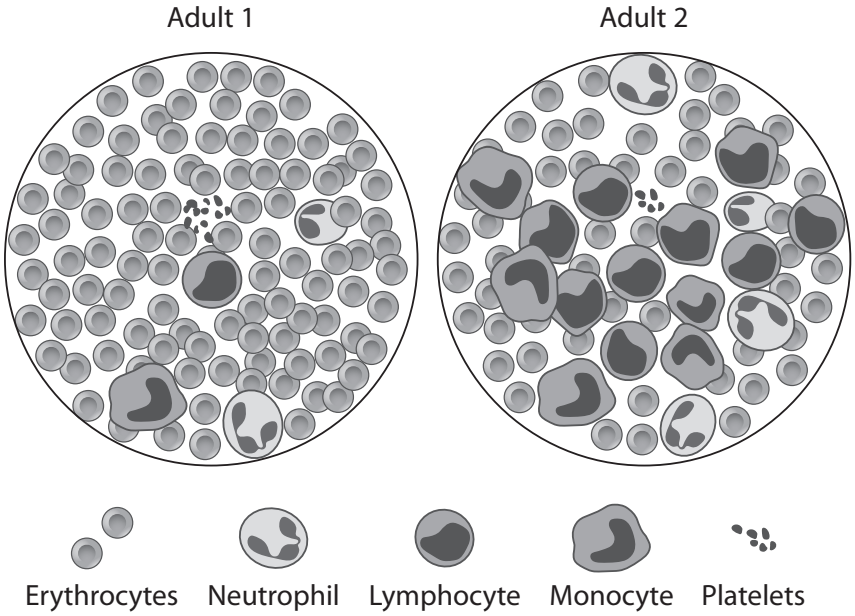
Exercise with a beta blocker



Analyse the information to explain the results of this investigation.

(3)

3 The diagrams show blood samples from two adult patients as seen using a microscope.



(a) (i) The diameter of the monocyte in Adult 1 is 20 μm.

Calculate the magnification of the blood sample.

(2)

Answer .....

(ii) Compare and contrast the blood sample from Adult 1 with the blood sample from Adult 2.

(3)

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(iii) Explain the likely causes of the differences seen in the sample from Adult 2.

(2)

(iv) Give one assumption that is made to enable a valid comparison between these two samples.

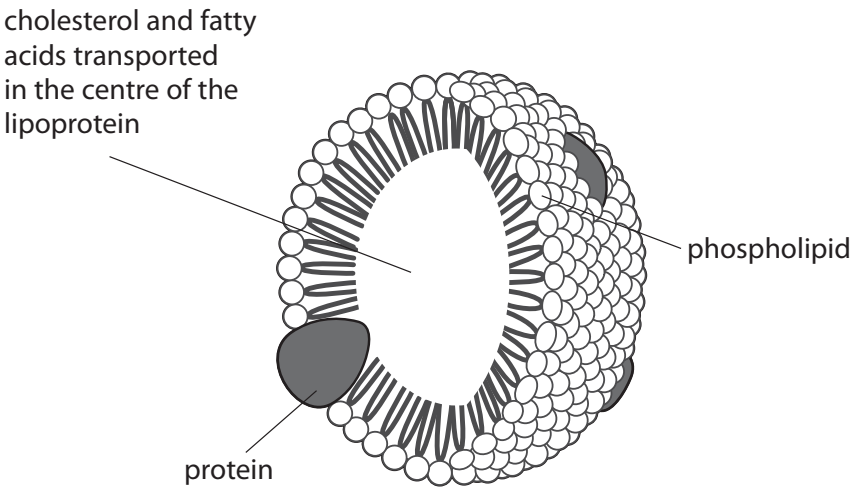
(1)

(b) Explain why Adult 2 had symptoms of tiredness.

(3)

7 High density and low density lipoproteins are spherical structures that transport cholesterol and fatty acids in the bloodstream.

The diagram shows a lipoprotein.



(a) Explain why the properties of lipoproteins enable cholesterol and fatty acids to be transported in the bloodstream.

(3)

(b) The table shows some information about two types of lipoprotein, high density lipoprotein (HDL) and low density lipoprotein (LDL).

Information about lipoproteins	HDL	LDL
density range / g cm^{-3}	1.063 to 1.210	1.019 to 1.063
typical diameter / nm	8	22
typical volume / nm^3	268	
percentage of protein (%)	50	20

(i) Complete the table to show the volume of a typical LDL using the formula:

$$\frac{4}{3}\pi r^3 \quad \text{where } \pi = 3.14$$

(2)

(ii) Analyse the information to explain why LDLs have a lower density range than HDLs.

(2)

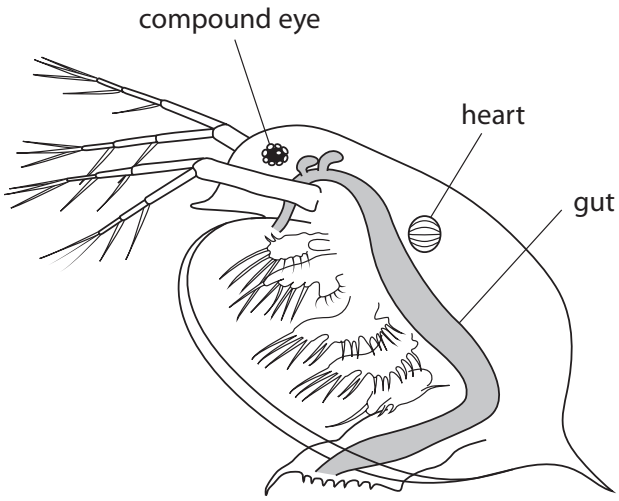
(iii) Explain why raised levels of LDLs may increase the risk of heart disease.

(4)

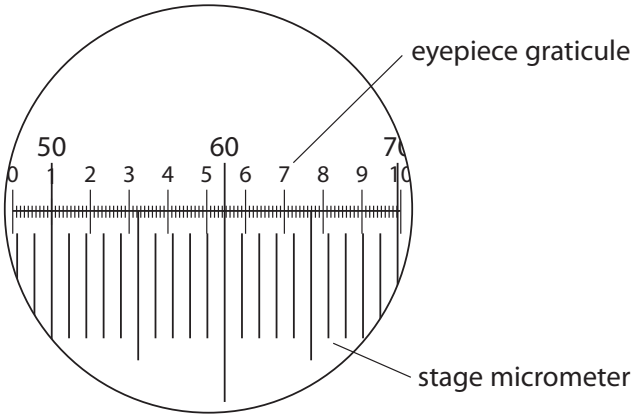
3 Water fleas are small animals that live in pond water.

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)

.....

.....

(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

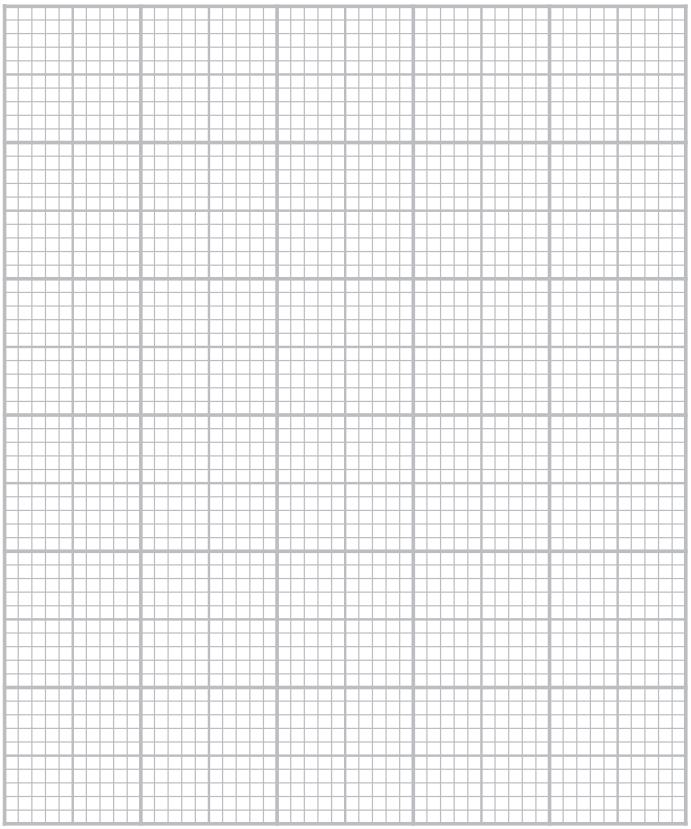
$$SD = \sqrt{\frac{\sum (X - \bar{X})^2}{n - 1}}$$

(2)

Answer .....

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

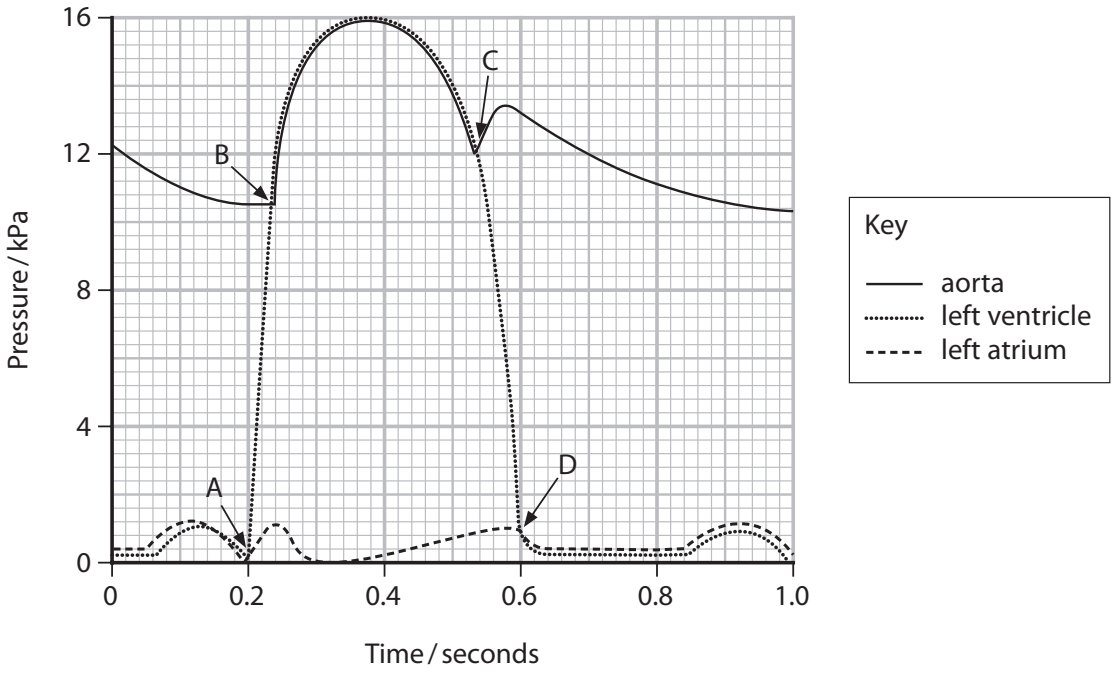
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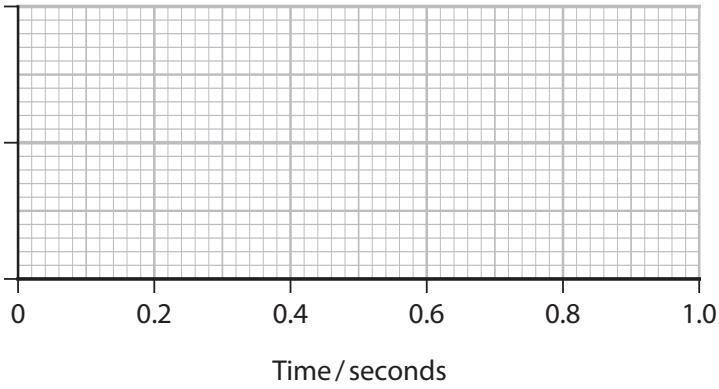


(iii) Explain why abiotic variables should be controlled in this investigation.

(2)

7 The graph shows the pressure changes in the left side of the heart and in the aorta during the cardiac cycle.





(a) (i) Draw, on the blank grid, an ECG recording for this cardiac cycle and label the parts P, Q, R, S and T.

(2)

(ii) Determine how many cardiac cycles there are in one minute, using the graph.

(1)

Answer .....

(b) Explain what is happening at each point, labelled A, B, C and D, on the graph.

(4)

(c) Describe the myogenic stimulation of the heart.

(4)

8 The production of tissue fluid is vital for cells in the human body.

(a) (i) Explain why the production of tissue fluid is vital for cells in the human body.

(2)

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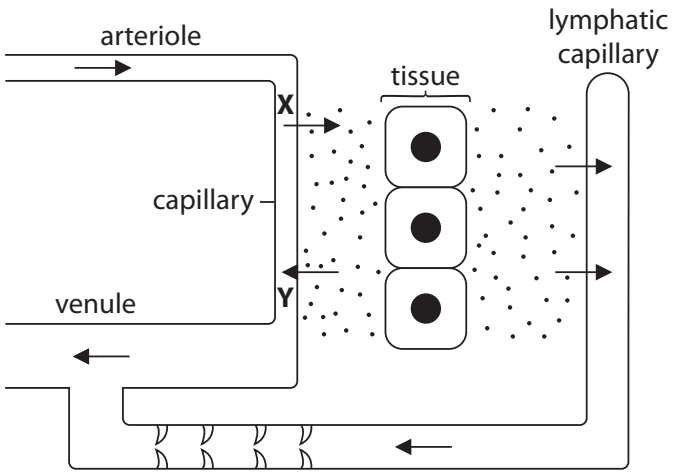
(ii) Tissue fluid makes up 16% of the mass of a human body.

Calculate the mass of tissue fluid, in grams, that would be found in a person with a mass of 80 kg.

(2)

Answer ..... g

(b) The diagram shows the production and circulation of tissue fluid.



(i) Which of the following describes the pressures at **X** and **Y** in the diagram?

(1)

	Blood hydrostatic pressure / kPa		Plasma oncotic pressure / kPa	
	At X	At Y	At X	At Y
☒ **A**	3.3	2.0	3.3	2.0
☒ **B**	3.3	3.3	4.7	2.0
☒ **C**	4.7	2.0	3.3	3.3
☒ **D**	4.7	3.3	2.0	3.3

(ii) Compare and contrast the transport of fluid in a vein with its transport in a lymph vessel.

(2)

(c) In some parts of the world, mosquito bites can infect people with roundworms called *Wuchereria bancrofti*.

The roundworms block lymph vessels and prevent proteins in tissue fluid entering the lymph vessels.

This causes a disease called lymphatic filariasis (LF). One symptom of LF is swelling of the legs.

Which of the following explains why someone with LF has swollen legs?

(1)

☒ **A** turgor pressure in blood is higher than in tissues

☒ **B** turgor pressure in blood is lower than in tissues

☒ **C** oncotic pressure in blood is higher than in tissues

☒ **D** oncotic pressure in blood is lower than in tissues

(d) The World Health Organisation (WHO) considers LF to be a global health problem affecting over 120 million people in 73 countries.

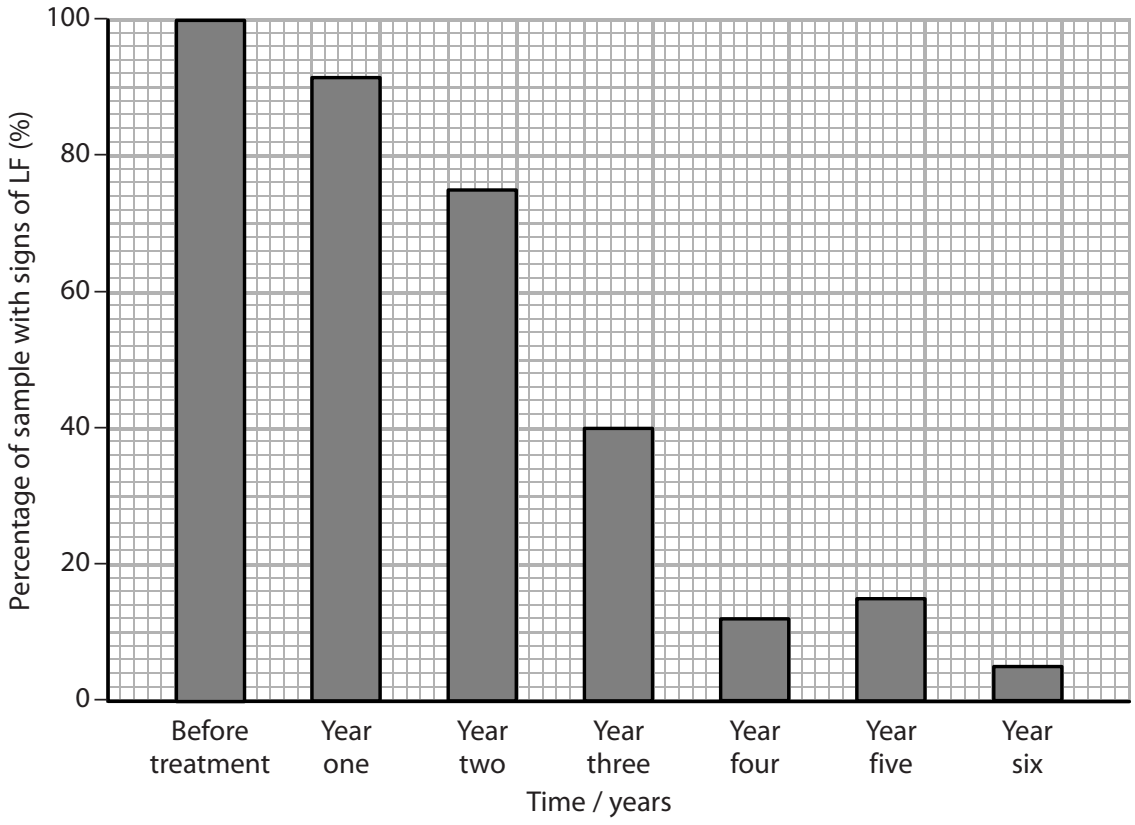
Scientists investigated whether drug treatment could protect people from LF.

All the people in one area were given drugs to kill the roundworms that cause LF.

This was done every year for six years.

Each year, a sample of five hundred people was randomly selected and tested for signs of LF.

The graph shows the results of this investigation.



The scientists claimed that LF could be eradicated by using this drug treatment.

Analyse the data to criticise this claim.

(4)

8 The photograph shows a glacier that is melting. As the glacier gradually melts, it leaves behind bare rock.



(Source: © CHARLES D. WINTERS/SCIENCE PHOTO LIBRARY)

Scientists sampled the soil from areas that had been uncovered for different lengths of time after the glacier ice had melted.

The table shows the results from the samples.

Length of time since glacier melted / years	Soil depth / cm	Mass of nitrate in soil / mg m^{-2}	Mass of leaf litter that falls to ground each year / g m^{-2} yr^{-1}
5	5.2	3.8	1.5
15	6.4	4.1	1.7
40	7.0	5.3	12.8
100	9.2	21.8	277.0
150	10.8	35.4	335.0
200	15.1	53.3	277.0
250	16.2	61.4	261.0

(a) Which of the following should be used to determine if there is an association between length of time since the glacial ice has melted and soil depth?

(1)

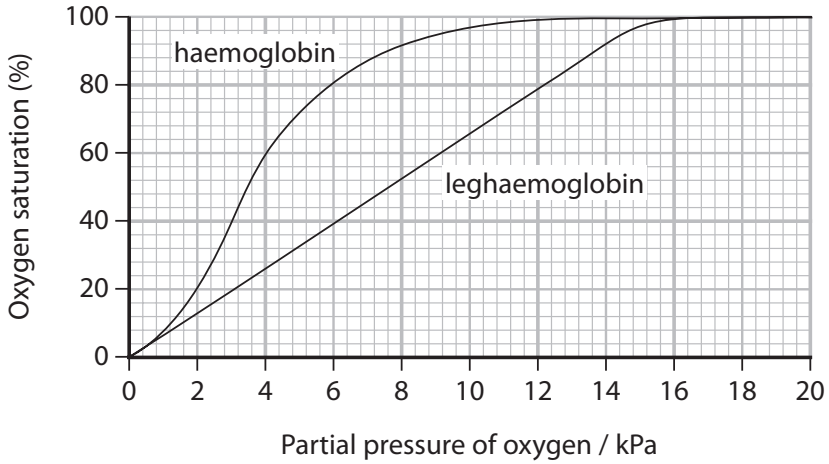
- ☒ **A** chi squared
- ☒ **B** correlation coefficient
- ☒ **C** standard deviation
- ☒ **D** t-test

(b) Explain how succession brings about the changes in the soil during this period of time.

(5)

(c) The roots of some of the plants growing around the glacier were found to contain an oxygen binding protein called leghaemoglobin.

The graph shows the oxygen dissociation curve for leghaemoglobin and the oxygen dissociation for haemoglobin.



(i) Leghaemoglobin is a protein that is similar in structure to myoglobin. Both of these proteins have one subunit.

Explain how the oxygen dissociation curve shows that the structure of leghaemoglobin is more similar to myoglobin than to haemoglobin.

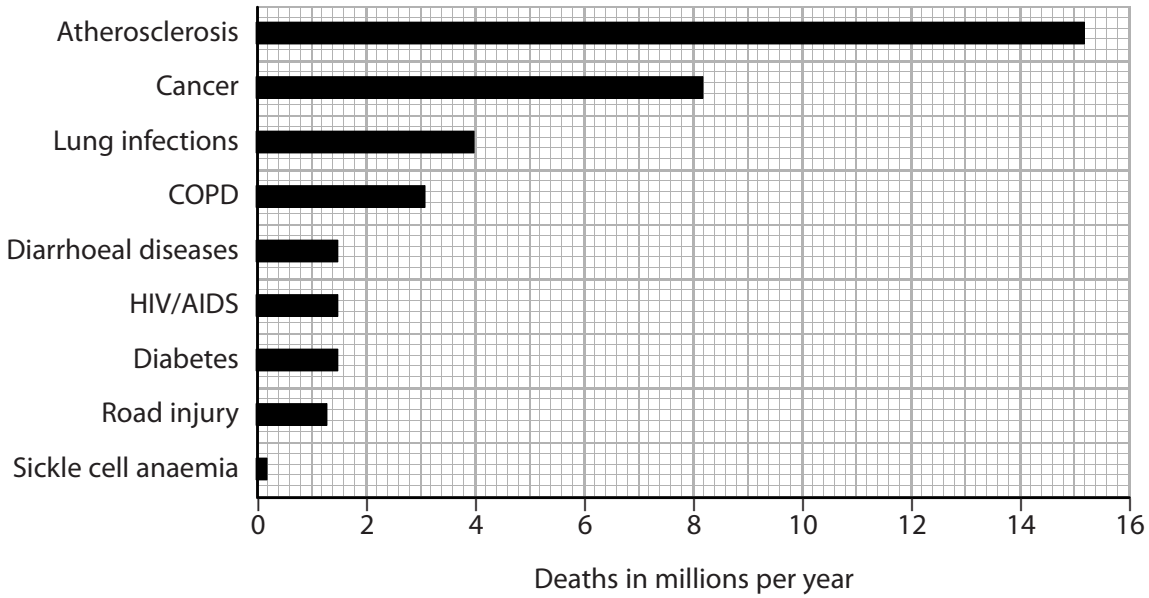
(3)

(ii) Explain how leghaemoglobin enables these plants to grow in waterlogged and compact soils.

(3)

8 There are many disorders that affect the health of people.

The graph shows the number of people in the world who die each year from different health disorders.



(a) The graph shows that atherosclerosis kills more people than any of the other disorders.

This is mainly due to its development in the coronary arteries.

(i) State the number of deaths caused by atherosclerosis.

Give your answer in standard form.

(1)

Answer .....

(ii) Describe how atherosclerosis develops in the coronary arteries.

(3)

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*(b) Some health disorders, such as sickle cell anaemia, have a genetic basis.

People who are at risk of these disorders can be identified using genetic tests.

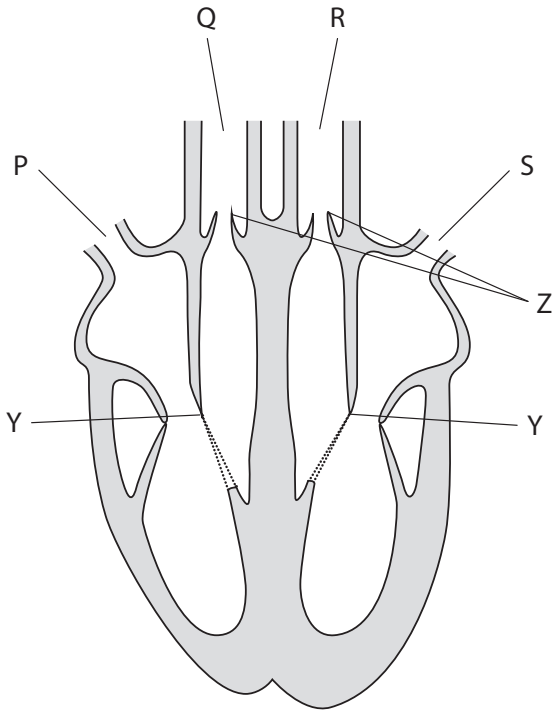
Hospital managers need to predict the future cost of treating people with health disorders.

It has been claimed that the Hardy-Weinberg equation ($p + q = 1$ or $p^2 + 2pq + q^2 = 1$) could be used to predict the number of people who would need treatment for health disorders.

Discuss the validity of this claim.

(9)

7 The diagram shows a human heart and blood vessels.



(a) (i) Give **one** reason why the heart is divided into left and right sides.

(1)

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(ii) State why there is a difference in the thickness of the muscle of the atria and the muscle of the ventricles.

(1)

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(b) (i) Which blood vessel carries deoxygenated blood towards the heart?

(1)

- ☒ **A** P
- ☒ **B** Q
- ☒ **C** R
- ☒ **D** S

(ii) Which describes the state of the valves at Y and Z when the ventricles are in systole?

(1)

- ☒ **A** Y closed and Z closed
- ☒ **B** Y closed and Z open
- ☒ **C** Y open and Z closed
- ☒ **D** Y open and Z open

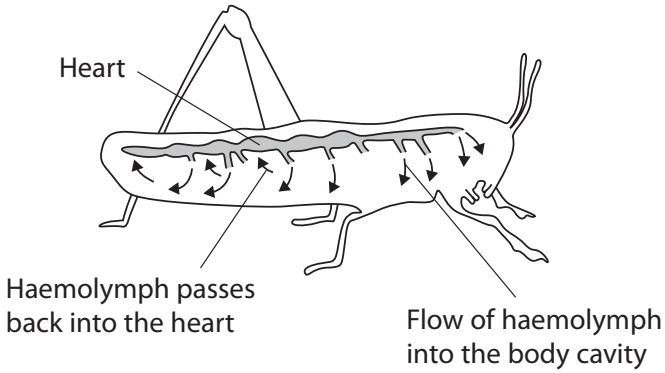
(c) Describe how the structure of blood vessel R differs from the structure of blood vessel S.

(3)

(d) The heart of an insect is a long tube with valves. It pumps fluid, called haemolymph, into the body cavity so that fluid bathes the body cells.

The haemolymph then passes back into the heart from the body cavity.

The diagram illustrates the circulatory system of an insect.



(i) Compare and contrast the structure of the circulatory system of an insect with the structure of the circulatory system of a mammal.

(4)

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(ii) Give **two** substances that are carried in the haemolymph for the growth of an insect.

(2)

1 .....

2 .....

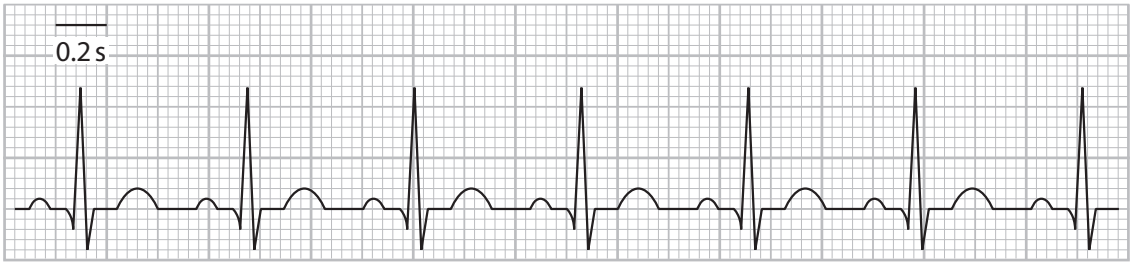
(Total for Question 7 =13 marks)

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

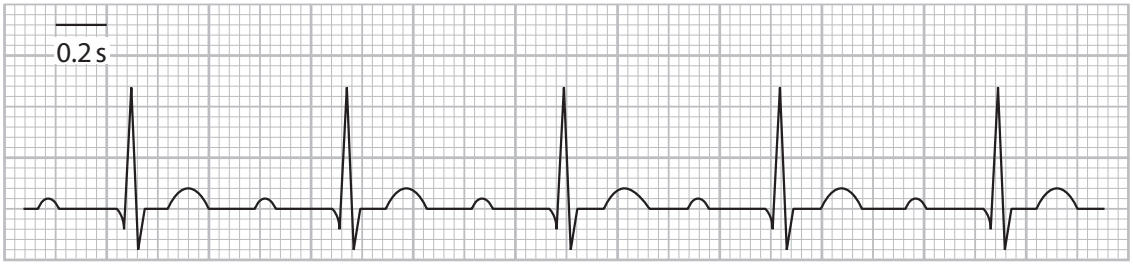
(2)

(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

(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)

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(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)

9 Coronary heart disease is a major cause of death in Europe.

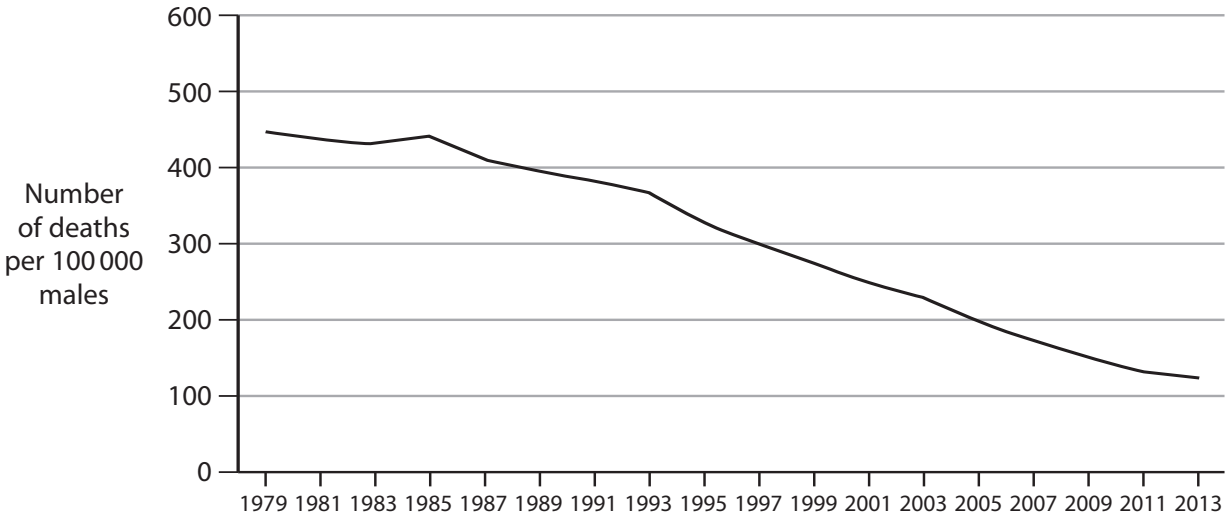
(a) Explain how atherosclerosis can cause coronary heart disease and can lead to death.

(4)

*(b) The table shows the change in the number of deaths from coronary heart disease in males and females in some European countries, and the whole of Europe, between 1990 and 2019.

Country or region	Number of deaths per 100 000 of population		Percentage change from 1990 to 2019 (%)
	1990	2019	
Albania	389	314	–19
Bulgaria	701	541	–23
France	196	91	–53
Montenegro	418	436	+4
Republic of Ireland	357	133	–63
UK	314	132	–58
Europe (all countries)	393	242	–38

The graph shows the number of deaths of males, per 100 000, from coronary heart disease in the UK from 1979 to 2013.



It has been suggested that the change in deaths from coronary heart disease in the UK is due to improved lifestyle choices, and that coronary heart disease could be reduced to almost zero in the UK if people made better choices.

Discuss the validity of this suggestion.

Use the data and your own knowledge to support your answer.

(9)

10 The Northern elephant seal is a mammal found in the Eastern Pacific Ocean.



In the nineteenth century, Northern elephant seals were hunted and this reduced the population to about 20 seals.

The seals were listed as an Appendix II species when CITES was established in the 1970s.

The population has now recovered to over 100 000 individuals.

The seals in this population have developed health problems, including a high mortality rate for newborn pups, deformities and weak immune systems.

(a) (i) Describe the role of treaties such as CITES in maintaining global biodiversity.

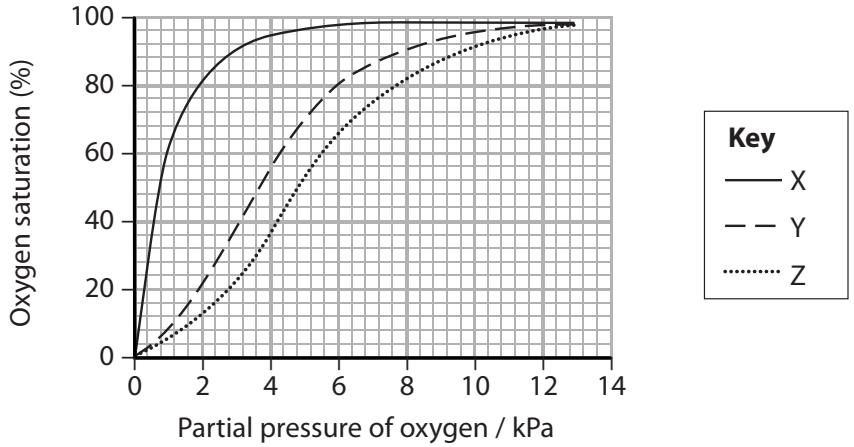
(2)

(ii) Explain why, although the population of seals has recovered, many of the seals have health problems.

(2)

(b) Northern elephant seals have a high concentration of haemoglobin in their blood.

The graph shows the oxygen dissociation curves for myoglobin, adult haemoglobin and fetal haemoglobin.



Which of the rows correctly matches each curve with myoglobin, adult haemoglobin and fetal haemoglobin?

(1)

	Myoglobin	Adult haemoglobin	Fetal haemoglobin
☒ **A**	X	Y	Z
☒ **B**	X	Z	Y
☒ **C**	Y	Z	X
☒ **D**	Z	X	Y

(c) Northern elephant seals are able to dive to great depths and hold their breath for up to two hours.

The tables show data for four diving mammals.

Species	Maximum time holding breath / min	Maximum diving depth / m	Mass of animal / kg
bottlenose dolphin	5	20	200
harbour seal	17	19	24
Weddell seal	82	400	400
Northern elephant seal	119	437	400

Species	Volume of oxygen in body / $cm^3\ kg^{-1}$	Concentration of haemoglobin in blood / $g\ dm^{-3}$	Total blood volume / $cm^3\ kg^{-1}$	Percentage of stored oxygen in different body tissues		
				lungs	blood	muscle
bottlenose dolphin	36	14	71	34	27	39
harbour seal	57	21	132	13	54	33
Weddell seal	87	210	173	5	66	29
Northern elephant seal	97	216	207	4	71	25

(i) Calculate the total mass of haemoglobin in a Northern elephant seal.

(3)

Answer .....

*(ii) Analyse the data to explain how marine mammals are adapted for diving.

(6)

7 Increased blood pressure is one risk factor associated with atherosclerosis.

A study investigated the effect of aspirin on the risk of having a heart attack or a stroke.

In the study, which lasted 10 years, 12 000 adults with one or more risk factors for atherosclerosis were used.

The adults were split into two equal sized groups.

Each adult in one group was given 100 mg of aspirin every day and each adult in the other group was given a placebo.

The list shows the results of this study:

- 4.29% of the people who received aspirin died
- 4.48% of the people who received the placebo died
- there was no effect on the incidence of strokes
- people who took the aspirin experienced twice the bleeding into the digestive system compared with people in the placebo group
- the numbers of people with bleeding into the digestive system in both groups was low.

(a) (i) Explain how increased blood pressure increases the risk of atherosclerosis.

(4)

(ii) Describe how **three** factors, other than increased blood pressure, can increase the risk of atherosclerosis.

(3)

(iii) Calculate the total number of people who died in this study.

(2)

Answer .....

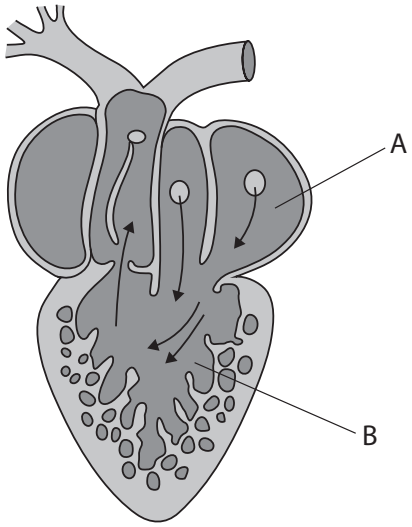
(b) Discuss whether patients at risk of a heart attack or stroke should take a 100 mg dose of aspirin every day.

(5)

5 The structure of a frog heart is different from those of mammals and fish.

The diagram shows the structure of a frog heart.

The arrows show the direction of blood flow.



(a) (i) Name the parts of the heart labelled A and B.

(2)

A .....

B .....

(ii) Compare and contrast the structure of the frog heart with the structure of the mammalian heart.

(3)

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(b) Amphibians, such as the frog:

- absorb oxygen through their lungs and through their moist skin
- have a lower metabolic rate than mammals
- have a double circulation system.

(i) State one difference between the double circulation system of the frog and that of the mammal.

(1)

(ii) Explain how the circulatory system of the frog is adapted for the metabolism and gas exchange of the frog.

(4)

(c) Describe the sequence of stimulation that occurs in a mammalian heart in one cardiac cycle.

(4)

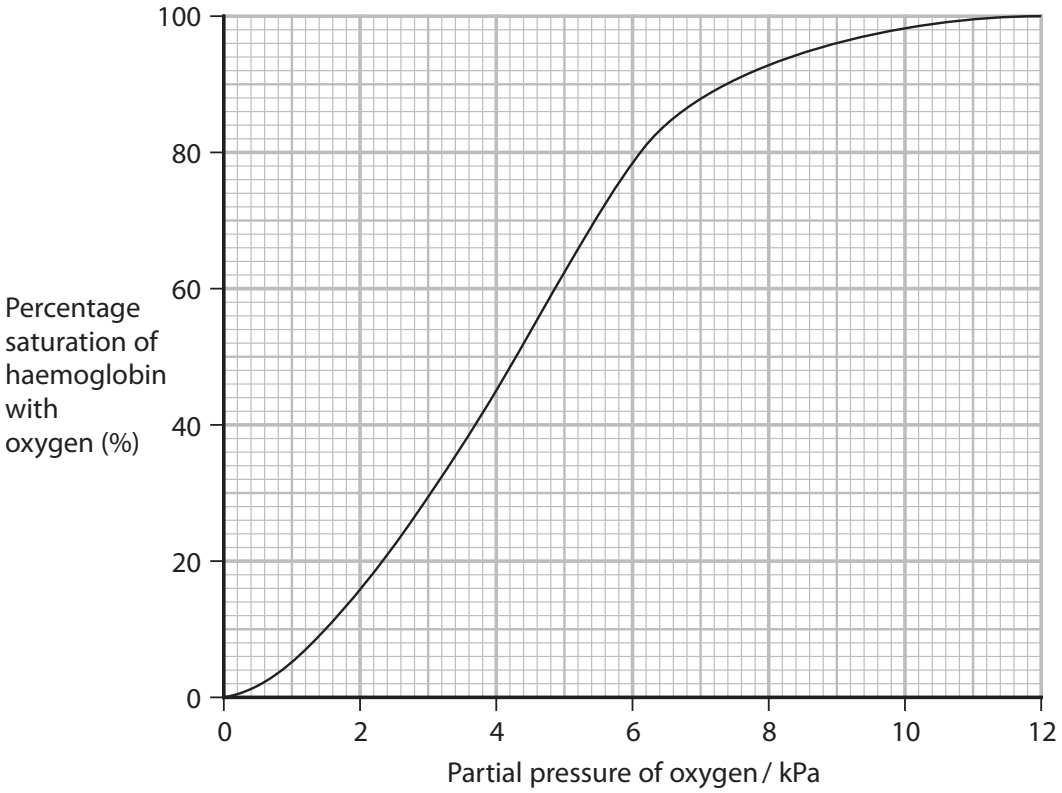
8 Haemoglobin transports oxygen around the human body.

(a) (i) Explain how the structure of haemoglobin enables it to combine with oxygen in the blood vessels of the lungs.

(3)

(ii) The partial pressure of carbon dioxide affects how readily haemoglobin picks up and releases oxygen.

The graph shows an oxygen dissociation curve for haemoglobin in blood in the lungs.



The oxygen dissociation curve for haemoglobin in blood in the tissues of respiring muscle is different.

Sketch this curve onto the axes.

(1)

(iii) Explain the advantage of this change in the position of the oxygen dissociation curve.

(2)

(b) Beta thalassaemia is an inherited condition affecting the gene for beta-globin (HBB gene).

People with beta thalassaemia have less or no beta-globin.

The most common form is a recessive condition caused by a mutation in the HBB gene.

(i) State the probability that two parents who are heterozygous for this condition would have a child who has beta thalassaemia.

(1)

(ii) Explain why a person who is heterozygous does not show the symptoms of beta thalassaemia.

(2)

(c) Overall, the proportion of people with beta thalassaemia is 30 in 1000.

In some parts of the world it is much higher.

In one Mediterranean island, 280 in 1000 people have beta thalassaemia.

(i) Calculate the probability that a person on this island is heterozygous for beta thalassaemia.

Use the Hardy–Weinberg equation

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

Give your answer to two significant figures.

(3)

Answer .....

(ii) Give **two** reasons why this value may not be accurate.

(2)

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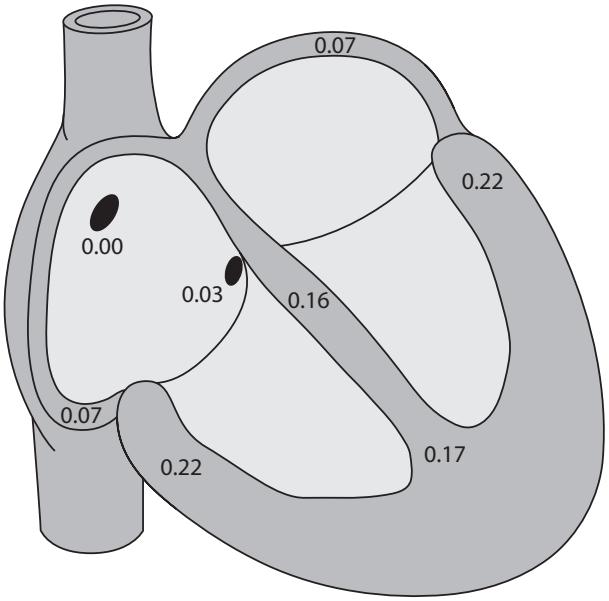
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9 The diagram shows the time taken in seconds for an impulse to travel through the human heart.



(a) Analyse the information to explain how the times shown in the diagram relate to the cardiac cycle.

(5)

(b) The mean heart rate of this heart was 72 beats per minute.

Calculate how long the ventricles are relaxed during one cardiac cycle.

(2)

Answer ..... s

(c) The effect of exercise on the pH of blood plasma and heart rate was investigated.

The investigation used a sample of three people.

The table shows the results of the investigation before and after excercise.

Activity	Mean pH of blood plasma	Mean heart rate / beats min^{-1}
Rest	7.4	72
Exercise	7.2	94

(i) Analyse the data to explain how the pH of blood plasma affects heart rate.

(4)

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(ii) There were errors in the design of this investigation that reduced the validity of the data.

Explain how this investigation should have been designed to ensure the data was valid.

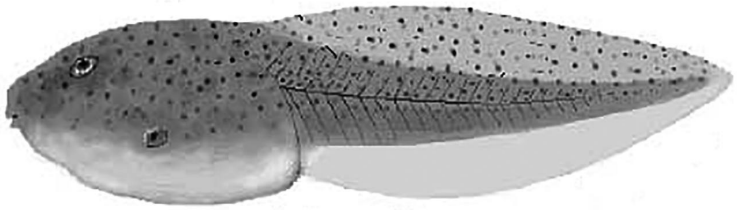
(4)

11 The adult American bullfrog, *Rana catesbeiana*, can live in water or on land.

Adult frogs lay eggs in water where they are fertilised.

The fertilised eggs develop into tadpoles that live only in water.

The photograph shows a tadpole.



(a) State the domain to which *Rana catesbeiana* belongs.

(1)

(b) Adult frogs use lungs for gas exchange but tadpoles use gills.

Explain how gills are adapted for gas exchange.

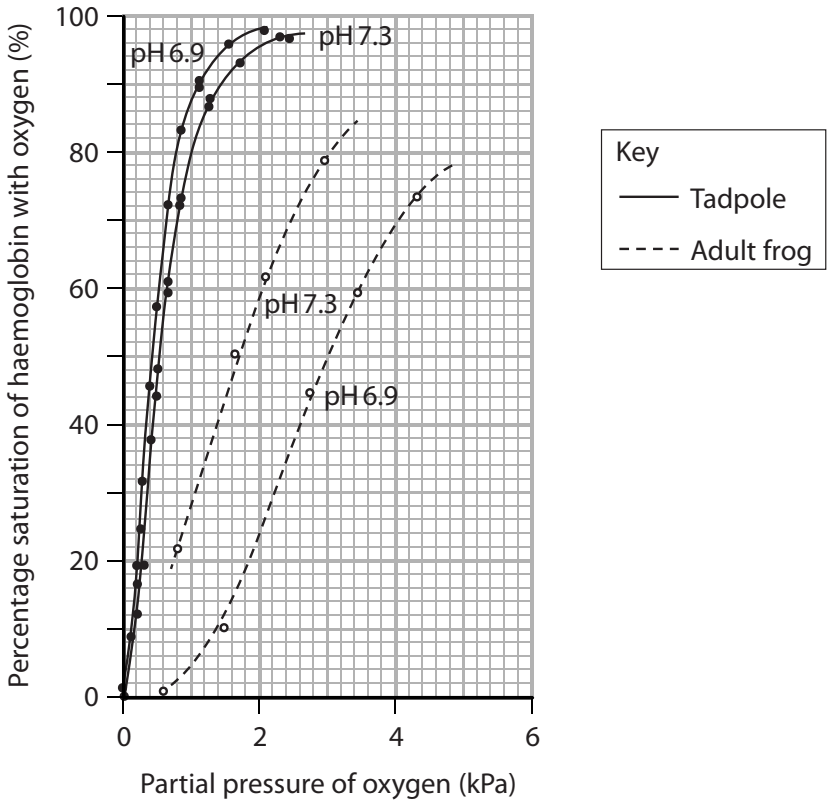
(3)

(c) (i) Human activity can cause pollution that reduces the oxygen concentration in water.

Explain why a low oxygen concentration in the water would lower the pH of the blood of the tadpole.

(3)

*(ii) The graph shows the effect of pH on the oxygen dissociation curves of haemoglobin for adult frog blood and tadpole blood.

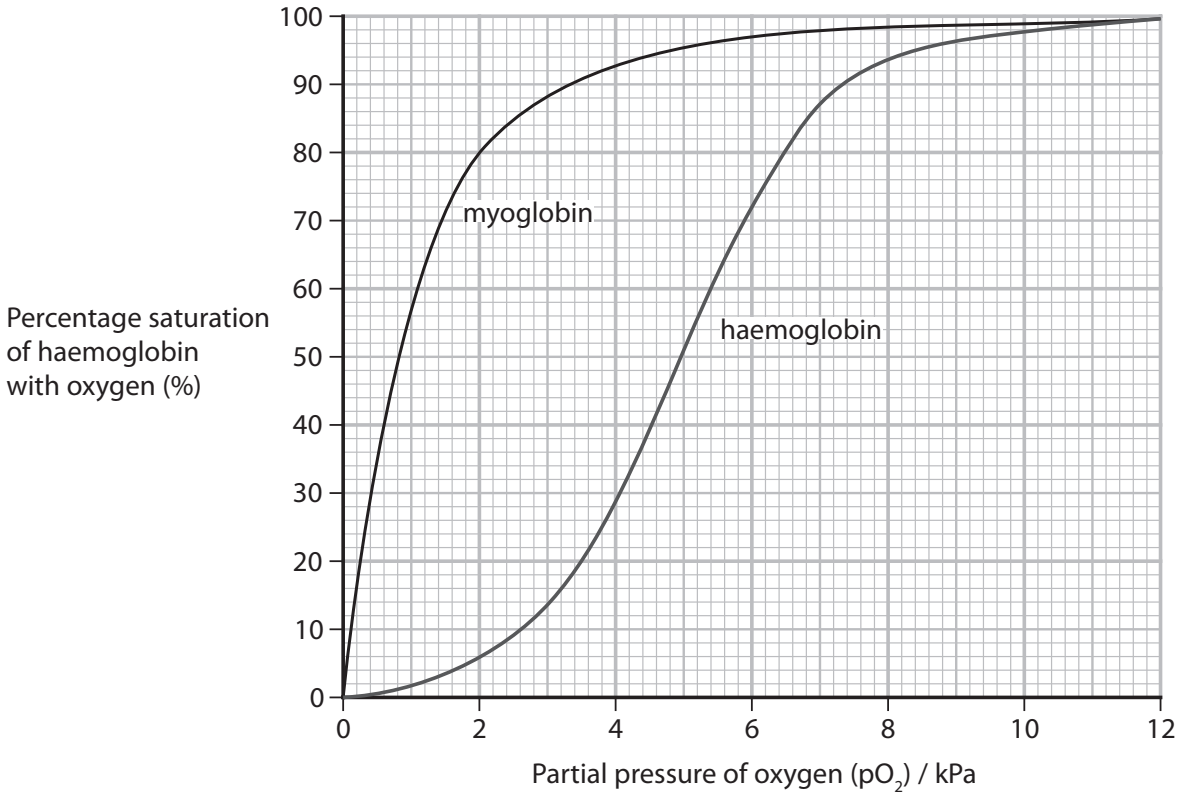


The adult frog can either live on land or in water. The tadpole always lives in water.

Discuss how the shape and position of the dissociation curves reflect the habitat in which these animals live.

(9)

8 The graph shows the oxygen dissociation curves of human haemoglobin and human myoglobin.



(a) (i) Calculate the volume of oxygen bound to haemoglobin at a partial pressure of oxygen of 6 kPa in 100 cm^3 blood.

The concentration of haemoglobin is 15 g per dm^3 blood.

When fully saturated, there is 1.36 cm^3 oxygen per g of haemoglobin.

(3)

Answer .....

(ii) Explain why the oxygen dissociation curves for haemoglobin and myoglobin are different.

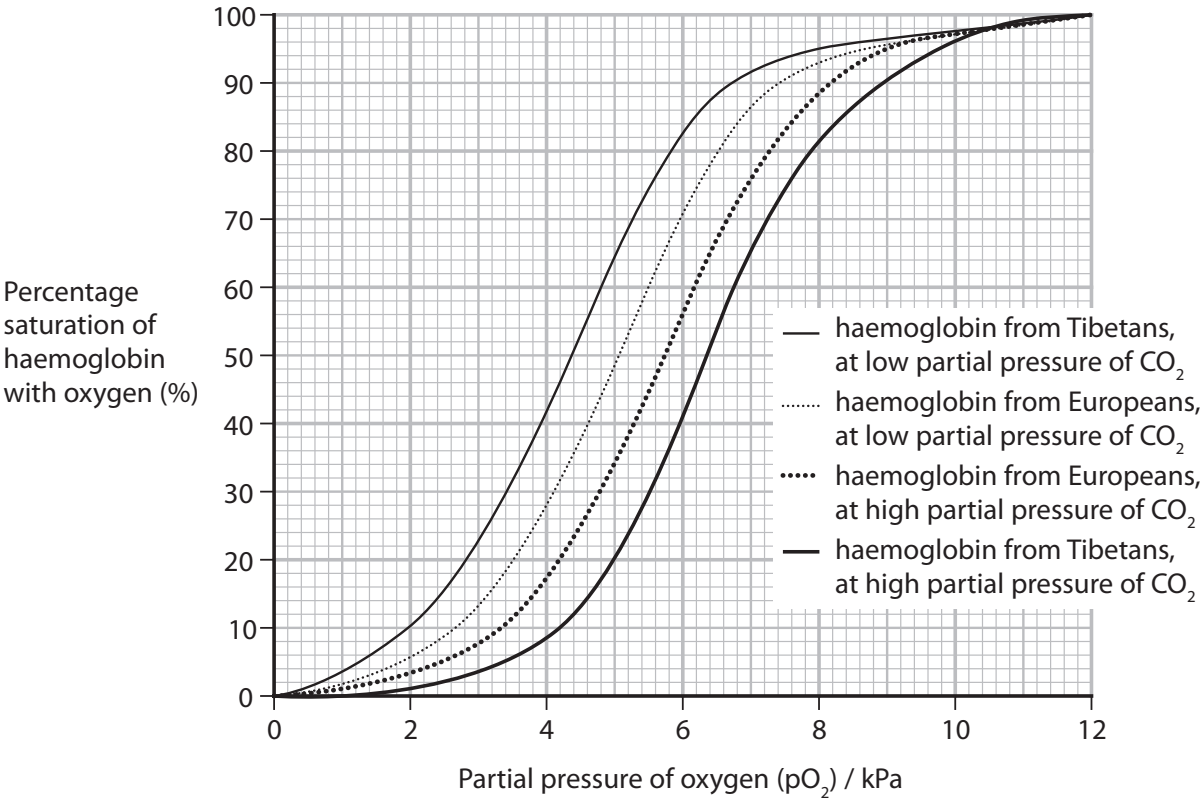
(4)

(b) In an investigation, the oxygen dissociation of haemoglobin from Tibetan people and European people was compared.

The Tibetan people were living at high altitude.

The European people were living at low altitude.

The graph shows the results of this investigation.



Comment on the oxygen dissociation curves of the Tibetan people.

(4)

(c) Tibetan populations have a recessive allele that helps them to survive at high altitude.

In a village in Tibet, 1950 people out of a population of 2500 people carry two copies of this allele.

(i) Calculate the number of heterozygous people in the village.

Use the Hardy-Weinberg equation

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

(3)

Answer .....

(ii) This allele is currently found only in human populations in Tibet.

The allele has also been found in the fossil bones of an extinct form of modern humans called the Denisovans.

Fossils of Denisovans have been found in Tibet.

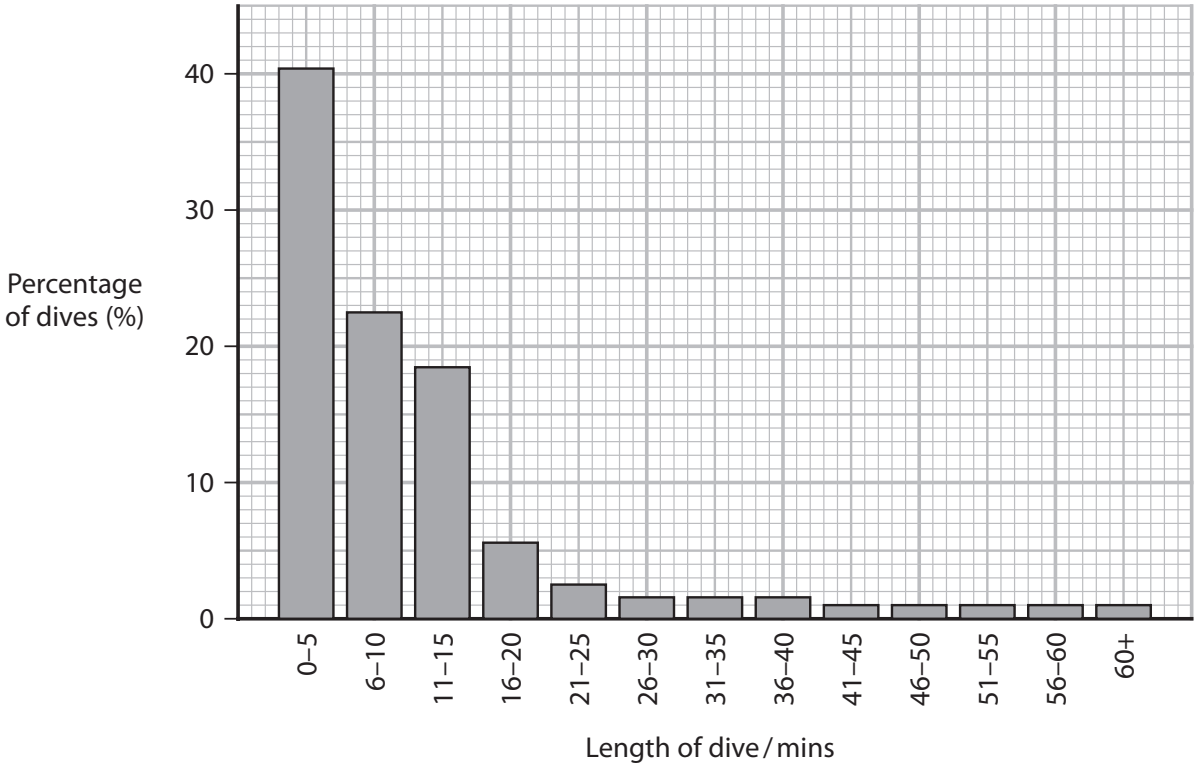
Explain why scientists think that the Denisovans belonged to the same species as modern humans.

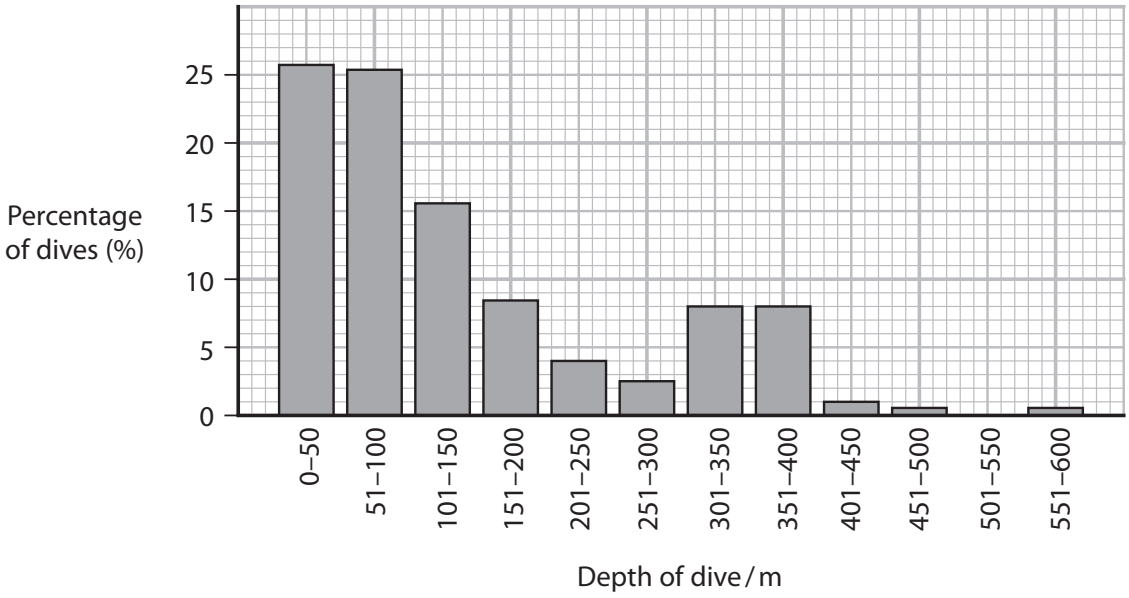
(2)

9 Weddell seals spend a lot of their time swimming underwater, diving to find food and diving to avoid predators.

However, they do have to come to the surface to breathe.

(a) The graphs give some information about dives by Weddell seals.





Comment on the conclusions that can be made about the dives of these seals.

(4)

(b) Weddell seals carry higher concentrations of oxygen in their bodies than humans.

(i) The haemoglobin of Weddell seals is adapted to carry higher levels of oxygen than the haemoglobin of humans, at each partial pressure of oxygen.

Which row of the table describes the haemoglobin of the Weddell seal?

(1)

	Position of oxygen dissociation curve compared with human haemoglobin	Affinity for oxygen compared with human haemoglobin
☒ **A**	to the left	higher
☒ **B**	to the left	lower
☒ **C**	to the right	higher
☒ **D**	to the right	lower

*(ii) The table shows how much oxygen is stored in different parts of the body of humans and Weddell seals.

Part of body	Total oxygen stored / a.u. kg^{-1} body tissue	
	humans	Weddell seals
lungs	12	3
blood	10	58
muscle	2	23
body fluids, other than in the blood	2	2

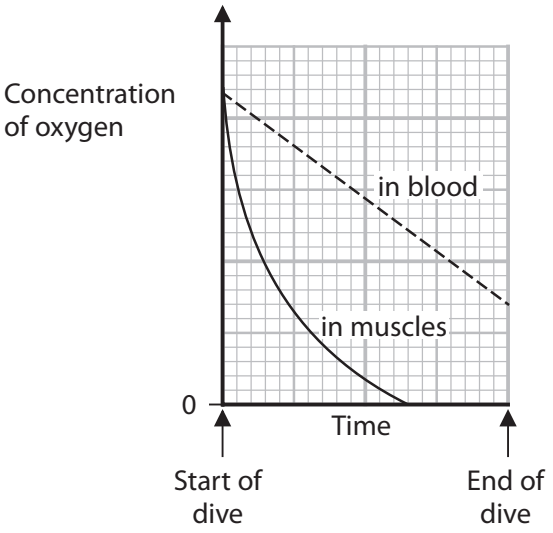
Weddell seals also store erythrocytes in their spleen that are released into the bloodstream during deep dives.

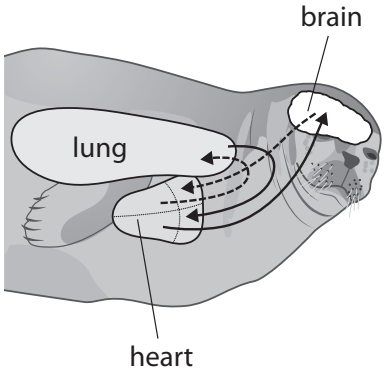
Analyse the data to explain the differences between these two mammals.

(6)

(c) An investigation studied the change in the concentration of oxygen in the blood and muscles of a Weddell seal during a dive.

The graph shows the results of this investigation and the diagram shows part of the circulation of blood in the seal during the dive.





Key

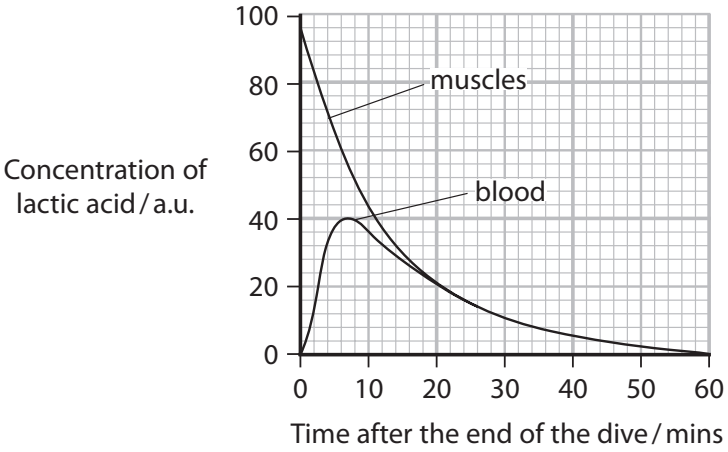
oxygenated blood

deoxygenated blood

Analyse the data to explain these results.

(3)

(d) The graph shows the changes in the lactic acid concentration in the muscles and blood of a Weddell seal, after a prolonged dive.



Explain the importance of these changes after the Weddell seal comes to the surface to breathe.

(3)

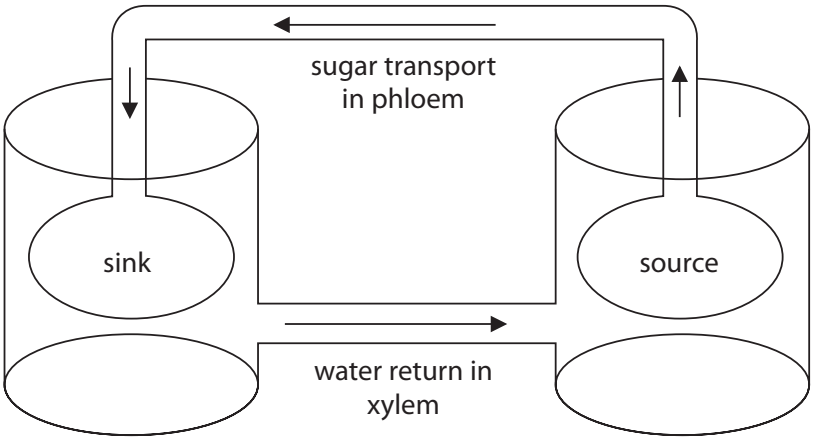
SUB-TOPIC 4(d)

TRANSPORT IN PLANTS

26 questions in this sub-topic · 273 marks · lowest tariff first

8 Sucrose is synthesised and transported through plants.

The diagram represents the mass-flow hypothesis for sucrose transport in a plant.

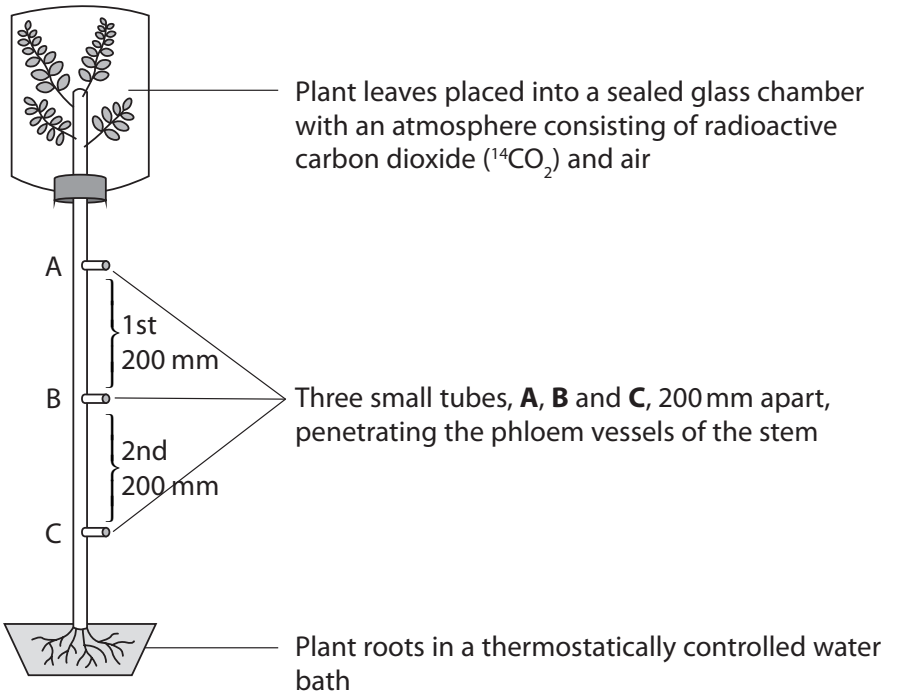


(a) Which row in the table shows the conditions present in the sink and the source of a plant carrying out rapid photosynthesis?

(1)

	Sink		Source	
	Sucrose concentration	**Water potential**	**Sucrose concentration**	**Water potential**
☒ **A**	high	low	high	low
☒ **B**	high	low	low	high
☒ **C**	low	high	high	low
☒ **D**	low	high	low	high

(b) The effect of root temperature and oxygen on the movement of sucrose through a plant was investigated using the apparatus shown in the diagram.



The water bath was set at 10 °C and a solution from each of the small tubes was collected. The time taken for radioactive sucrose to travel the first 200 mm and the second 200 mm was recorded.

The experiment was repeated at 20 °C and 30 °C.

The whole experiment was then repeated replacing the air with nitrogen gas (N_2).

The results are shown in the table.

Glass chamber containing	Temperature of roots / °C	Time taken for sucrose to travel 200 mm / hr			Mean rate of sucrose transport / mm hr^{-1}
		From A to B	From B to C	Mean	
$^{14}CO_2$ + air	10	3.25	3.50	3.38	59.17
$^{14}CO_2$ + air	20	2.35	2.45	2.40	83.33
$^{14}CO_2$ + air	30	1.75	1.83		
$^{14}CO_2$ + N_2	10	6.50	6.25	6.38	31.35
$^{14}CO_2$ + N_2	20	6.25	6.10	6.18	32.36
$^{14}CO_2$ + N_2	30	6.45	6.11	6.28	31.85

(i) Calculate the mean rate of sucrose transport when the plant is kept in $^{14}CO_2$ + air whilst at 30 °C.

Show your working.

(1)

Answer ..... mm hr^{-1}

(ii) Analyse the data in the table to explain the effect of temperature and oxygen on sucrose transport.

(4)

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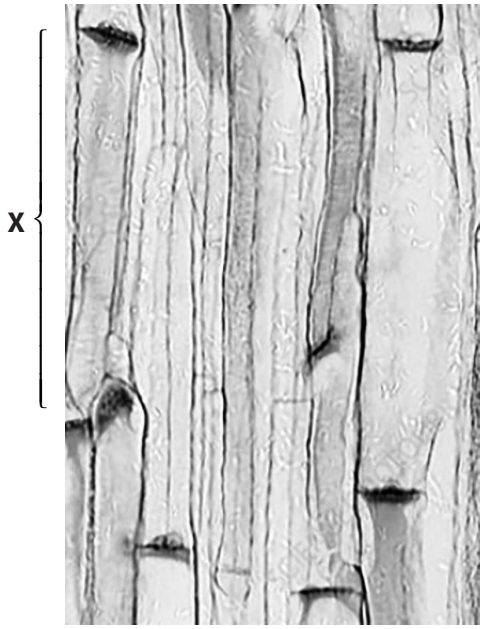
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(Total for Question 8 = 6 marks)

1 Plant stems contain xylem and phloem, tissues specialised for transport.

The photomicrograph shows a longitudinal section of phloem tissue.



(a) (i) Draw the cell labelled **X**.

(2)

(ii) Explain how phloem tissue is adapted for its function.

(3)

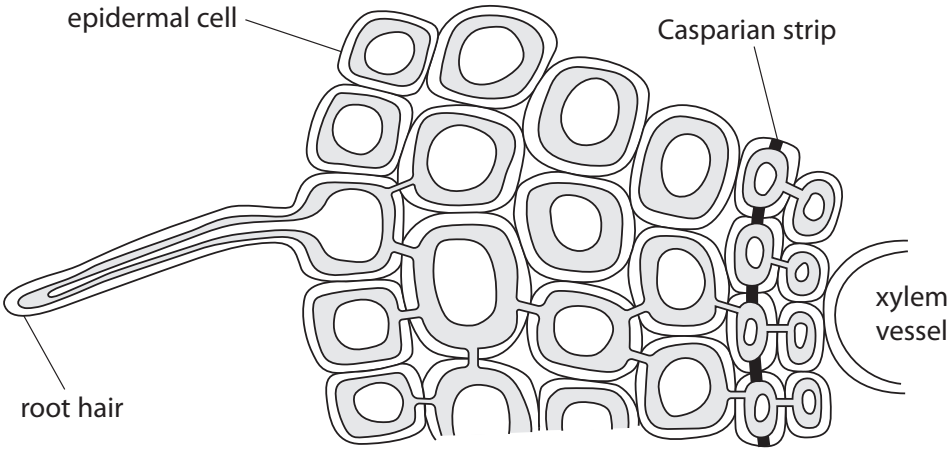
(b) State why stains, such as methylene blue, are sometimes used when preparing a microscope slide.

(1)

(Total for Question 1 = 6 marks)

2 Water can move through plant cells.

(a) The diagram shows the cells in a plant root.



(Source from: https://cronodon.com/BioTech/Plant_Transport.html)

(i) On the diagram, draw the symplastic pathway that water takes from the soil to the xylem vessel.

(2)

(ii) The length of the root hair cell in the diagram is 60 mm.

The magnification of the diagram is ×100.

Calculate the actual length of the root hair cell in micrometres.

(2)

Answer ..... μm

(b) Explain how the cohesion-tension model accounts for the transport of water from plant roots to leaves.

(4)

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4 Transpiration moves water and mineral ions from the roots to the leaves of plants.

(a) Which box in the table shows the mineral ions needed to make an amino acid and which box shows those needed to make DNA?

(2)

Molecule	Mineral ions needed to make the molecule			
	nitrate ions only	phosphate ions only	both nitrate and phosphate ions	neither nitrate nor phosphate ions
amino acid	☒	☒	☒	☒
DNA	☒	☒	☒	☒

(b) Water enters the root hair cells and moves through the root tissues by the apoplastic and symplastic pathways.

(i) Root hairs have a large surface area that increases the rate of uptake of water.

The surface area of a root hair is rounded up to $3.14 \times 10^5\ \mu m^2$.

Which is the actual surface area of this root hair?

(1)

☒ **A** $31\,460\ \mu m^2$

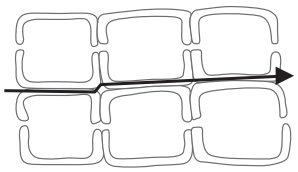
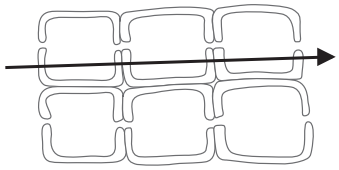
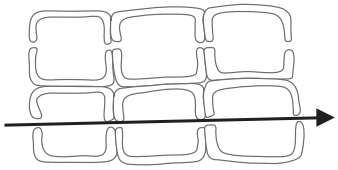
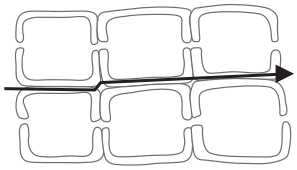
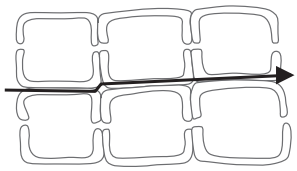
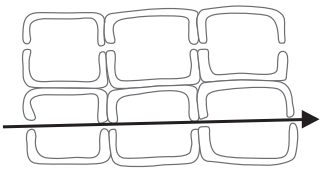
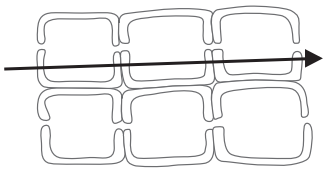
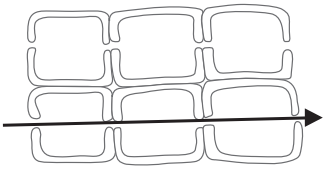
☒ **B** $314\,600\ \mu m^2$

☒ **C** $313\,900\ \mu m^2$

☒ **D** $3\,139\,000\ \mu m^2$

(ii) Which row of the table shows the movement of water through the apoplastic and symplastic pathways?

(1)

	Apoplastic pathway	Symplastic pathway
☒ A		
☒ B		
☒ C		
☒ D		

(iii) Water moves through the root tissue due to a difference in water potential between one cell and the next cell.

Which row of the table describes this movement?

(1)

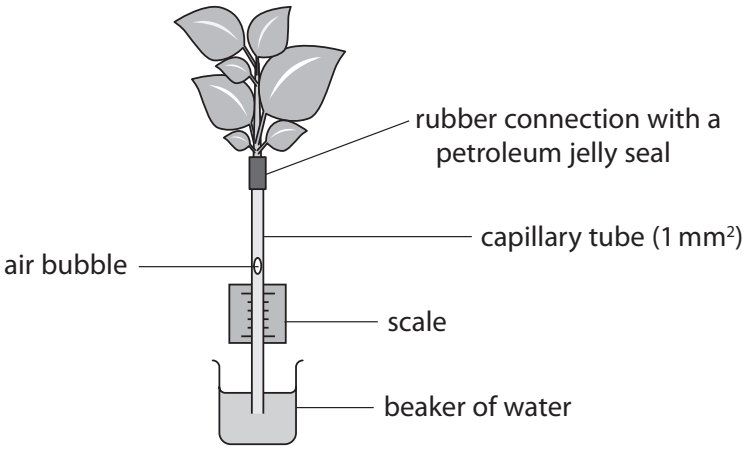
	Direction of water movement with respect to water potential	Direction of water movement with respect to concentration of solutions
☒ A	higher to lower	concentrated to dilute
☒ B	higher to lower	dilute to concentrated
☒ C	lower to higher	concentrated to dilute
☒ D	lower to higher	dilute to concentrated

(c) Explain how transpiration depends on the dipole nature of water.

(3)

2 A student investigated the effect of moving air on transpiration in a leafy shoot.

The diagram shows the potometer used by the student.



(a) In this investigation, a leafy shoot was cut from a plant.

The leafy shoot was then put under water and the stem inserted into the rubber connection.

Explain how this procedure should be modified to produce accurate readings.

(2)

(b) During the investigation, the air bubble moved off the scale very quickly.

Explain how this potometer could be modified to obtain repeat readings.

(2)

(c) The student measured the distance in millimetres that the air bubble moved during a five-minute period in moving air and in still air.

(i) Explain how the student could convert these readings into a transpiration rate using the units $mm^3\ cm^{-2}\ min^{-1}$.

(3)

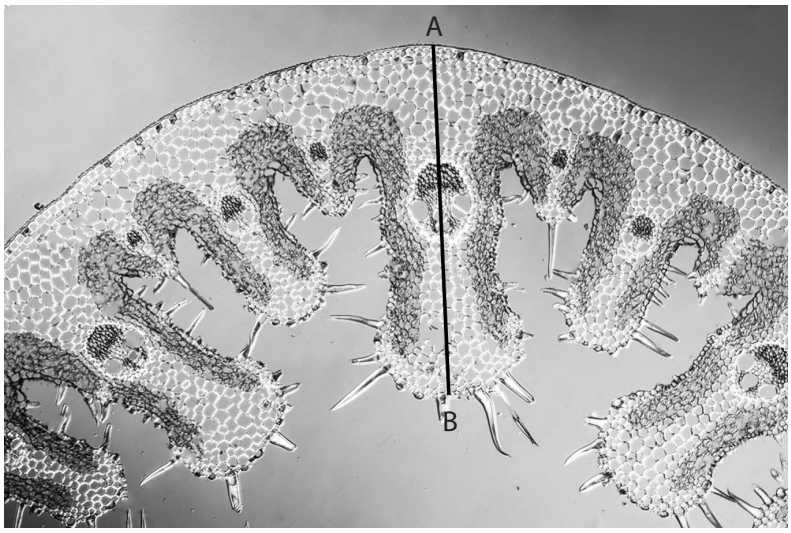
(ii) The table shows the mean results and standard deviations of this investigation.

Mean rate of transpiration / $mm^3\ cm^{-2}\ min^{-1}$	
In moving air	**In still air**
3.2 ± 0.3	0.8 ± 0.2

Explain the results of this investigation.

(2)

3 The photograph shows a cross-section of a leaf from marram grass, *Ammophila arenaria*, as seen using a light microscope.



Source: © Dr. Norbert Lange/Shutterstock

Marram grass grows in sand dunes where little freshwater is available.

This plant has many adaptations that enable it to survive and grow in these conditions:

- leaves that are curved inwards
- leaves that have hairs
- stomata that are sunk in pits
- a thick waxy cuticle on the outside surface of the leaves

(a) State the genus to which marram grass belongs.

(1)

.....

(b) (i) The line AB shown on the actual leaf sample is 4 mm.

Calculate the magnification of the photograph.

(2)

Answer .....

(ii) Explain how **two** of these adaptations enable this plant to survive in dry sand.

(2)

(iii) Marram grass also contains extra xylem tissue that strengthens the leaves.

Explain why these plants need extra xylem in their leaves.

(2)

(c) Cells in the roots of marram grass have a very low water potential.

Explain how this adaptation enables the marram grass to survive in the sand dunes.

(2)

5 The photographs show leaves from six species of plant.



Daffodil



Frogbit floating on water



Sunflower



Maize



Oak tree



Pea

In an investigation into transpiration, a survey was carried out to measure the distribution of stomata on leaves.

The table shows the results of this investigation.

Plant species	Density of stomata in leaf surface / number per mm^2	
	Upper epidermis	Lower epidermis
Beech tree	0	340
Daffodil	65	68
Frogbit (floating leaf)	89	0
Maize	52	58
Oak tree	0	450
Pea	100	220
Sunflower	85	156
Sycamore tree	0	860

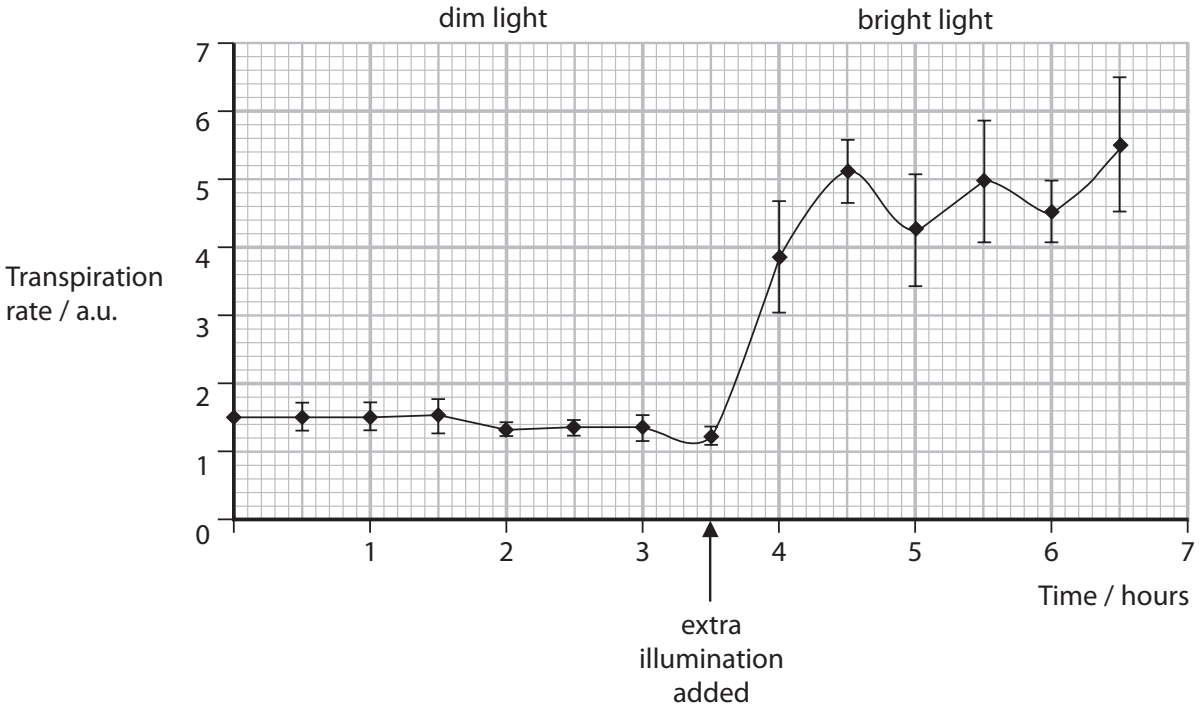
(a) Analyse the data and the photographs to explain the distribution of the stomata.

(5)

(b) As part of this investigation, the effect of light on the transpiration rate of seven-day-old maize seedlings was measured.

The transpiration rate of maize seedlings placed in dim light was measured every 30 minutes for 3.5 hours. Extra illumination was then added and the transpiration rate again measured every 30 minutes for another 3.5 hours.

The graph shows the results of this investigation.



(i) Calculate the approximate percentage increase in the transpiration rate due to the extra illumination.

(2)

Answer .....

(ii) Explain two factors that should have been controlled in this investigation.

(2)

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3 Xylem and phloem tissues transport molecules and ions through plants.

(a) Give the meaning of the term **tissue**.

(1)

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(b) The table gives some information about the structures of xylem and phloem tissues.

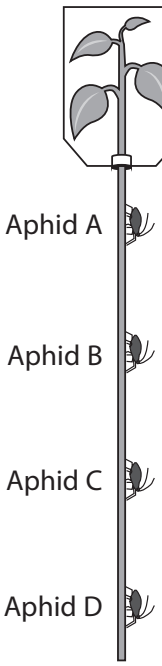
For each statement, put **one** cross ☒ in the appropriate box, in each row, to show whether these statements are true for both types of tissue, xylem tissue only, phloem tissue only or neither type of tissue.

(3)

Statement	Type of tissue			
	both xylem and phloem	**xylem only**	**phloem only**	**neither xylem nor phloem**
Contain sieve plates	☒	☒	☒	☒
Have cellulose in the cell walls	☒	☒	☒	☒
Have mitochondria	☒	☒	☒	☒

(c) Aphids are insects that can be used to study the transport of sugars in the phloem.

The diagram shows how this is done.



1. The leaves of a plant are covered with a glass chamber containing radioactive carbon dioxide.
2. The plant produces radioactive sugars by photosynthesis.
3. Aphids, A, B, C and D are attached to the stem and allowed to feed on the contents of the phloem.
4. The aphids are analysed to determine the time at which radioactivity first appeared in their bodies.

(i) Which disaccharide is transported in the phloem?

(1)

- ☒ **A** fructose
- ☒ **B** glucose
- ☒ **C** lactose
- ☒ **D** sucrose

(ii) In an experiment, the time between radioactivity appearing in aphid A and aphid D was 210 minutes.

The distance between these two aphids was 50 cm.

Calculate the rate of flow of phloem contents between these two aphids, in cm hour^{-1}.

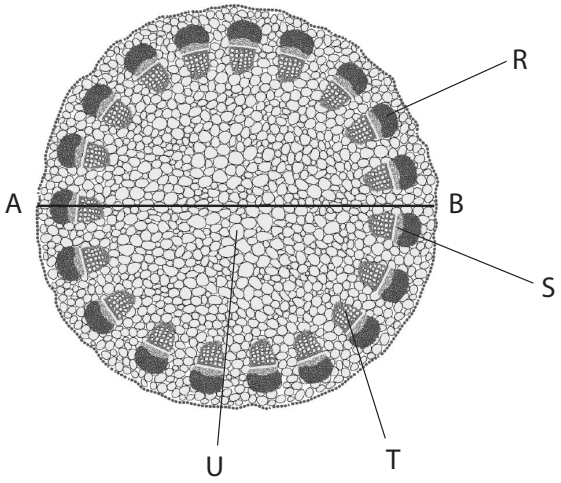
(1)

Answer ..... cm hour^{-1}

(iii) Describe how sugars are transported through the phloem.

(3)

2 (a) The photograph shows a section through a plant stem as seen using a light microscope.



(Source: © Aldona Griskeviciene/Shutterstock)

(i) Which structure is the xylem?

(1)

- ☒ **A** R
- ☒ **B** S
- ☒ **C** T
- ☒ **D** U

(ii) The actual diameter of the stem section A to B is 12 mm.

Calculate the magnification of the photograph.

(2)

Answer .....

(b) (i) Which **one** of the following is a function of the xylem vessels in a plant?

(1)

- ☒ **A** transport of amino acids from leaves to growing regions
- ☒ **B** transport of mineral ions from roots to growing regions
- ☒ **C** transport of sucrose from leaves to growing regions
- ☒ **D** transport of water from leaves to stem

(ii) Which **one** of the following describes transport in the phloem?

(1)

- ☒ **A** the movement of substances is downwards only
- ☒ **B** the movement of substances is a passive process
- ☒ **C** the movement of substances is upwards only
- ☒ **D** the movement of substances is upwards and downwards

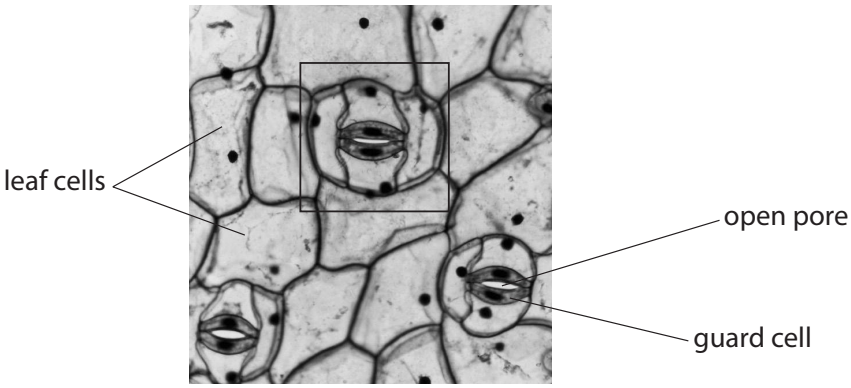
(c) Xylem and phloem are involved in the transport of substances in plants.

Compare and contrast the structure of xylem and phloem tissues.

(4)

4 Stomata are pores found on the under-surfaces of leaves. They are surrounded by a pair of guard cells.

The photograph shows three stomata, as seen using a light microscope.



(Source: © Science History Images/Alamy Stock Photo)

(a) Draw the cells in the box on the photograph, at a magnification × 2 of the photograph.

(3)

*(b) The pores are closed in the dark and open in the light.

When the pores are open, the width of the pores increases.

Potassium ions are involved in the opening of the pores.

Devise an investigation to determine the effect of potassium ion concentration on the width of the pores of stomata.

(6)

2 The rate of transpiration in plants can be measured using a potometer.

(a) (i) Explain why the stem of a plant should be cut under water before it is inserted into a potometer.

(2)

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(ii) Which combination of the following factors would increase the rate of transpiration the most?

(1)

- ☒ **A** high wind speed, low humidity, high temperature
- ☒ **B** low wind speed, low humidity, high temperature
- ☒ **C** high wind speed, high humidity, high temperature
- ☒ **D** high wind speed, low humidity, low temperature

(b) Which of the following shows the order of the structures a water molecule would pass through as it moves from the soil along the symplastic pathway in a root?

(1)

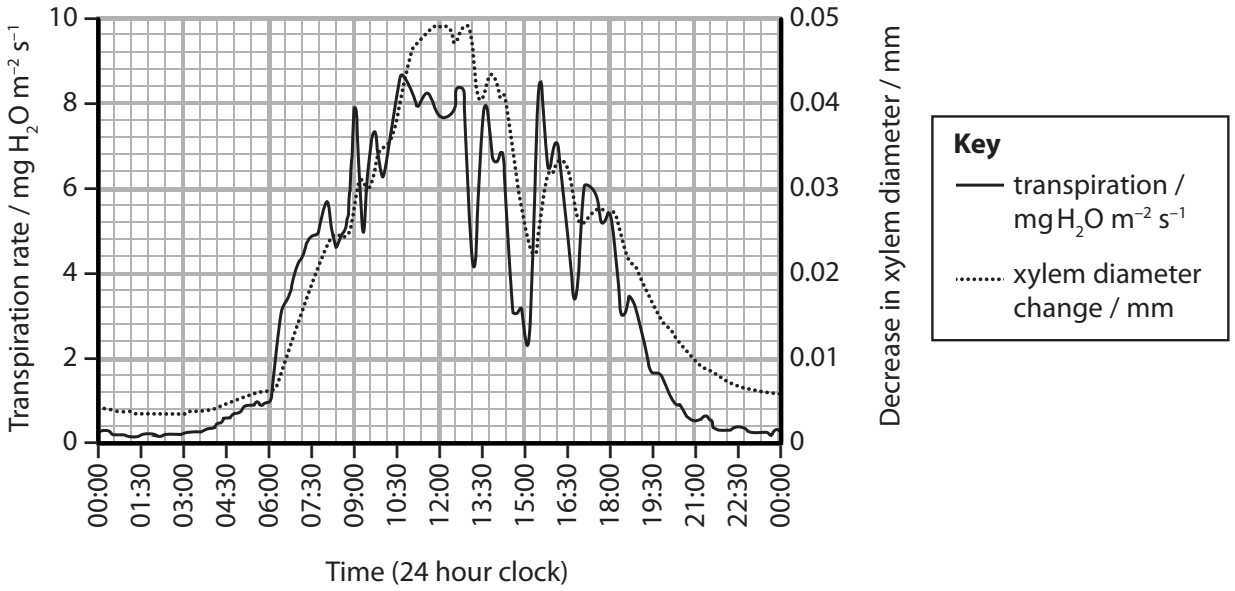
- ☒ **A** cell wall only
- ☒ **B** cell wall, cell membrane, cytoplasm
- ☒ **C** cytoplasm only
- ☒ **D** cell membrane, cytoplasm, cell wall

*(c) Scientists investigated the transpiration of pine trees over a 24-hour period.

The mass of water lost per second and the total area of the leaves were measured.

The decrease in diameter of xylem vessels was also measured over the same 24 hours.

The results are shown in the graph.



Using your knowledge of cohesion-tension theory, explain the changes in xylem diameter and transpiration rate over the 24-hour period.

(6)

(Total for Question 2 = 10 marks)

3 Mineral ions are transported from the soil into the cytoplasm of plant root cells.

The table shows the concentration of sodium ions and chloride ions in soil and in the cytoplasm of plant root cells.

Location	Ion concentration / mg dm^{-3}	
	Sodium	Chloride
soil	28	25
cytoplasm	1988	3750

(a) (i) Give the ratio of sodium ions in the soil to those in the cytoplasm.

(1)

.....

(ii) Which of the following describes how these mineral ions are transported into the cytoplasm of plant root cells?

(1)

☒ **A** active transport through carrier proteins

☒ **B** diffusion through the phospholipid bilayer

☒ **C** facilitated diffusion through the phospholipid bilayer

☒ **D** mass transport through carrier proteins

(b) Water is also taken up by plant root cells.

(i) Which of the following describes the pathway taken by this water before entering the xylem?

(1)

☒ **A** apoplast only

☒ **B** apoplast and symplast

☒ **C** neither apoplast nor symplast

☒ **D** symplast only

(ii) Explain how this water is transported in the xylem to the leaves.

(3)

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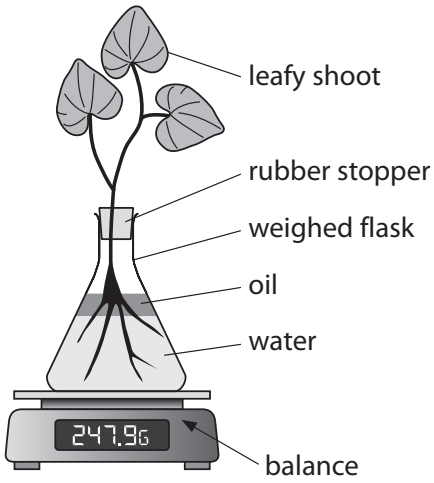
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(c) Transpiration involves the loss of water vapour from leaves.

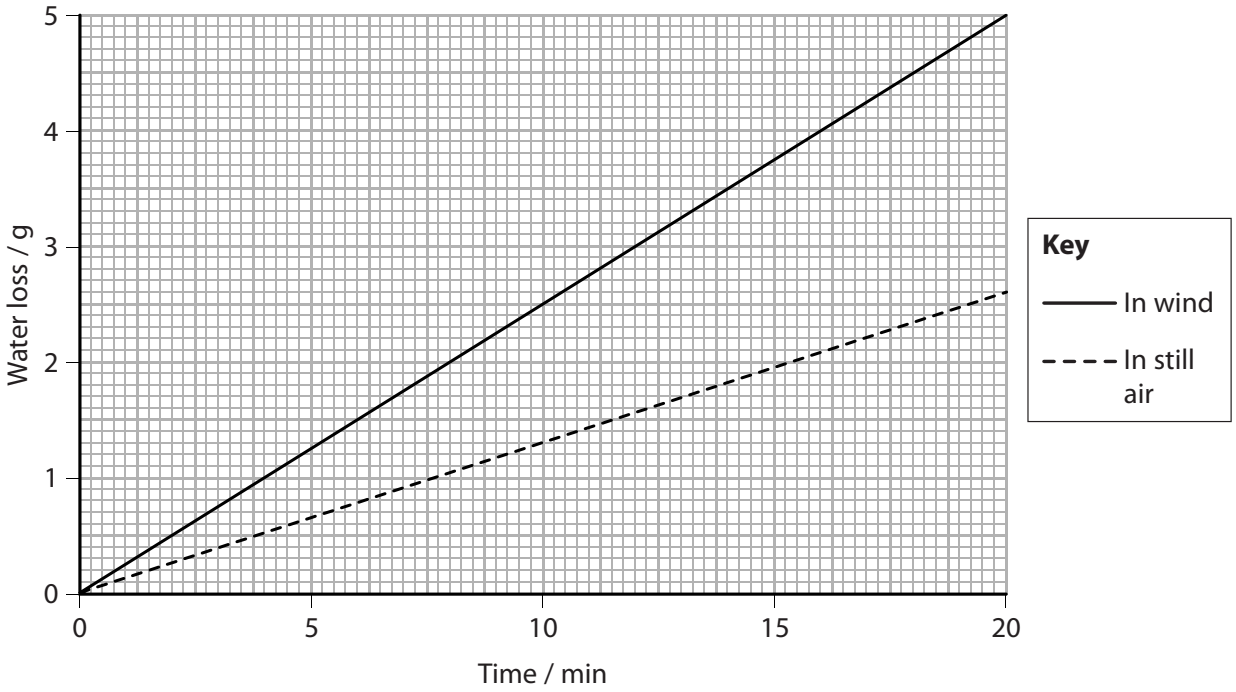
The rate of transpiration can be measured using the apparatus shown in the diagram.



A student used this apparatus to investigate how wind affected the rate of transpiration by a plant.

The mass of water lost by a plant was measured during a twenty-minute period in still air. This was repeated in wind.

The graph shows the results.



(i) Calculate the increase in the rate of water loss caused by wind.

(2)

Answer ..... g min^{-1}

(ii) The student was told that this investigation was not valid because certain variables had not been controlled.

Explain how the student could modify this investigation to improve its validity.

(2)

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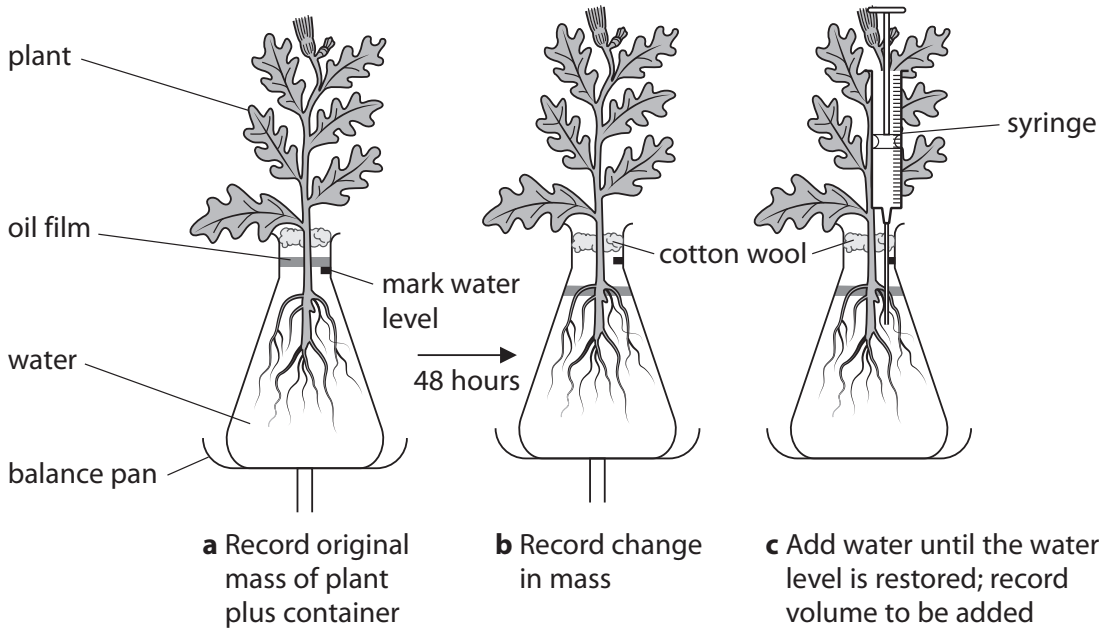
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4 An experiment was carried out to measure the rate of uptake and loss of water in a plant, using a mass potometer.

A plant with roots was set up in a flask on a balance and the mass of the plant and apparatus was recorded as shown in the diagram.



The plant was left for 48 hours and the change in mass and volume of water that the plant had absorbed were measured.

The results showed that the plant had lost 3.1 g in 48 hours.

A volume of 3.2 cm^3 of water was added to restore the original water level in the flask.

(a) The correct conclusion from these results is

(1)

- ☒ **A** the plant absorbed more water than it lost
- ☒ **B** the plant lost more water than it absorbed
- ☒ **C** the rate of respiration and photosynthesis are the same
- ☒ **D** the rate of transpiration and absorption are the same

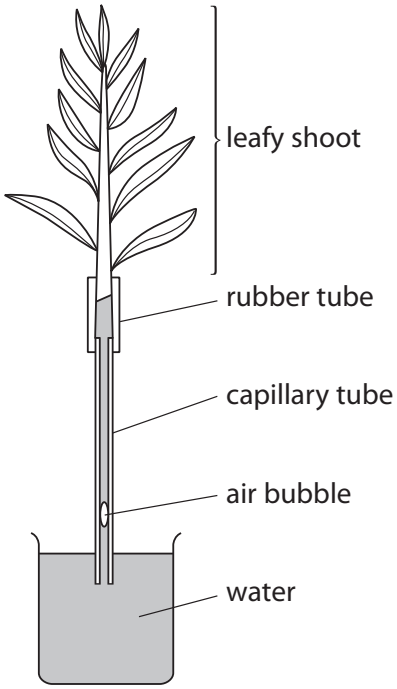
(b) In which of these conditions would water uptake be slowest?

(1)

- ☒ **A** cold, dry and bright conditions
- ☒ **B** cold, humid and dark conditions
- ☒ **C** warm, dry and bright conditions
- ☒ **D** warm, humid and bright conditions

(c) Water uptake in plants can also be investigated using a bubble potometer.

The diagram shows a bubble potometer.



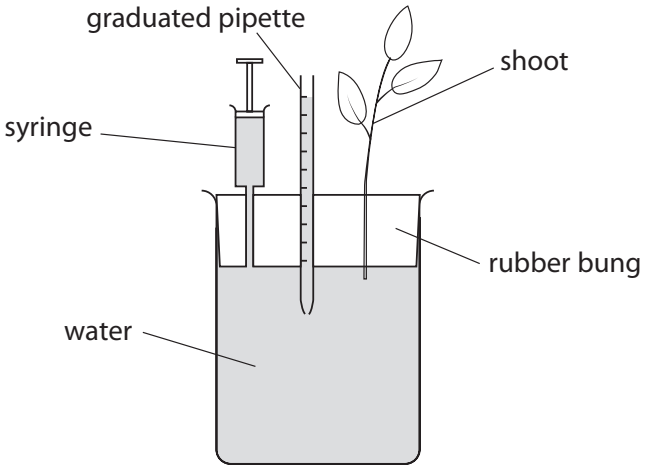
(i) Compare and contrast the mass potometer with the bubble potometer as methods of measuring the rate of transpiration.

(4)

(ii) Describe how the bubble potometer can be used to investigate the effect of wind speed on the rate of water uptake.

(4)

3 The diagram shows a type of potometer.



(Source from: Science and Plants for Schools: www.saps.org.uk)

The leaves of the shoot must be kept dry when assembling the potometer under water in a sink.

The syringe plunger is pushed down until the water level is raised to zero in the graduated pipette.

The water level in the graduated pipette is used to measure water uptake by the shoot.

(a) (i) Explain why the apparatus should be assembled under water.

(2)

(ii) Explain why the leaves must be kept dry whilst assembling the apparatus.

(2)

(b) (i) Explain how this potometer can be used to investigate the effect of light intensity on the rate of water uptake by this shoot.

(4)

(ii) This potometer measures the uptake of water by a plant shoot.

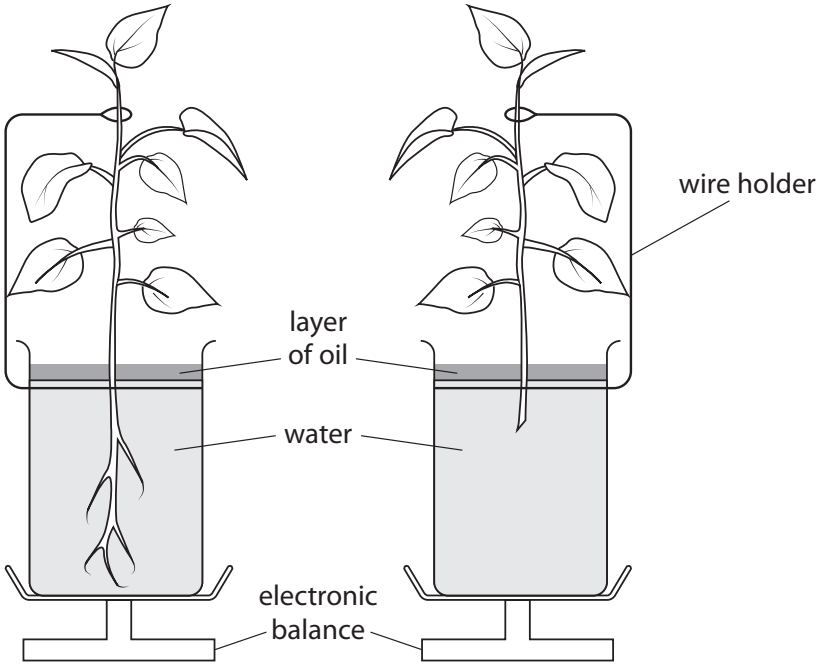
Give **two** reasons why the water lost by transpiration is less than the water taken up by the plant shoot.

(2)

(Total for Question 3 = 10 marks)

3 A student investigated the rate of water loss by a seedling.

The diagram shows the apparatus used in this investigation.



The student recorded the mass of each apparatus every 10 minutes for three hours.

(a) (i) State the hypothesis being tested by the investigation.

(1)

(ii) Explain **one** feature of the plants that should be controlled in this investigation.

(2)

(iii) State the function of the layer of oil in this apparatus.

(1)

(b) The student assumed that the rate of water loss is equal to the rate of water uptake.

Explain why these two rates could be different.

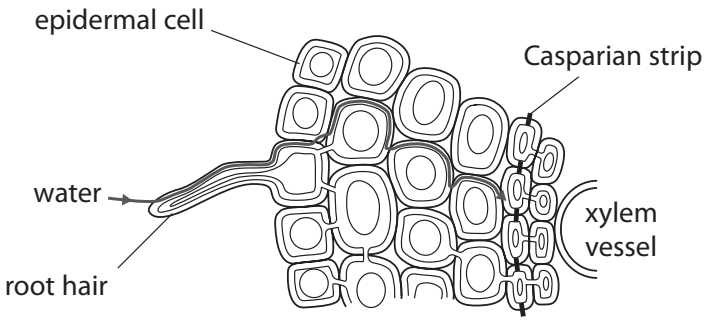
(2)

(c) Describe how this investigation could be modified to determine the effect of humidity on the rate of water uptake by seedlings.

(4)

7 The primary productivity of plants depends on their ability to synthesise carbohydrates and transport solutes to cells.

(a) The diagram shows the movement of water across a root.



What is the name of the water movement pathway shown in the diagram?

(1)

- ☒ **A** apoplastic pathway
- ☒ **B** diffusion pathway
- ☒ **C** osmotic pathway
- ☒ **D** symplastic pathway

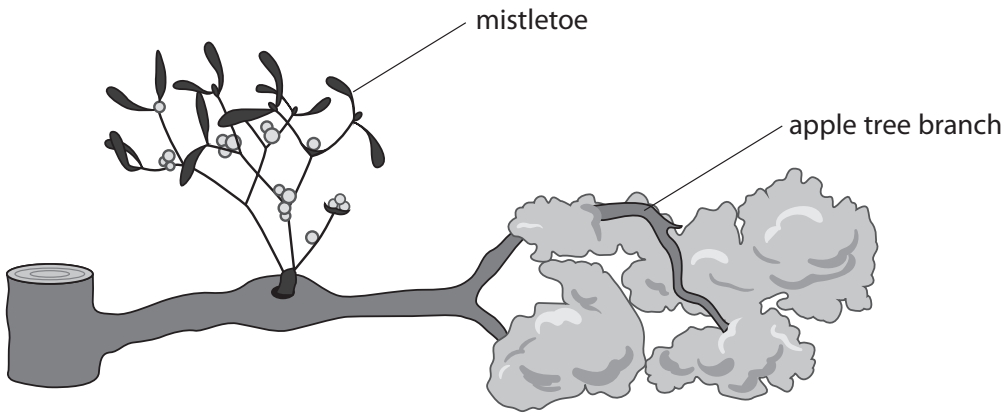
(b) Explain how the mass-flow hypothesis accounts for the movement of sugars from leaves to roots.

(4)

*(c) Mistletoe is a plant that is a parasite on trees.

Mistletoe has green leaves. Mistletoe also has a modified root that grows into the xylem of a tree.

The diagram shows mistletoe growing on an apple tree branch.



The effect of mistletoe on the growth of apple trees was investigated.

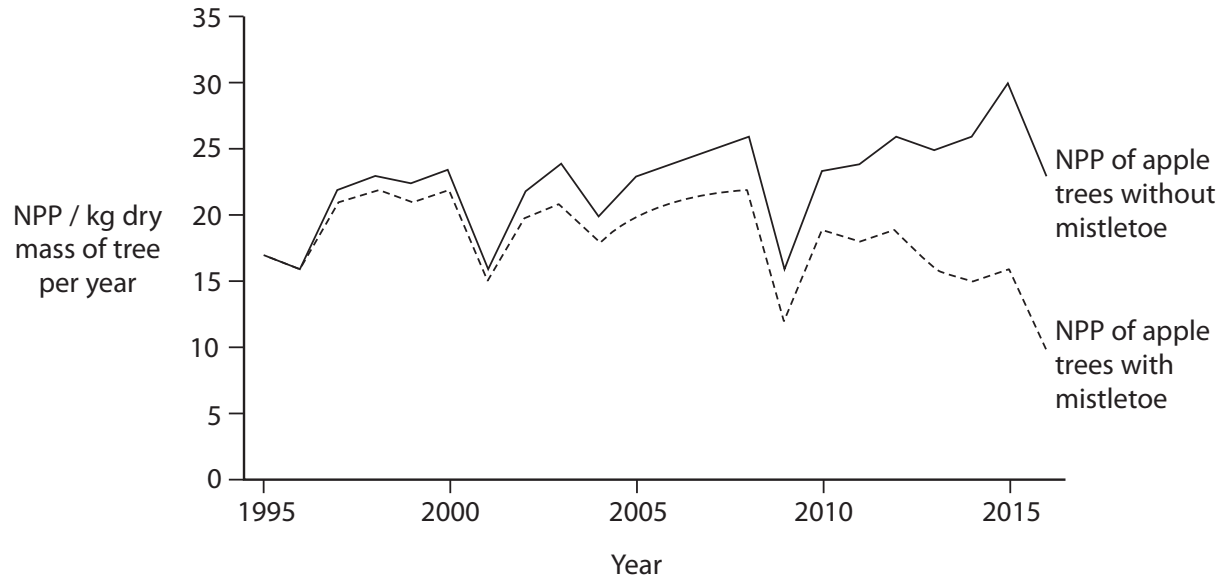
Every year for 20 years, scientists selected apple trees infected with mistletoe and measured the:

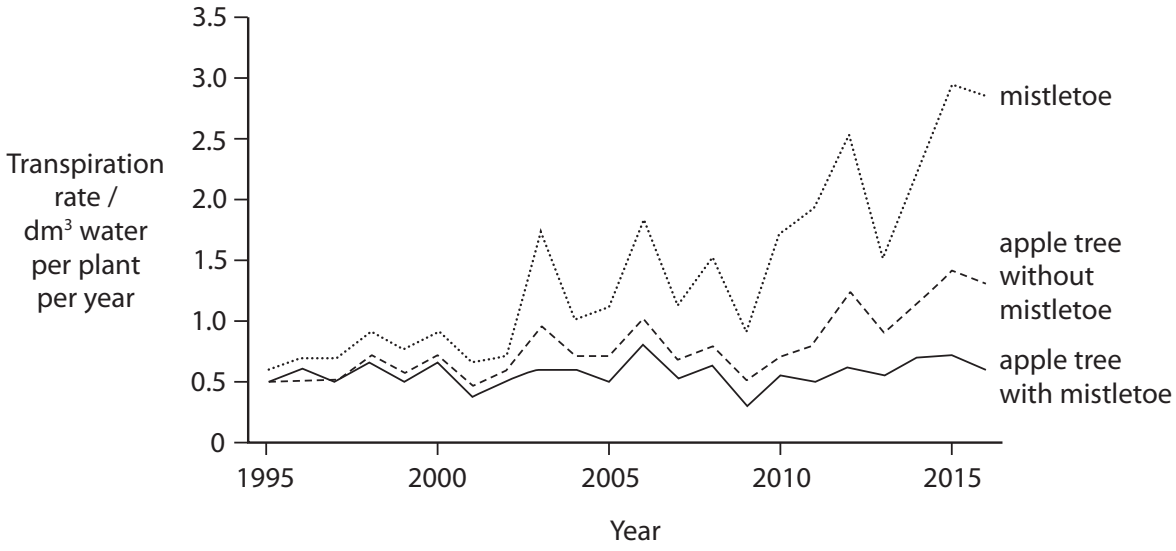
- mean net primary productivity (NPP) of the apple trees
- transpiration rate of the apple trees
- transpiration rate of the mistletoe branches on the apple trees

They also determined the mineral content of the apple tree leaves after 20 years.

A control group of apple trees not infected with mistletoe was included in this investigation.

The graphs and table show the results of the investigation.





Apple tree leaves from	Nitrogen content / mg per g of leaf	Calcium content / mg per g of leaf
trees infected with mistletoe	8.50	6.45
trees not infected with mistletoe	10.60	8.90

Analyse the data to explain the effect of mistletoe on the NPP of apple trees.

(6)

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.

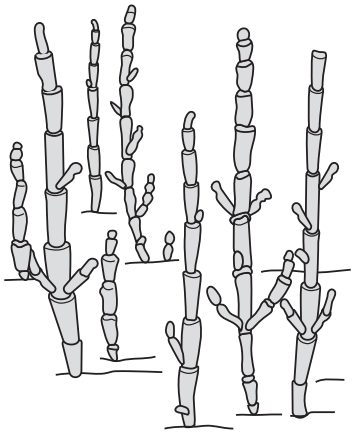
(i) Which row in the table causes the highest rate of transpiration from a plant?

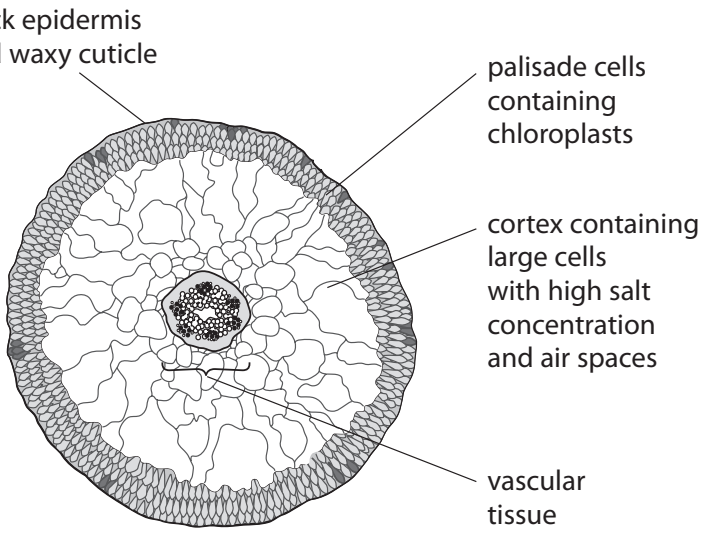
(1)

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

(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)

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(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)

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(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.

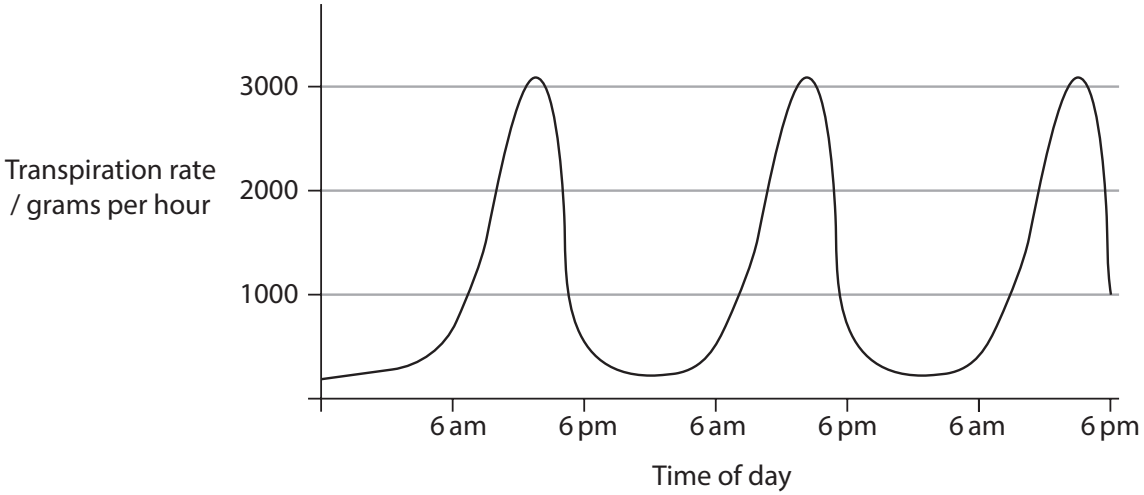
(4)

7 Scientists measured the transpiration rate of alfalfa plants.

(a) State what is meant by the term **transpiration**.

(1)

(b) The graph shows the change in transpiration rate, measured in grams per hour, for three successive days.



(i) Explain the changes in transpiration rate from 6 am to 6 pm.

(3)

(ii) The scientists also examined the effects of soil temperature, relative humidity and air temperature on transpiration rate.

Soil temperature / °C	Relative humidity	Transpiration rate at different air temperatures / grams per hour			
		22 °C	27 °C	32 °C	Mean
10	35%	13.7	13.3	12.3	**13.1**
	53%	10.5	13.5	13.5	**12.5**
	65%	13.2	13.3	19.2	**15.2**
	Mean	**12.5**	**13.4**	**15.0**	**13.6**
25	**Relative humidity**	**Transpiration rate at different air temperatures / grams per hour**			
		22 °C	**27 °C**	**32 °C**	**Mean**
	35%	19.7	27.5	31.2	**26.1**
	53%	23.0	27.5	28.5	**26.3**
	65%	22.5	24.7	29.5	**25.6**
	Mean	**21.7**	**26.6**	**29.7**	**26.0**

Analyse the data in the table to comment on the factors that influence transpiration rate.

(4)

(c) Transpiration can be measured in the laboratory using a cut leafy shoot.

Describe how you could accurately measure the effect of changing light intensity on the rate of transpiration of a cut leafy shoot in the laboratory.

(3)

6 A student measured the distribution of two plant species at the coast.

The distribution was measured from the high water line to 170 m inland.

(a) State what is meant by the term species.

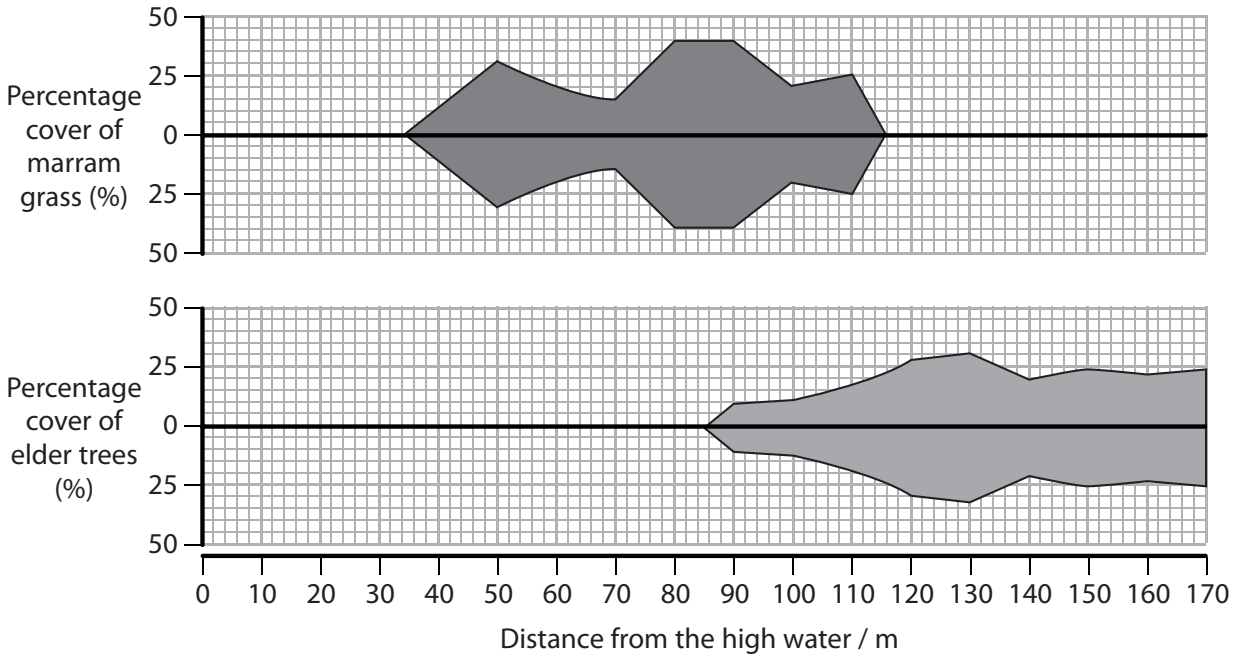
(1)

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(b) The student represented the distribution of the two plant species in a kite diagram as shown.

The height of each kite diagram represents the percentage cover of plant species at different distances from the high water line.



(i) Compare and contrast the distribution of marram grass and elder trees.

(2)

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(ii) Explain how the student could have collected the data shown in the diagram.

(3)

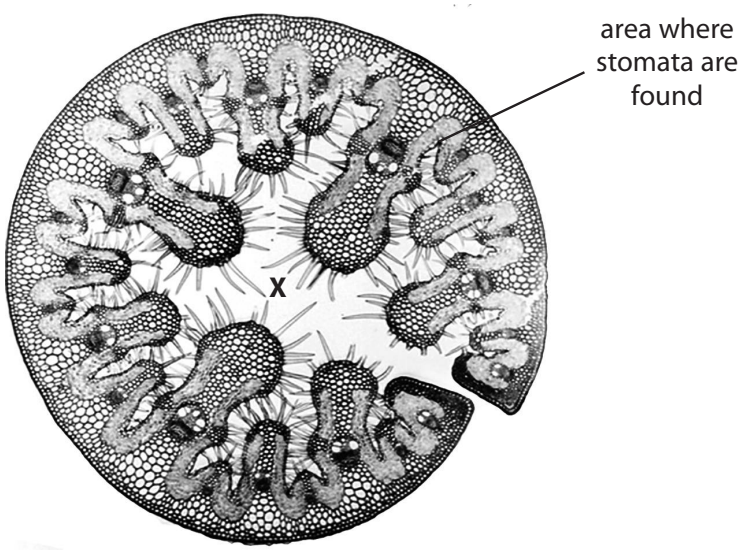
(c) The student measured the water content of the soil from the high water line to 170 m inland.

Describe how the student could have carried out these measurements.

(3)

(d) Marram grass leaves are adapted to enable the plants to survive in dry soil.

The photograph shows a section of a marram grass leaf, as seen using a light microscope.



Explain how the structure of this leaf ensures that the water potential at X remains high.

(3)

8 Water enters a plant through root hair cells and then travels by the apoplastic and by the symplastic pathways.

(a) Describe the differences between the apoplastic and the symplastic pathways.

(3)

(b) Herbicides are chemicals used to control the growth of weeds.

Herbicides that are absorbed from the soil also travel through the apoplastic and symplastic pathways.

The rate of absorption of herbicides is affected by their chemical properties.

(i) Explain how the properties of herbicide molecules affect their ability to pass through plant cell membranes.

(3)

(ii) Some herbicides are applied to the soil.

Explain how these herbicides will be transported to the leaves.

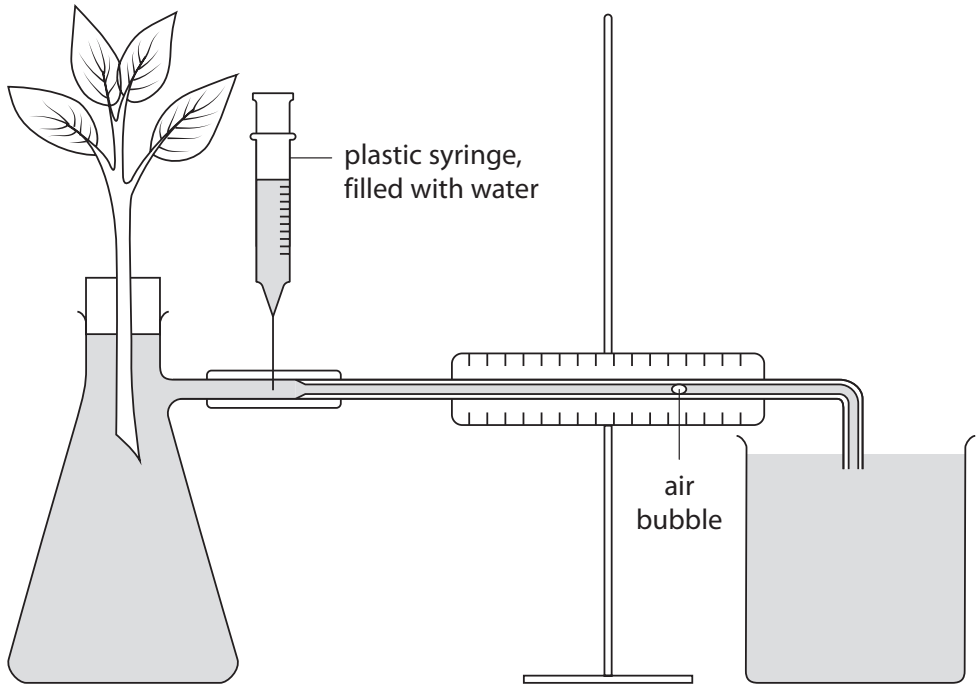
(2)

(c) To grow plants successfully in a glasshouse, the humidity needs to be controlled because the humidity would be higher in the summer than in the spring.

Explain why the humidity in a glasshouse would be higher in the summer than in the spring.

(5)

6 The diagram shows apparatus used by a student to investigate water uptake by a leafy shoot.



This apparatus was used in a variety of environmental conditions and the following results were obtained.

Environmental condition	Rate of water uptake / mm min^{-1}				
	minute 1	minute 2	minute 3	minute 4	Mean
control	20	19	17	21	19
increased humidity	14	14	15	16	15
increased wind speed	26	24	25	25	25
increased air temperature	26	28	26	25	
lower light intensity	17	16	15	17	16
removal of 50% of leaves	10	12	11	11	

(a) (i) Give the name of the apparatus.

(1)

(ii) Explain **one** precaution that needs to be taken when setting up this apparatus before it can be used to measure the water uptake of the leafy shoot.

(2)

(iii) Explain why the water uptake of the leafy shoot may not be the same as the water transpired.

(2)

(b) Determine which condition produced the greatest change in the mean rate of water uptake.

(2)

(c) (i) State how the student could vary the humidity around the shoot.

(1)

(ii) Give **one** way in which the temperature could be increased without affecting the validity of this investigation.

(1)

(iii) Describe how the student would use the syringe to convert the results into a measure of the volume of water uptake in $mm^3\ min^{-1}$.

(2)

(d) Explain the effect of increasing humidity on the rate of water uptake by the leafy shoot.

(2)

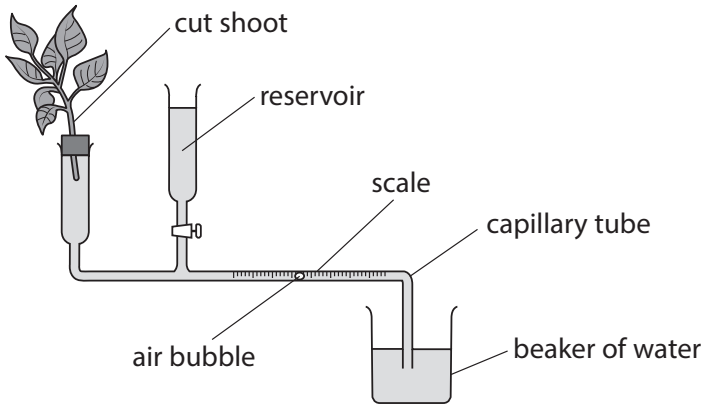
9 Water moves through xylem vessels in a plant during transpiration.

Phloem tissue is responsible for transport of organic materials such as sucrose.

(a) Compare and contrast the structure of xylem tissue and phloem tissue.

(3)

(b) A student used the potometer shown in the diagram to investigate the rate of water uptake in a leafy shoot.



The student investigated the effect of a combination of environmental conditions on the rate of water uptake.

The table shows the results of this investigation.

Conditions	Distance moved by the bubble in 5 minutes / cm					
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Mean
Still air, in light	2.4	2.2	2.2	2.2	2.1	2.2
Moving air, in light	6.5	6.7	6.4	6.2	6.3	6.4
Still air, in dark	0.9	0.4	0.0	0.0	0.0	0.3
Moving air, in dark	1.7	0.8	0.0	0.0	0.0	0.5

(i) The internal diameter of the capillary tubing is 0.3 mm.

The volume of a cylinder is calculated using the formula

$$\pi r^2 h$$

Calculate the mean rate of water uptake for the shoot in moving air, in the light.

Give your answer in $mm^3\ min^{-1}$ to two significant figures.

(3)

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

(ii) Analyse the data to explain the results of this investigation.

(3)

(iii) Describe how this investigation could be modified to make a valid comparison of water loss from the upper and lower surfaces of the leaves.

(4)

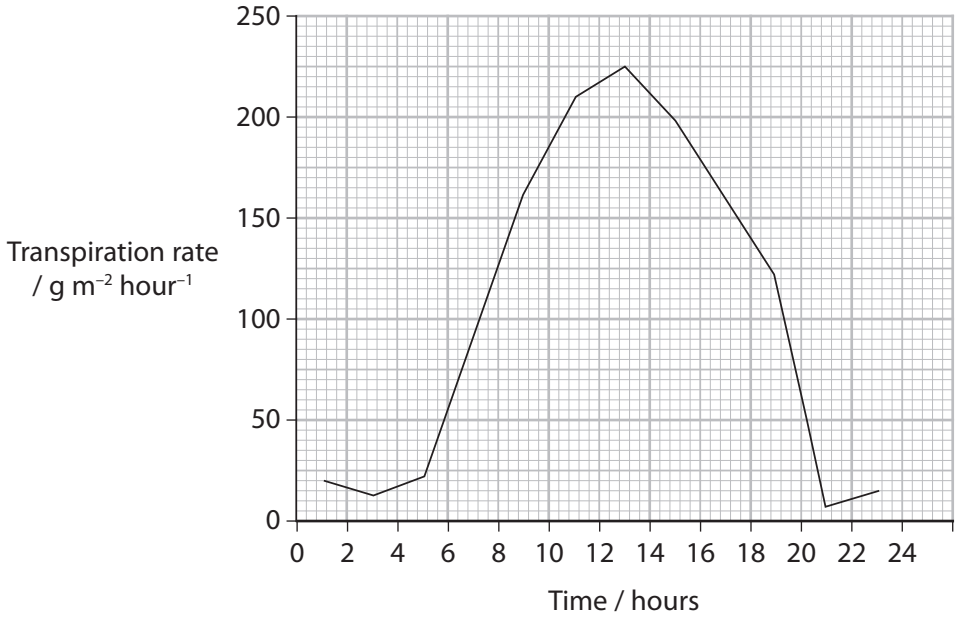
9 Transpiration is the loss of water from the leaves of plants.

(a) Water moves through xylem vessels in a plant during transpiration.

Explain **one** way in which xylem vessels are adapted for their function.

(2)

(b) The graph shows the rate of transpiration in oat seedlings during one day. Windspeed and humidity were controlled.



(i) Calculate the mean rate of change in transpiration from five to thirteen hours.

Give your answer to **one decimal place**.

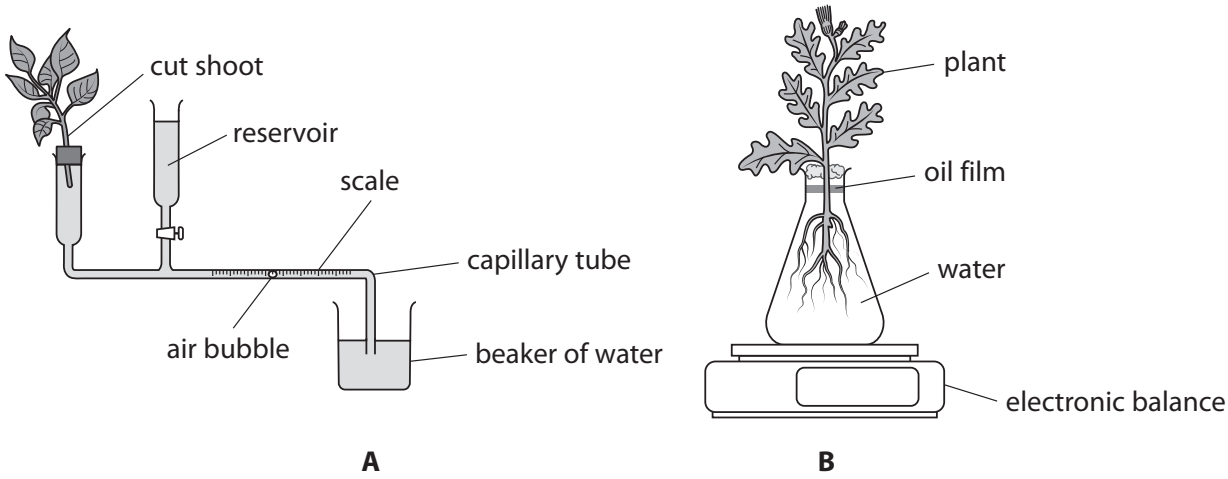
(1)

Answer ..... g m^{-2} hour^{-1}

(ii) Explain the shape of the graph over the 22-hour period.

(3)

(c) The diagrams show two types of potometer, A and B.



A **B**

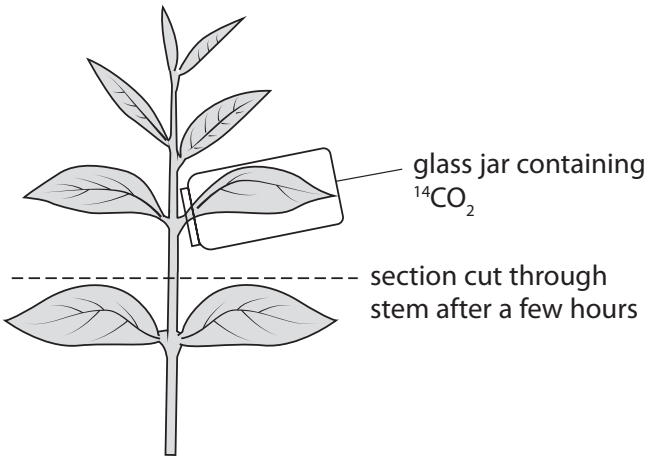
Evaluate which type of potometer would be better to measure the rate of transpiration.

(5)

(d) A scientist investigated the movement of sugar from the leaf to the roots of a plant.

One leaf was supplied with carbon dioxide containing the radioisotope ^{14}C.

The diagram shows part of the apparatus used by the scientist.

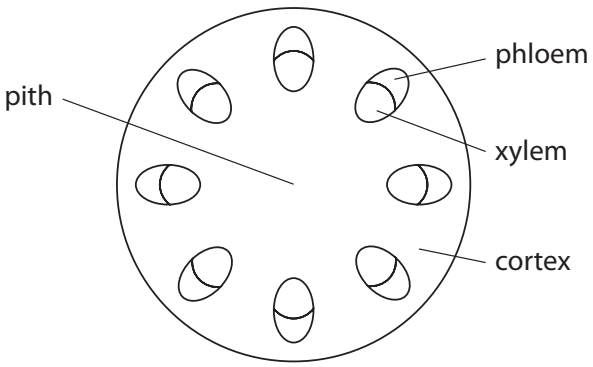


The sugar produced by photosynthesis in this leaf is radioactive.

After a few hours, a section was cut through the plant stem and placed on photographic film.

Structures containing radioactive material will cause darkening of the film.

The diagram shows the structure of the stem when a section is cut.



(i) Shade the areas you would expect to be darker because they are transporting radioactive sugar.

(1)

(ii) Name the radioactive sugar causing this darkening on the film.

(1)

.....

(Total for Question 9 = 13 marks)

7 Xylem and phloem are involved in transport in plants.

(a) (i) Which row of the table shows some of the substances transported in xylem and phloem?

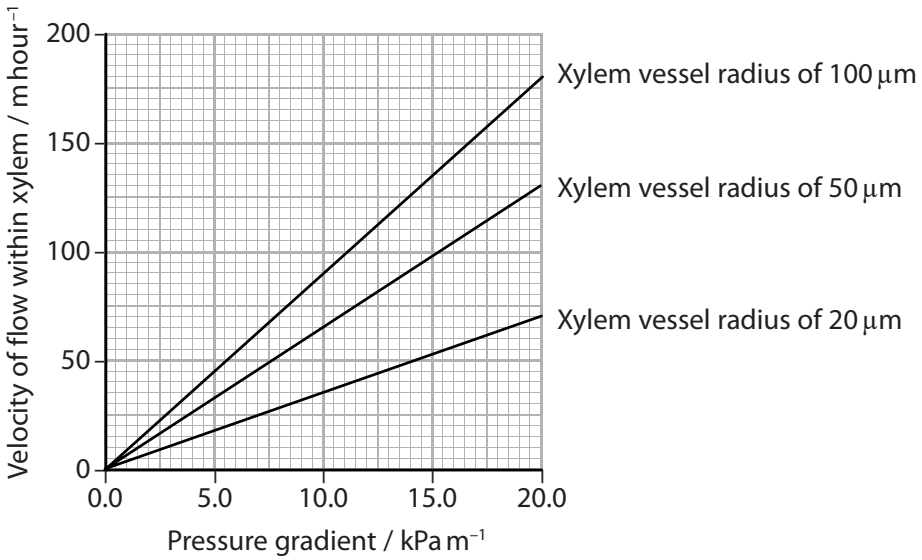
(1)

		Xylem	Phloem
☒	**A**	water only	sucrose only
☒	**B**	water only	water and sucrose
☒	**C**	water and mineral ions	sucrose only
☒	**D**	water and mineral ions	water and sucrose

(ii) Describe the differences between the structure of xylem and that of phloem.

(3)

(b) The graph shows the effect of pressure gradient on the velocity of flow within three xylem vessels.



(i) Describe the effect of pressure gradient and radius on the velocity of flow within the xylem vessels.

(2)

(ii) Calculate the percentage increase in the velocity of water flowing through a xylem vessel of radius 20 μm and a xylem vessel of radius 100 μm, at a pressure gradient of 17.5 kPa m^{-1}.

(2)

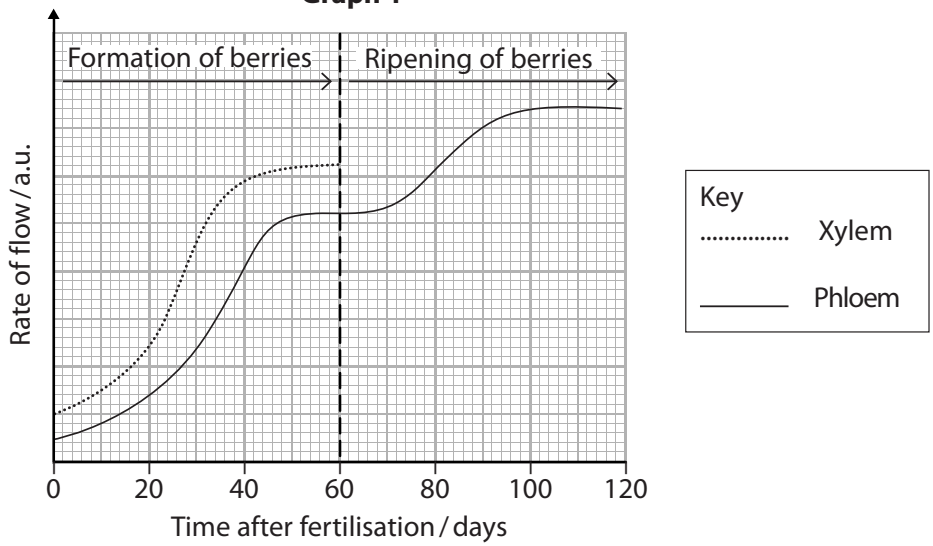
Answer .....

*(c) Double fertilisation in some plants leads to the development of fruits, such as berries.

In an investigation, the rate of flow in xylem during the formation of berries was measured. The rate of flow in the phloem during the formation and ripening of the berries was also measured.

The results are shown in graph 1.

Graph 1



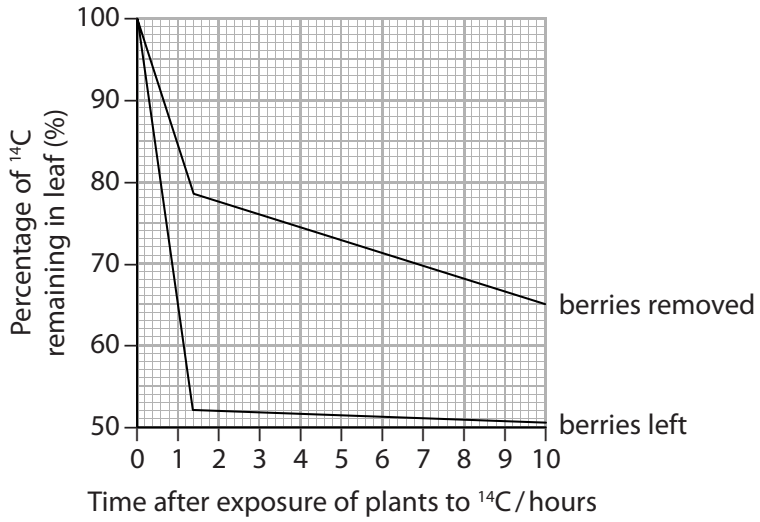
In a second investigation, two plants with berries were exposed to radioactive carbon dioxide (^{14}C).

After exposure to ^{14}C, the berries were removed from one plant and left on the second plant.

The percentage of ^{14}C remaining in the leaves of each plant was determined during the next 10 hours.

The results are shown in graph 2.

Graph 2



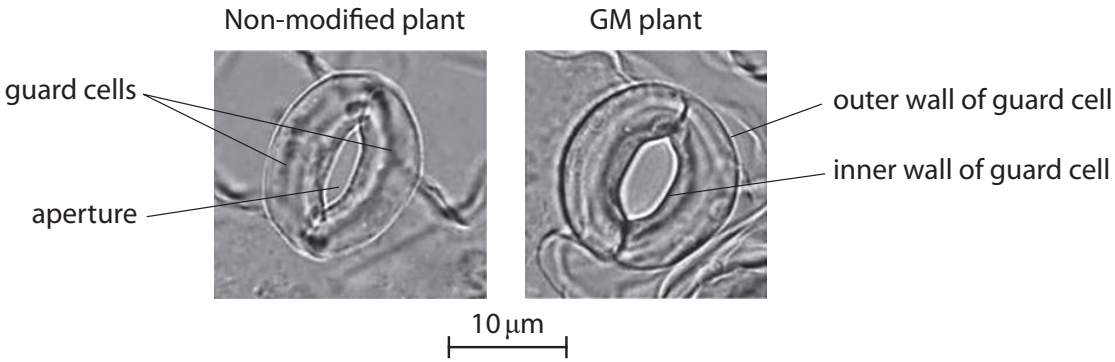
Analyse the data to explain the role of double fertilisation, xylem and phloem in the development of the berries.

(6)

8 Genetically modified (GM) crop plants have been produced that have stomata with a wider aperture than non-modified crop plants.

This difference in the width of the aperture is only evident in daylight.

The photographs show the appearance of each type of stoma in daylight.



Sourced from: http://www.aip.nagoya-u.ac.jp/en/public/nu_research/images/Wang_f1.jpg

(a) (i) Calculate the magnification of the GM plant photograph using the scale bar.

Give the answer in standard form.

(2)

Answer .....

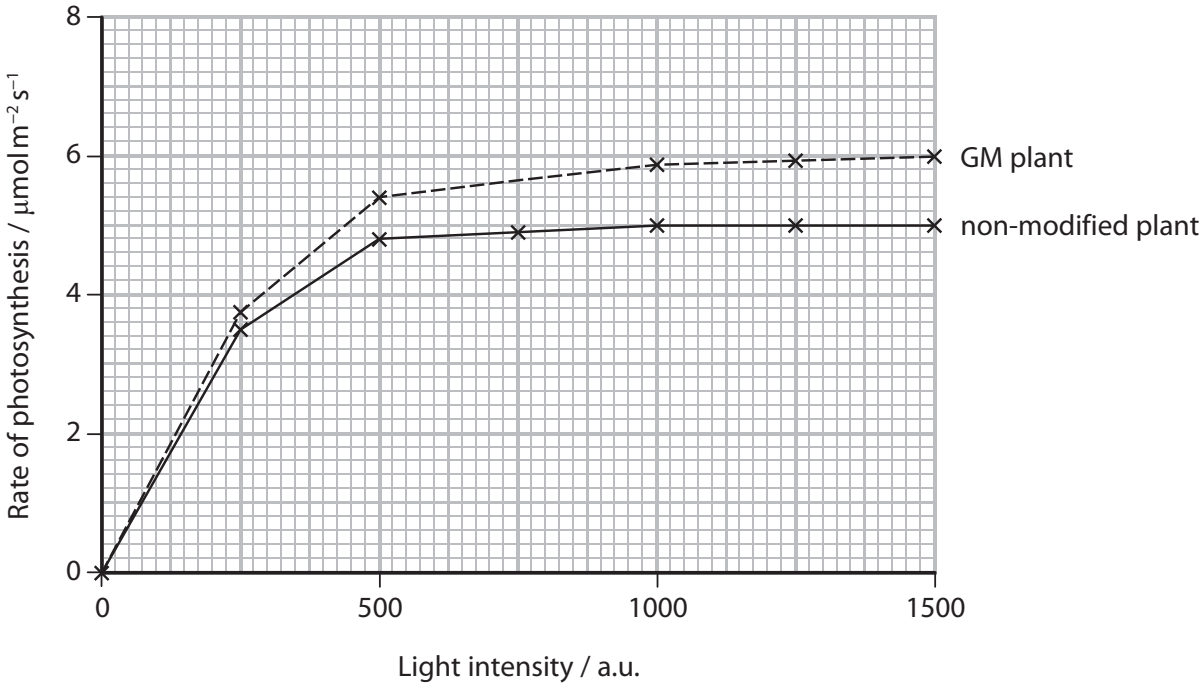
(ii) Calculate how many times wider the aperture of the stoma of the GM plant is compared with the stoma of the non-modified plant.

(1)

Answer .....

(b) An investigation was carried out to compare the effect of light intensity on the rate of photosynthesis in GM plants with the effect in non-modified plants.

The graph shows the results of this investigation.



(i) The rate of photosynthesis is expressed as $\mu mol\ m^{-2}\ s^{-1}$.

Describe what was measured to find the rate of photosynthesis.

(3)

(ii) Explain the results of this investigation.

(3)

(c) Explain why the wider stomata in GM crop plants could increase their yield.

(3)

(d) The flow chart shows some of the steps involved in opening the aperture of a stoma.

Hydrogen ions actively transported out of the guard cells

↓

Potassium ions diffuse into the guard cells

↓

Starch broken down into malate

↓

Water moves into the guard cells

↓

Aperture of the stoma widens

(i) What happens when hydrogen ions are actively transported out of the guard cells?

(1)

☒ **A** ADP and phosphate ions are converted into ATP by a hydrolysis reaction

☒ **B** ADP and phosphate ions are converted into ATP by a condensation reaction

☒ **C** ATP is broken down into ADP and phosphate ions by a condensation reaction

☒ **D** ATP is broken down into ADP and phosphate ions by a hydrolysis reaction

(ii) Which of the following explains why water moves into the guard cells?

(1)

☒ **A** malate lowers the water potential of the cytoplasm

☒ **B** malate raises the water potential of the cytoplasm

☒ **C** starch lowers the water potential of the cytoplasm

☒ **D** starch raises the water potential of the cytoplasm

(iii) Which of the following explains why the aperture of the stoma widens?

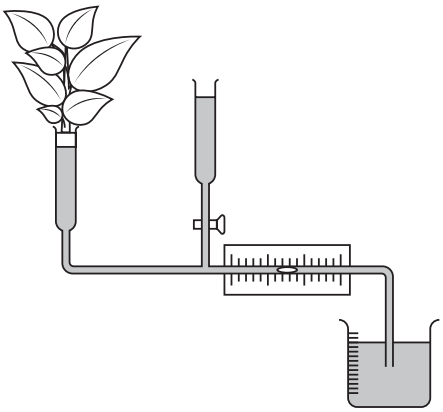
(1)

- ☒ **A** The guard cells become smaller and the inner wall of the guard cell is more flexible than the outer wall
- ☒ **B** The guard cells become smaller and the inner wall of the guard cell is less flexible than the outer wall
- ☒ **C** The guard cells become larger and the inner wall of the guard cell is more flexible than the outer wall
- ☒ **D** The guard cells become larger and the inner wall of the guard cell is less flexible than the outer wall

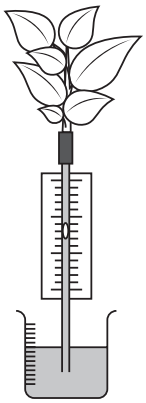
(Total for Question 8 = 15 marks)

8 A bubble potometer can be used to investigate the water uptake by a plant shoot under different environmental conditions.

The diagram shows two types of bubble potometer, A and B.



Potometer A



Potometer B

(a) State **one** advantage of using potometer A compared with using potometer B.

(1)

.....

.....

.....

(b) A student used potometer B and an electric fan to investigate the effect of air movement on the rate of water uptake by a leafy shoot.

The table shows the results obtained.

Fan speed setting	Rate of bubble movement / mm min^{-1}			
	1	2	3	Mean
off	42	38	43	41
low	63	58	60	60
medium	82	78	83	81
high	82	80	78	80

Explain the effect of changing fan speed on the rate of the air bubble movement.

(2)

(c) Some variables in this investigation are difficult to control.

These variables and other factors associated with the apparatus reduce the accuracy and validity of the results.

(i) Explain **one** variable that is difficult to control in this investigation.

(2)

(ii) Explain **one** factor that may reduce the accuracy of potometer B.

(2)

(d) The distance moved by the bubble in one minute can be converted to rate of water uptake in $mm^3\ min^{-1}$.

The volume of water taken up by the shoot can be calculated using the formula

$$v = \pi r^2 h$$

where v is the volume of water

r is the radius of the capillary tube and

h is the length in mm that the bubble has moved.

The capillary tube has a diameter of 1.0 mm.

(i) Calculate the mean rate of water uptake by the shoot when the fan speed setting was high.

Give your answer to two significant figures.

(3)

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

(ii) Describe how the student could determine the rate of water uptake per cm^2 of leaf surface.

(2)

(e) Describe how the student could use potometer B to measure the effect of temperature on the rate of water uptake.

(3)

MARK SCHEMES

official Pearson Edexcel mark schemes

Question Number	Answer	Additional Guidance	Mark
1(a)	**The only correct answer is A** **B** is incorrect because when ATP is hydrolysed it releases energy **C** is incorrect because ATP is hydrolysed not phosphorylated **D** is incorrect because ATP is hydrolysed not phosphorylated		(1)

Question Number	Answer	Additional Guidance	Mark
1(b)	**The only correct answer is A** **B** is incorrect because large hydrophobic molecules can diffuse through the phospholipid bilayer C is incorrect because small hydrophobic molecules can diffuse through the phospholipid bilayer **D** is incorrect because water passes by osmosis from a high solute potential to a lower solute potential		(1)

Question Number	Answer	Additional Guidance	Mark
1 (c)	An explanation that makes reference to the following: • (0 to 10 minutes) molecule A increases faster because active transport is faster than diffusion (1) • (20 to 30 minutes) concentration of molecule B levels off as there is no longer a {concentration/diffusion} gradient (1)	Accept A is transported by active transport and B by diffusion for 1 mark. Accept B has reached equilibrium/concentration equal inside and outside	(2)

Number	Answer	Additional Guidance	Mark
1(a)	An answer that makes reference to the following: **A** phospholipid (bilayer) and **B** (glyco) protein / (channel) protein / (integral) protein / (carrier) protein / (intrinsic) protein		**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An explanation that makes reference to four of the following: • polar molecules are {charged / water soluble / hydrophilic} (1) • {phosphate / head} is hydrophilic / {fatty acids / tails} are hydrophobic (1) • {phosphate / head} on outer side / {fatty acids / tails} on inside (1) • therefore {polar / charged / ionic} substances do not pass through the {hydrophobic centre / fatty acids / tails} (1) • and so pass through {carrier / channel} proteins (1)		**(4)**

Question Number	Answer	Additional Guidance	Mark
1(a)(i)	**The only correct answer is** C **A** is incorrect because magnesium ions are not incorporated into amino acids or nucleotides **B** is incorrect because magnesium ions are not incorporated into amino acids **D** is incorrect because magnesium ions are not incorporated into nucleotides		(1)

Question Number	Answer	Additional Guidance	Mark
1(a)(ii)	An explanation that makes reference to the following: • because water is {(di)polar } (solvent) (1) • ions form charged attractions / electrostatic attractions (with it) (1)	**ACCEPT** charged / hydrophilic **ACCEPT** form hydrogen bonds	(2)

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that makes reference to the following: • more nitrate ions are taken up in the presence of oxygen (1) • nitrate ions are taken up faster in the presence of oxygen (1) • Nitrates are taken up by (diffusion and) active transport in presence of oxygen/ nitrates only taken up by diffusion without oxygen present (1)	ACCEPT converse	(2)

	M
ıvolve water uptake	ɔt have a nucleus
⁄olve fusion of membranes	ɔt have a nucleus
does not involve the fusion of membranes	multicellular / is a kingdom

	Additional guidance			Additional guidance
lowing:	Accept converse		n / 15mm /	Example of calculation 15000 ÷ 20
)			d divides by 20 to get	= 750
ɾ enters cell	Ignore water potential is lower in solution / water potential similar			Correct answer gains full marks, w no working shown.

	Additional Guidance
	ACCEPT other correct ratios

	Additional Guidance	Mark
: permeability} (1) ntact (1) 0.2 and 0.4) (1)	**ACCEPT** dry but not if linked to dry mass **DO NOT ACCEPT** to calculate mean	**(3)**

	Additional Guidance
	y axis labelled 'percentage change in mass' / crossing 0% (1)

3 (a)	• large numbers of mitochondria (1) • to provide ATP for active uptake of {glucose / salts / amino acids} (1) • microvilli providing large surface area (1) • for many carrier proteins for {glucose / salts / amino acids} (1)	**Accept** correct named minerals	**4**

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	B ☒ **B** 1 and 3 *A is incorrect because facilitated diffusion does not move substances against a gradient* *C is incorrect because facilitated diffusion does not move substances between phospholipids* *D is incorrect because facilitated diffusion does not move substances against a gradient*		**1**

Question Number	Answer	Additional Guidance	Mark
3 (b)(ii)	C increased permeability of the collecting duct to water, producing more concentrated urine *A is incorrect because ADH increases the permeability of the collecting duct* *B is incorrect because ADH increases the permeability of the collecting duct* *D is incorrect because ADH results in more concentrated urine*		**1**

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to the following:		

Question Number			
1(a)(i)	• (calcium) pectate (1)	**IGNORE** middle lamella **DO NOT ACCEPT** any other molecule	(1)

Question Number	Answer	Mark
1(a)(ii)	**The only correct answer is C** ***A*** *is incorrect because statements 1 and 2 are correct and statement 3 is incorrect* ***B*** *is incorrect because statements 1 and 2 are correct and statement 3 is incorrect* ***D*** *is incorrect because statements 1 and 2 are correct and statement 3 is incorrect*	(1)

Question Number	Answer	Additional Guidance	Mark
1(b)	An explanation that makes reference to four of the following: • (decrease in concentration) due to K^+ {leaving (cell) / being used in synthesis of correct named molecule} **AND** (increase in concentration) due to K^+ being taken up (by cell) (1) • ions decrease {by (facilitated) diffusion / move down a concentration gradient} (1) • ions taken up by active transport (1) • (in aerobic conditions) oxygen available for aerobic respiration (1) • aerobic respiration generates (more) {ATP / energy} (1)	**PIECE TOGETHER** **ACCEPT** active transport cannot take place in anaerobic conditions **ACCEPT** converse **ACCEPT** converse	(4)

Question Number	Answer	Mark
1(a)(i)	**The only correct answer is D as V is cholesterol** *A is not correct because P is glycolipid* *B is not correct because Q is glycoprotein* *C is not correct because S is peripheral protein*	**(1)**

Question Number	Answer	Mark
1(a)(ii)	**The only correct answer is D as U is *integral protein*** *A is not correct because Q is glycoprotein* *B is not correct because R is phospholipid bilayer* *C is not correct because S is peripheral protein*	**(1)**

Question Number	Answer	Mark
1(a)(iii)	**The only correct answer is C as T allows water molecules into the cell** *A is not correct because P is glycolipid* *B is not correct because Q is glycoprotein* *D is not correct because U is cholesterol*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An explanation that includes the following points: • oxygen is a {small / uncharged/non-polar} molecule (1) • so enters cells by diffusion / from a high concentration to a lower one/ down a concentration gradient (1) • sodium is charged (1) • therefore enters {by a channel (protein) / by active transport / by facilitated diffusion} (1)	**Accept:** atom/particle **Reject** molecule / polar	**(4)**

(Total for Question 1 = 7 marks)

Answer	Additional Guidance	Mar
eference to five of the following: five concentrations of on (1) gth / shape / surface area to volume} of otato (1) tato {age / part of tissue / temperature} otato submerged in the solutions for the ces weighed before and after and dried (1) ange against (salt / sucrose) concentration where line cuts x-axis for carrot and potato	**Accept** locate isotonic point	**(5)**

	Additional Guidance	Mark
hree of the {move to / fuse arbohydrates /)	**Accept** quarternary structure formed / conjugated protein formed **Accept** package into vesicles	**(3)**

	Additional Guidance	Mark
the following: {increased diffusion / calcium ion channels oteins} limit rate (1) acilitated diffusion	**Accept** all calcium ion channels are being used	**(3)**

	Additional Guidance	Mar
	Do not accept nucleolus	**(1**

	Additional Guidance	Mar
	<u>Example of calculation:</u> magnification: 10 000 μm ÷ 1 μm = × 10 000 diameter: 54 mm ÷ 10 000 = 5.4 μm **Accept** range between 5.3 μm to 5.5 μm Correct answer with units gains full marks	**(2**

Number	Answer	Mark
2(a)(i)	**The only correct answer is B** ***A*** *is not correct because water does not leave the tissue* ***C*** *is not* correct because cells do not become flaccid **D** is not correct because *the cells will not burst*	**(1)**

Question Number	Answer	Mark
2(a)(ii)	**The only correct answer is C** ***A*** *is not correct because P will not decrease* ***B*** *is not correct because π will not decrease* ***D*** *is not correct because φ will change*	**(1)**

Question Number	Answer	Mark
2(a)(iii)	**The only correct answer is C** ***A*** *is not correct because the values are not 0 and 0* ***B*** *is not correct because the values are not -4.6 and 4.6* ***D*** *is not correct because the values are not 4.6 and 0*	**(1)**

Question Number	Answer	Mark
2(a)(iv)	**The only correct answer is B** ***A*** *is not correct because distilled water has a high water potential* ***C*** *is not correct because 0.1 molar sodium chloride does not have the lowest water potential* ***D*** *is not correct because 0.1 molar potassium chloride does not have the lowest water potential*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	An answer that makes reference to the following: • use 50% value / use term osmotic potential (1) • 0.43 (mol dm^{-3}) (1) • **-**1200 (kPa) (1)	 **ACCEPT** 0.42 to 0.44 **ACCEPT -**1120 to **-**1280	**(3)**

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that makes reference to the following: • time for water to move out of the cells / time for osmosis / to complete osmosis / reach equilibrium / time for plasmolysis to occur (1) • therefore accurate value of osmotic potential (1)		**(2)**

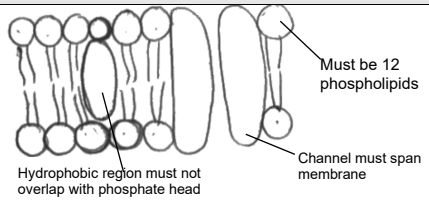
Question Number	Answer	Additional Guidance	Mark
4(a)(i)	**B** matrix	**A** is incorrect because crista are folds in the membrane **C** is incorrect because stroma is in chloroplasts **D** is incorrect because thylakoids are in chloroplasts	

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An explanation that makes reference to the following: • because the resolution of the microscope used for **P** is {lower / worse} (1) • to distinguish {the small distance between the two membranes / the membranes as separate structures} (1)	**ACCEPT** converse for **Q** throughout **DO NOT ACCEPT** magnification **ACCEPT** (inter membrane) space can be seen between membranes / the inner and outer membrane can be seen/ two lines can be seen	

Question Number	Indicative content
***4(b)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: • membranes both made of phospholipid bilayer with embedded proteins • lipid content is the phospholipid bilayer • phospholipids needed for {fluidity / compartmentalisation} • higher protein : lipid ratio in the inner membrane / more protein compared to lipid in the inner membrane • protein content equals lipid content in outer membrane • role of inner membrane is oxidative phosphorylation / chemiosmosis / synthesise ATP • inner membrane contains proteins involved in electron transport • inner membrane contains ATPase channels • movement of protons through ATPase channels results in ATP formation • proteins in outer membrane to allow pyruvate to pass through

Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain description of membrane structure 1 mark = 2 points 2 marks = 3 points
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages between the two membranes and their lipid and protein content 3 marks = explanation of ATPase or electron transport proteins or outer membrane 4 marks = explanation of two from ATPase, electron transport proteins, outer membrane
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which relates named protein molecules to the high protein content of the inner membrane 5 marks = explanation of ATPase, electron transport proteins and outer membrane 6 marks = clear, accurate account of oxidative phosphorylation

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	**The only correct answer is B** **A** is incorrect because R is the hydrophilic phosphate and S is the hydrophobic fatty acid **C** is incorrect because R is the hydrophilic phosphate and S is the hydrophobic fatty acid **D** is incorrect because R is the hydrophilic phosphate and S is the hydrophobic fatty acid		(1)

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	An answer that makes reference to the following: • 12 phospholipids arranged in a bilayer and channel protein spanning the width of the bilayer (1) • cholesterol drawn showing hydrophilic region {in / adjacent} to phosphate heads and hydrophobic region in amongst fatty acids (1)		(2)

Question Number	Answer	Additional Guidance	Mark
4(a)(iii)	A description that makes reference to the following: • to provide a hydrophilic channel (through the bilayer) (1) • for facilitated diffusion (1)	Accept allow movement of {hydrophilic molecules/large/polar/charged molecules/ions}	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An answer that makes reference to the following: • as temperature increases the permeability increases (1) • (presence of cholesterol) decreases permeability / increase in cholesterol decreases permeability (1)	Accept converse – no cholesterol, membrane is more permeable	(2)

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An explanation that makes reference to the following: • (Low heat energy of phospholipids) so very little kinetic energy (1) • phospholipids do not move so {molecules not able to/less pass through/ low rate of diffusion} (1)	Accept other terms e.g less fluid eq to do not move	(2)

l Guidance	Mark
rse statement	(3)

ver	Additional Guidance	Mark
the following: n gradient / from low to high (1) (1)	IGNORE from low concentration gradient to high concentration gradient	(2)

ver	Additional Guidance	Mark
e to the following: by) **osmosis** (1)	ACCEPT converse for epithelial cells	
loride ions / salt / solute} (1) the cell}	ACCEPT solute potential decreases {in intestine / outside the cell}	
ential (in the intestine) (1)		(3)

ver	Additional Guidance	Mark
e to the following: (1)	ACCEPT less space / reduced pathway	
less air enters alveoli / less gas gradient / less diffusion (into (1)		(2)

Number	Answer		Additional Guidance	Mark
7(a)	• surface area calculated • volume calculated • surface area to volume ratio calculated	(1) (1) (1)	28 8 3.5 : 1 unsimplified but correct ratio with no working = 2 max allow 2 for 3.5 alone	(3)

Question Number	Answer	Additional Guidance	Mark
7(b)	• A then B then C		(1)

Question Number	Indicative content	Mark
*7(c)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • use different shapes / surface area / lengths • place in water • use several chips of each shape / surface area / length • leave for stated time / 10 mins minimum • control temperature • control potato / species / strain / age • measure mass / volume of potato / volume of liquid absorbed • calculate mean values • submerge in water • potato chips blotted before weighing • control mass / volume of potato • calculate rate as g min^{-1} or cm^3 min^{-1}	(6)

Level	Marks	Descriptor
0	0	No awardable content
1	1-2	An explanation of how the investigation should be conducted but with limited analysis, interpretation. Generalised comments made. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. **L1 = 1 2 or more L1 = 2**
2	3-4	An explanation of how the investigation should be conducted with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. **2 or more L1 + 1L2 = 3 2L1 + 2 or more L2 = 4**
3	5-6	An explanation of how the investigation should be conducted is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured. **2L1 + 2 or more L2 + 1L3 = 5** **2L1 + 2 or more L2 + 2L3 = 6**

Question Number	Answer	Additional Guidance	Mark
6(a)	A description that makes reference to the following: • glycerol attached to two fatty acids (by ester bonds) (1) • and one phosphate attached to glycerol (1)	**ACCEPT** from a labelled diagram **NB** made from one glycerol two fatty acids and one phosphate = 1 mark if neither mark awarded	(2)

Question Number	Answer	Additional Guidance	Mark
6(b)	An explanation that makes reference to the following: • because the {two polar groups / outside layers} will interact with the aqueous environment (on each side of membrane) (1) • rest of molecule will provide hydrophobic barrier / there will be a hydrophobic layer (inside) (1)	**ACCEPT** form H bonds with water	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)(i)	• 1.5 (%)		(1)

Question Number	Answer	Additional Guidance	Mark
6(c)(ii)	A description that makes reference to two of the following: • bacteria with higher optimum growth temperatures have a greater percentage of branched chain fatty acids (1) • the greater the percentage of branched chain fatty acids the greater the range of optimum growth temperature (1) • an optimum growth temperature of more than 40°C needs at least 30% of branched chains (1)	**ACCEPT** positive correlation between optimum growth temperature and percentage of branched-chain fatty acids converse **ACCEPT** bacteria with optimum temperature between 20°C and 40°C had the greatest range in percentage of branched-chain fatty acids converse	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)	An explanation that makes reference to the following: • because membranes control {permeability / what can enter and leave the cell} (1) • such as {uptake of nutrients / uptake of oxygen / removal of waste products} (1) • because membranes need to be fluid for {movement / cell division} (1)	**ACCEPT** converse i.e. what would happen if membrane composition did not change **ACCEPT** membranes become more {permeable / leaky} at higher temperatures **ACCEPT** named nutrients / waste products	(3)

Number	Answer	Additional Guidance	Mark
6(a)(i)	An answer that makes reference to : • axes the correct way around with linear scale and labelled {concentration of sucrose and distance or S or sag} (1) • correct units sucrose concentration mol dm^{-3} and S mm (1) • points plotted correctly and joined (dot to dot) (1)	Allow dot to dot or smooth curve allow points plotted on non linear scale	(3)

Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	a calculation showing the following steps • calculation of difference between 0.2 and 0.4 • calculation of mean relationship	=7.5mm 7.5 ÷ 0.2 = 37.5 allow one mark for 7.5	(2)

Question Number	Answer	Additional Guidance	Mark
6(a)(iii)	An explanation that makes reference to the following points : • as concentration increases S increases (1)		(4)
	• At / above 0.2 mol the potato starts to lose water as water potential of potato higher than solution (1) • so (as water leaves cells) tissues turgor is lost so more S / distance / sag (1) • little change in S above 0.45 mol (as little water loss) (1)	new MP for overall analysis ignore incorrect ref to turgor increasing for this mp possibly delete these mps	

Question Number	Answer	Additional Guidance	Mark
6(b)	An answer that makes reference to two of: • reference to repeats / calculation of mean (1) • no reference to from same type potato / same temperature / same mass of potato (1) • difficult to measure sag /parallax / how clamped / sag may be due to other reasons (1)		(2)

(Total for question 6 = 11 marks)

Question Number	Answer	Mark
5(a)(i)	**The only correct answer is** **C facilitated diffusion** *A is not correct because it does not enter via active transport* *B is not correct because it does not enter via diffusion* *D is not correct because it does not enter via osmosis*	**(1)**

Question Number	Answer	Mark
5(a)(ii)	**The only correct answer is** D 1, 2 and 3 ***A** is not correct because statement 1 2 and 3 are correct* ***B** is not correct because statement 1 2 and 3 are correct* ***C** is not correct because statement 1 2 and 3 are correct*	**(1)**

Question Number	Answer	Mark
5(a)(iii)	**The only correct answer is** **B** a form of active transport in which large particles move out of cells ***A** is not correct because it is not transport into cells* ***C** is not correct because it is not passive transport* ***D** is not correct because it does not passive transport into cells*	**(1)**

Question Number	Answer	Mark
5(b)(i)	An explanation that makes reference to the following: • 60 ^{O}C as it shows the greatest range of absorbance / allow calculation of range (1) • 60 ^{O}C as it has the highest standard deviation (2)	**(2)**

Question Number	Answer	Additional guidance	Mark

5(b)(ii)	A calculation that shows: calculation of numerator divide by 7 calculation of s 0.01852 or 0.0185 or 0.02 scores 3	example calculation allow 1 mark for divide by 7 allow two marks for **0.000343** 0.01852 **Allow full marks for correct answer with no working**	**(3)**

Question Number	Answer	Mark
5(b)(iii)	An explanation that makes reference to three of the following: • as temperature increases the membrane permeability increases gradually then greater after 50^0 C (1) • (gradually at first) due to increased kinetic energy of pigment molecules (1) • as temperature increases the fluidity of membrane increases due to movement of phospholipids/ reduced bonding attraction between phospholipids (1) • (greatest increase above 50^0 C) as then the proteins in cell membrane start to denature and (more) pigment molecules escape (1)	**(3)**

(Total for Question 5 = 11 marks)

Question Number	Answer	Mark
6(a)	• P = turgor pressure (1) • π = osmotic potential (1)	**(2)**

Question Number	Answer	Mark
6(b) (i)	• 12	**(1)**

Question Number	Answer	Mark
6(b)(ii)	• points plotted correctly (1) • correct linear axes labelled with units (1) • straight lines joining points / allow line of best fit (1)	**(3)**

Question Number	Answer	Mark
6(b)(iii)	• correct value read of graph at 50% plasmolysis (1) 0.44-0.48	**(1)**

Question Number	Answer	Mark
6(b)(iv)	• corresponding value derived from table / Answer between 0.4 and 0.5 for molarity • units quoted as kPa / kPa **-1130--1460 (1)** **units kPa (1)**	**(2)** **allow 1 mark for answer without units** **units and wrong answer no mark**

Question Number	Answer	Mark
6(c)	An explanation that includes two of the following • At incipient plasmolysis cell wall is not touching cell membrane (1) • so turgor pressure P = 0 (1) • so osmotic potential of cell contents / π = water potential of cell / ψ (1)	**(2)**

(Total for Question 6 = 11 marks)

k
k
k

Answer	Additional Guidance	Mark
es reference to the following: {lowers the water potential / ates a concentration gradient / ential gradient} (1) oves in (to mucus) by osmosis (1)	**Accept** out (of cells)	**(2)**

Answer	Additional Guidance	Mark
es reference to the following: no concentration gradient / isotonic } (1) ot move / no osmosis (1)	**Do not accept** references to pure water	**(2)**

Answer	Additional Guidance
ference to the following: (1) age of carriers (1)	Example of calculation: $q^2 = 0.0004 / 4x10^{-4}$ q = 0.02 and p = 0.98 2pq = 0.0392 percentage of population who are carriers is 3.92% Correct answer with no working gains full marks

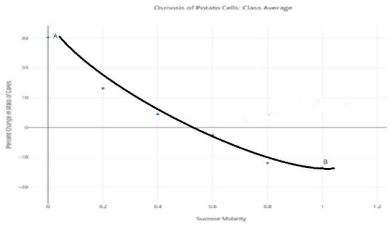
Answer	Additional Guidance
ference to the following: ather is) CC (1) each parent (1) offspring are CC and Cc (1) ing a carrier is 50% / 0.5 / ½ / 1:1 (1)	 Minus 1 if same letter not used or more than one letter to represent allele Sex inheritance loses mp1 and loses 1 mark for not using same letter

Question Number	Answer	Mark
4(a)(i)	**The only correct answer is B endocytosis** ***A*** *is not correct because diffusion does not require energy from respiration* ***C*** *is not correct because facilitated diffusion does not require energy from respiration* ***D*** *is not correct because* osmosis *does not require energy from respiration*	**(1)**

Question Number	Answer	Mark
4(a) (ii)	**The only correct answer is A active transport** ***B*** *is not correct because diffusion is not against a concentration gradient* ***C*** *is not correct because facilitated diffusion is not against a concentration gradient* ***D*** *is not correct because osmosis is not against a concentration gradient*	**(1)**

Question Number	Answer	Mark
4(a)(iii)	**The only correct answer is A active transport** ***B*** *is not correct because diffusion does not show this response to oxygen* ***C*** *is not correct because facilitated diffusion does not show this response to oxygen* ***D*** *is not correct because osmosis does not show this response to oxygen*	**(1)**

Question Number	Answer	Mark
4(a) (iv)	**The only correct answer is B carbon dioxide** ***A*** *is not correct because amino acids cannot enter a cell by diffusion* ***C*** *is not correct because glucose cannot enter a cell by diffusion* ***D*** *is not correct because protein cannot enter a cell by diffusion*	**(1)**

Question Number	Answer	Additional guidance	Mark
4(b) (i)	• a curve or straight line passing through / near all points		**(1)**

Question Number	Answer	Additional guidance	Mark
4(b)(ii)	• value read from student's graph 0.475-0.575	allow TE from student line	**(1)**

Question Number	Answer	Additional guidance	Mark
4 (b)(iii)	An explanation that makes reference to four of the following points: • water enters cell by osmosis (1) • as water potential of solution higher than ψ / water potential cell (1) • so that P / turgor pressure increases (1) • so ψ water potential cell becomes equal to 0. • until P / turgor pressure equals π / osmotic potential / and opposite (1) • as cell wall prevents further entry of water (1)	increases change in cell osmotic potential negligible	**(4)**

Question Number	Answer	Additional guidance	Mark
4 (b)(iv)	An explanation that makes reference to two of the following points: • cannot measure π / osmotic potential directly as ψ water potential of cell contains both π / osmotic potential and turgor pressure / P (1) • can only be measured by using method of incipient plasmolysis (1) • when ψ = π as P =0 (1)		**(2)**

(Total for Question 4 = 12 marks)

Number	Answer	Additional Guidance	Mark
7(a)	An answer that makes reference to the following: • osmosis is occurring (1) • at 3%, water has left the red blood cells (by osmosis) (1) • at 0.5% and 0.3%, water has gone into the cells (by osmosis) (1) • at 0.5% and 0.3% the cells have burst (and cannot be seen) (1) • 0.7% is close to the water potential of the cells' cytoplasm (1)	Allow correct reference to {hypertonic / hypotonic / isotonic} solution or to water potential Allow at 3% water leaving RBC by diffusion Allow water potential of cells' cytoplasm is between 0.7 and 1%	**(4)**

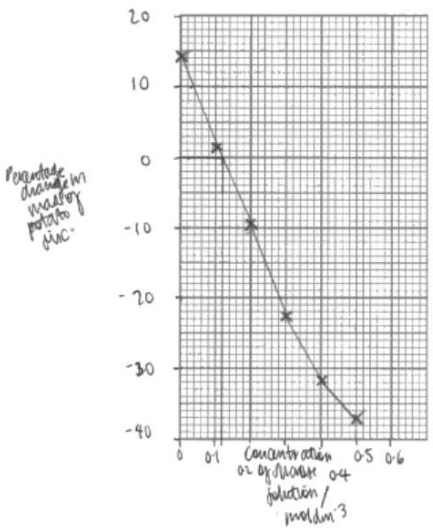
Question Number	Answer	Additional Guidance	Mark
7(b)	An explanation that makes reference to the following: • the osmotic potential of the red blood cells is equivalent to 3% glucose or 6% sucrose (1) • because the molecular mass of sucrose is twice that of glucose (1) • because it is the number of molecules that determine the osmotic potential, not % concentration (1)	Allow twice the concentration of sucrose is needed to have the same effect Accept sucrose as a disaccharide whereas glucose is a monosaccharide	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(c)(i)	An answer that makes reference to the following: • hypothalamus		**(1)**

Question Number	Answer	Additional Guidance	Mark
7(c)(ii)	An explanation that makes reference to four of the following: • sweating occurs causing loss of water from the blood (1) • therefore the water potential of the blood falls (1) • osmoreceptors are stimulated (1) • causing the pituitary gland to secrete {antidiuretic hormone / ADH} (into the blood) (1) • causing the {collecting ducts / kidney tubules} in the kidney to reabsorb more water (into the blood) (1)		**(4)**

Number	Answer	Additional Guidance	Mark
6(a)(i)	A calculation which includes the following: • correct answer (1)	(Ψ = 400 + (-500)) = - 100	**(1)**

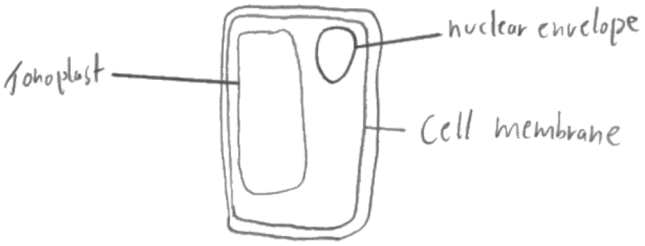
Question Number	Answer	Additional Guidance	Mark
6(a)(ii)	An explanation that includes two of the following: • (water moves) out (of cell) by **osmosis** (1) • (because water moves) from an area of {high / higher} water potential to an area of {low / lower} water potential (1)	**Allow ecf from 6ai** Accept water moves from -100 kPa to -400 kPa by osmosis Accept water moves down a water potential gradient Accept correct answers expressed in terms of {concentration of water / osmotic potential / solute concentration / hypotonic / hypertonic}	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	An answer that includes the following: • axes correctly orientated and labelled with units (1) • all values accurately plotted on linear scale (1) • points joined with straight lines (1)	Example graph 	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An answer that includes the following: • correct intercept obtained (1)	(Molarity =) 0.11 - 13	**(1)**

Question Number	Answer	Additional Guidance	Mark
6(b)(iii)	An answer that includes five of the following: **Strengths:** • use of cork borer to give {standard / equal} size pieces (1) • cut into discs to increase surface area (1) • 12 hours was enough time for osmosis to occur (1) • all discs taken from the same tuber (1) • range of concentrations used {was appropriate / gave positive and negative values} (1) **Weaknesses:** • discs must be submerged in sucrose solution (1) • discs should be the same {width / thickness / size} (1) • only one disc in each solution (so mean could be calculated) (1) • discs should be blotted dry (before being reweighed) (1) • test more molarities near intercept point (1) • temperature should be controlled (1) • need to use a conversion table to get the {osmotic / water} potential (1)	**At least one strength and one weakness for maximum marks** Accept same surface area for equal size Accept no further movement of water occurs Accept only one potato was used Accept use an equal volume of sucrose solution (for each concentration) Accept repeats Accept smaller intervals of molarities should be tested Accept need to convert concentrations to {osmotic / water} potential	**(5)**

(Total for Question 6 = 12 marks)

3(a)(i)	• drawing of cell containing cell wall, vacuole and nucleus (1) • three membranes correctly labelled (1)	 Shape of cell does not matter – can include other structures Do not accept chloroplasts eg tonoplast, cell (surface) membrane, nuclear membrane / envelope, ignore mitochondrial / Golgi / chloroplast membrane	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	An answer that includes the following • phospholipid bilayer (1) • proteins embedded / protein channels (1)	 Accept integral / intrinsic / carrier proteins Accept correct detail of named organelle membrane	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	A description that contains two of the following: • as temperature increases <u>absorbance</u> increases (until 50C) (1) • increase is greatest between 40°C and 50°C (1) • (absorbance) {levels off / plateaus} {at / above} 50°C (1)	Ignore permeability Accept converse Accept positive correlation between absorbance and temperature increase Accept increase is sigmoid / not linear Ignore mean is lower at 60°C	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An explanation that contains **one of the following**: • increasing temperature causes increased permeability (1) • betalain (molecules) can pass through the {tonoplast / cell membrane} if it is {disrupted / gaps form} (1) **and one from:** • as temperature increases membrane becomes more fluid (1) • above 40°C proteins in the membrane are denatured (1)	Accept pigment for betalain Accept betalain (molecules) cannot pass through the {tonoplast / cell membrane} unless it is disrupted Accept as temperature increases membrane is disrupted Accept at <u>higher</u> temperatures proteins in the membrane are denatured Ignore references to enzymes	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that includes four of the following: • less than 20cm^3 water in boiling tube (1) • different beetroot used (1) • beetroot pieces may be longer than 1cm (1) • beetroot pieces may not have been rinsed (1) • beetroot pieces may have been left in tubes longer than 20 minutes (1) • tubes may have been shaken (1) • example of incorrect use of colorimeter (1)	**Answers must be consistent with higher absorbance ie directional** Accept ref to slanted ends / larger surface area Ignore blotted dry Accept left for in tubes for too long Accept cylinder may have been damaged / squeezed as it was removed from tube Accept cuvettes scratched / have fingerprints incorrect filter used colorimeter not zeroed	**(4)**

(**Total for Question 3 = 12 marks**)

Number	Answer	Additional Guidance	Mark
5(a)(i)	A description that includes the following: • correct ratio (3:1) (1) • {correct volume of stock solution and water / make up other volumes in correct ratio and use 10cm^3} (1)	Accept any correct eg 15 cm^3 and 5 cm^3 7.5 cm^3 stock and 2.5 cm^3 water Accept 7.5 cm^3 stock and make up to 10 cm^3 (using measuring cylinder / volumetric flask)	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	An answer that includes the following: • axes correctly orientated and labelled with units (1) • all values accurately plotted on linear scale (1) • scattergraph with straight line joining points (1)	Must be Mean % of plasmolysed cells Allow tolerance of half a small square	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(a)(iii)	An answer that includes the following: • correct value for 50% plasmolysis (1)	0.37 (mol dm^{-3}) Accept range of 0.36 – 0.38	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(a)(iv)	An answer that includes the following: • correct value for 0.37 mol dm^{-3} (1)	**Allow ecf from 5aiii** - 980 (kPa) (+ or – 20 of any value which matches their answer to 5aiii) Do not accept + values	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(a)(v)	An answer that includes: water potential = turgor pressure + osmotic potential (1)	Accept $\Psi = P + \pi$ $\Psi = \Psi_P + \Psi_S$ Accept solute potential for osmotic potential	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(a)(vi)	An answer that includes the following: • correct value for water potential (1)	**Allow ecf from 5aiv** - 980 (kPa)	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that includes the following: • (tissue collected from same onion) as different onions may have (cell sap with a) different {osmotic / solute} potential (1) • (all tubes kept in waterbath) as temperature affects rate of osmosis (1) • (count more than one field of view) as it may not be representative (1)	Accept different onions may have (cells with) different water potential Accept correct directional answer eg as temperature increases, rate of osmosis increases Accept to increase sample size to calculate standard deviation to identify outliers / anomalous results	**(3)**

Total for Question 5 = 12 marks

Answer	Additional Guidance	Mark
eference to the following: ance value (1) sorbance value (1)		(2)

eptable Answers	Additional Guidance	Mar
es reference to the following:) esence of chlorophyll (1)		(2)

eptable Answers	Additional Guidance	Mar
es reference to the following: gment} was present (1) re damaged /		(2)

Answer	Additional Guidance	Mar
es reference to the following: amages / dissolves / affects} ane eable / allows pigment out} (1)		(2)

Answer	Additional Guidance	Mark
eference to five of the following: age / same position on plant} because this of pigment (1) the same part of the leaf because this of pigment (1) . / size of leaf disc / diameter of leaf disc} oncentration of pigment (1) e because temperature affects the rate of ethanol so chlorophyll is diluted the same l concentration to sistent / identify anomaly / deviation / allow statistical test} (1) pigment (1)		(5)

9BIO3

9BIO3

	Additional Guidance	Mark
g: enter by diffusion (1) (1) ytosis / exocytosis / vesicles (1)		(3)

	Additional Guidance	Mark
ce}		(1)

Answer
cells
spholipid
s lipid soluble molecules from entering the cell

Answer
holesterol
holesterol
holesterol

	Additional Guidance	Mark
	ving: ity} (1))	(2)

	Additional Guidance	Mar
	ing: lues /	(1)

	Additional Guidance	Mark
	ared	(2)

	Additional Guidance	Mar
	r; r} (1)	(2)

	Additional Guidance	Mark
	Example of calculation 0.42 ÷ 6 = 0.07 square root of 0.07 = 0.26 Correct answer with no working gains full marks **ACCEPT** one mark for 0.42 / 0.418/ 0.4184 in working	(2)

(Total for Question 2 = 13 ma

Number	Answer	Additional Guidance	Mark
7(a)(i)	A description that includes three of the following: • moved {across membrane / into cell / into root} by carrier proteins (1) • against a concentration gradient (1) • using ATP (1)	Ignore channel proteins Accept from a low to a high concentration	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	A description that includes the following • suitable mineral ion named (1) • appropriate function given (1)	eg **nitrate / (ammonium)** – formation of amino acids / proteins / enzymes / nucleic acids / nucleotides / DNA / RNA / chlorophyll **phosphate** – formation of nucleotides / nucleic acids / DNA / RNA / ATP / ADP / amino acids **calcium** – formation of middle lamella / calcium pectate **magnesium** – formation of chlorophyll Accept other correct mineral ions with correct functions	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	there is no difference in the (mean) height of {*Galium verum* / Lady's bedstraw} growing in meadows and dunes (1)	Accept no significant difference in the (mean) height of {*Galium verum* / Lady's bedstraw} growing in meadows and dunes	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	An answer that includes the following: • use of random numbers to select sampling site (1) • use of (frame or point) quadrat (to define sampling area) in meadow and dune (1) • measurement of {height / length} of {*Galium verum* / Lady's bedstraw} (1) • large sample size or use of running mean (1) • attempt to control relevant named variable (1)	Accept description of setting up grid and using co-ordinates for random sampling Accept closest plant to point selected in meadow and dune eg at least 10 plants in each place eg shading / slope / grazing / trampling / time of year / use of herbicide Ignore soil type / pH / temperature / time of day	**(5)**

Question Number	**Answer**	**Additional Guidance**	**Mark**
7(b)(iii)	An explanation that includes the following • t-test (1) • (because it) tests for the difference between the means of two sets of values (1)	Accept other suitable test eg Mann Whitney U test Accept it tests for a (significant) difference between two sample sets	**(2)**

Total for Question 7 = 13 marks

Question Number	Answer	Additional Guidance	Mark
9(a)(i)	An explanation that makes reference to the following: • phosphate heads are {polar / charged / hydrophilic}, so interact with / face the aqueous environment (inside and outside of cell) (1) • fatty acid tails form a {non-polar / hydrophobic } barrier / layer (on inside) (1) • (so control the) movement of { polar/charged / non-lipid soluble / water soluble } molecules into and out of the cell (1)	**Accept** waterproof layer **Accept** (only) allow lipid soluble molecules through	(3)

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	• number of phospholipids in 1 μm^2 calculated (1) • number of phospholipids in bilayer given (1) • answer in standard form (1)	Example of calculation: 1 000 000 ÷ 0.3 = 3 333 333.3333 **1** mark for 1 000 000 ÷ 0.3 / 3 333 333.3333 **Accept** x 2 as ecf from mp 1 3 333 333.3333 × 2 = 6 666 666.7 / 6 666 666.67 **2** marks for 6 666 667 /6 666 666.67 **Accept** answers in standard form as ecf for mp1 or 2 **2** marks for 3.3 x10^6 6.7 × 10^6 with no working out gains 3 marks	(3)

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	A description that makes reference to the following: • number of carbons/hydrogens in the fatty acid tail (1) • the number of carbon carbon double bonds (1)	**Accept** length of fatty acid tail /different R group chain **Accept** some are saturated / monounsaturated / polyunsaturated **Accept** different alcohol groups attached to phosphate **Accept** some have only one fatty acid tail and some have more	(2)

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An answer that makes reference to three of the following: **Similarities (max 2)** • all contain all four types of phospholipid (1) • A is the commonest in all four types of membrane (1) • B has the second highest percentage in all four types (1) **Differences (max 2)** • each membrane has a different { ratio/ percentage } of the four types of phospholipid (1) • C has the lowest percentage in the cell membrane and D has the lowest percentage in the other types of membrane (1) • the relative proportions of B, C and D are different in the cell membrane compared with the other three types of membrane (1)	**Accept** D is lowest in all except the cell membrane **Accept** description of the order of the types	(3)

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference to the following: • when vesicles containing { proteins / (poly)peptides / lipids / steroids } from the endoplasmic reticulum fuse with the Golgi apparatus (1) • some of the membrane of the Golgi apparatus comes from the endoplasmic reticulum (1)	**Accept** vesicles from ER move to the Golgi apparatus where proteins are modified	(2)

Question Number	Answer	Additional Guidance	Mark
6(a)	An answer that includes the following: • movement of water from a region of high(er) water potential to a region of lower water potential (1) • through a partially permeable membrane (1)	**Ignore** dilute to concentrated **Accept** semi-permeable membrane	**(2)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	• Calculation of Volume (1) • Calculation of ratio (1) • Answer to one decimal place (1)	**Example of calculation** Vol = 3.93cm3 **Do not accept 3.92 cm³** SA/Vol = 17.3/3.9 = 4.402 4.4:1 **Correct answer gets 3 marks** 2 marks ecf for 3.92 cm^3 2 marks 1:0.2 2 marks π=3.1 Vol = 3.875 Ratio = 4.5:1	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b) (ii)	• calculation of Σ(x-mean)^2 (1) • calculation of S (1) • calculation of √S 1.1 (1)	Example of calculation 4.99 or 5 (1) 1.2475 or 1.25 (1) √1.2475 = 1.1169 √1.25 = 1.118 3 marks =1.1 Correct answer gains full marks.	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b) (iii)	An explanation that includes 5 marks out of the following: • as temperature increases so does the percentage change in mass of cylinders (1) • due to increased kinetic energy (of water molecules) (1) • so water diffuses by osmosis into potato faster (1) • as fewer intermolecular bonds / hydrogen bonds between water molecules (1) • shown by decrease in water viscosity with increased temperature (1) • changes in membrane structure increased permeability (1)	**Accept** (increased K.E) breaks H-bonds **Accept** named changes to do with temp e.g. increased movement of phospholipids, denaturing of membrane proteins	**(5)**

(Total for Question 6 = 13 marks)

9 (a)	N		**(1)**

Question Number		Additional Guidance	Mark
9 (b)	An explanation that makes reference to four of the following: • (because) there are more species of woody plants in the older hedges (1) • If hedges were destroyed {there would be a large loss of biodiversity / many species would be lost} (1) • older hedges provide more niches (1) • (so that) more species of {invertebrates / vertebrates / animals / plants} (are associated with older hedge) (1) • (Therefore) hedges provide {shelter / food / nesting sites} / allow safe movement of animals (for {interbreeding / genetic variation}) (1)	Accept there is a positive correlation Accept if hedges were destroyed it would take a long time {for biodiversity to recover / for species number to recover} / if hedges are destroyed there are less niches Accept some plants are found only in older hedges Accept biodiversity increases as age of hedge increases	**(4)**

Question Number	Answer	Additional Guidance	Mark
9 (c)	• avoid {bias / underestimate / overestimate} (1)	Accept to get a representative sample	**(1)**

Question Number	Answer	Additional Guidance	Mark
9 (d)(i)	An answer that makes reference to one of the following: • stems are {stronger / less likely to break / better supported} • more {mineral ion / water} transport (1)		**(1)**

Question Number	Answer	Additional Guidance	Mark
9 (d)(ii)	A description that makes reference to three of the following: • cut thin sections (of the stem) (1) • from same height of stem in young and old plants (1) • {use a stain / named stain} to see xylem (1) • measure thickness of xylem tissue (1)	Accept cut a core (if rings are being measured) Measure thickness of {rings / xylem} 1 mark if potometer used in method	**(3)**

Question Number	Answer	Additional guidance	Mark
9 (e)	An answer that makes reference to five of the following: • cut potato into chips of same size as this {gives equal surface area (to volume ratio) / affects osmosis} (1) • place potato chips in range of {salt / sucrose} solutions to allow {osmosis / water to enter / water to leave} (1) • blot chips to remove surface water (1) • measure (percentage) change in {mass / length} and {determine loss or gain of water / plot graph} (1) • identify where line crosses x axis as this represents {no change in mass / length / the estimate of water potential} (1) • compare these lines for different ages of potato tissue (1) • use same temperature as this affects {osmosis / diffusion} / leave potato for same time in solutions as this affects {osmosis / diffusion} / use same {potato / variety of potato} as this affects {water potential / osmosis / diffusion} (1)	Accept use a cork borer to give samples of standard size (linked to SA or osmosis) Accept dry using a paper towel Accept measure initial {length / mass} and final {length / mass} to find change	**(5)**

Question Number	Answer	Additional guidance	Mark
8(a)	A description that makes reference to the following: • diffusion - the movement of molecules / ions / particles down a concentration gradient (1) • facilitated diffusion - the movement of molecules / ions / particles down a concentration gradient via specific transmembrane integral proteins / channels / carrier molecules (1) • osmosis - the movement of water down a water potential gradient (through a partially permeable membrane) (1)	allow high to low water conc.	**(3)**

Question Number	Answer	Mark
8 (b)(i)	An answer that makes reference to: • to remove excess pigment (on surface of discs) (1)	**(1)**

Question Number	Answer	Mark
8(b)(ii)	An explanation that makes reference to two of the following: • maintain the discs at the same constant temperature / control temperature / stop temperature affecting permeability (1) • temperature may cause {changes in membrane structure / denature proteins in membrane / lipid bilayer} causing pigment to leak out (1)	**(2)**

Question Number	Answer	Additional guidance	Mark
8(b)(iii)	$\Sigma (x - x)^2$ (1) substitution and division square root to obtain SD = 0.09 (3)	Example of calculation 0.0388 ÷ 5 = 0.00776 √0.00776 = 0.09 **Allow** 1 mark for 0.0388 or 0.00776 **Allow** 1 mark for dividing by 5 **Allow** 2 marks for 0.088 etc	**(3)**

Question Number	Answer	Acceptable answers	Mark
8 (b)(iv)	• 0 %	**0 / zero / distilled water**	**(1)**

Question Number	Answer	Additional Guidance	Mark
8b(v)	An explanation that makes reference to the following: • because standard deviation uses all of the values /data (1) • not biased by outlier / less effected by one extreme / anomaly (1)	**Accept** converse for range	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b)(vi)	An explanation that makes reference to **three** of the following: • ethanol can pass through cell membrane (1) • increasing ethanol {increases fluidity of / dissolves} lipid bilayer (1) • (so) membrane becomes more permeable (1) • allows pigment to diffuse out of cell / allows pigment to leak out (1)		**(3)**

(Total for Question 8 = 15 marks)

Number	Answer	Additional Guidance	Mark
3(a)	A description that makes reference to five of the following: • equal mass and shape of carrot tissue cut (1) • carrot tissue submerged in (boiling tubes with) known volume of water (1) • placed in water baths at stated range of temperatures for a stated length of time (1) • contents {filtered / decanted} (1) • absorbance measured / colour charts used (1) • graph plotted / statistical analysis of results (1) • appropriate step to ensure validity (1)	Allow use of cork borer and same length Allow {same surface area / equal cubes} Allow 5 – 100°C (must be at least 5 temps), for 5 – 30 mins Allow transmission measured Allow all tissue from same {carrot / age of carrot} Allow repeats at each temperature and {mean / SD} calculated	**(5)**

Question Number	Answer	Additional Guidance	Mark
3(b)	An answer that makes reference to the following: • conversion of mg to g (1) • division by 750 and calculation of percentage (1)	1265.25 mg = 1.26525 g (0.1687 g in 100g) = 0.17 (%) Correct answer with no working gains 2 marks Otherwise correct answer to wrong power of 10 gains 1 mark Correct answer with wrong number of decimal place gains 1 mark	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(c)(i)	An answer that makes reference to the following: • Prpr (1)	Allow $C^{Pr}C^{pr}$	**(1)**

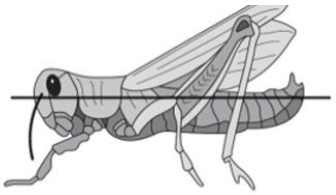
Question Number	Answer	Additional Guidance	Mark
3 (c)(ii)	an answer that makes reference to the following: • number of each calculated (1) • number of each phenotype identified (1)	26:52:26 / 26:51:26 / 1 : 2 : 1 26 dark purple, 52 light purple, 26 white	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(c)(iii)	An answer that makes reference to the following: • O – E calculated for each phenotype (1) • square the values for O-E and divide by E (1) • χ^2 calculated (1)	Example calculation 5, 1, -6 0.961538462, 0.019231, 1.38462 2.37 / 2.4 / 2.365 Correct answer with no working gains full marks Allow ecf for expected numbers from cii	**(3)**

Question Number	Answer	Additional Guidance	Mark
3(c)(iv)	An explanation that makes reference to the following: • critical value (at p = 0.05) is 5.991 (1) • calculated value is less than the critical value (1) • p > 0.05 so the conclusion is likely to be valid (1)	 Allow correct number indicated in table Allow 2.37 is less than 5.991 (gets mp1 &2) p> 0.05 / 5% that differences between observed and expected are due to chance (so it is valid) Allow p> 0.05 so purple colour is controlled by a single gene with two codominant alleles	**(3)**

Number	Answer	Additional Guidance	
1	An explanation that that makes reference to four of the following: • (air/oxygen) into spiracles to tracheae to tracheoles (1) • by diffusion (1) • tracheoles provide large surface area / tracheoles are thin for short diffusion pathway / tracheoles contain fluid to allow oxygen to dissolve / tracheoles supply oxygen to cells / tissues (1) • air sacs provide store of air / oxygen (1) • abdominal movements move air / ventilate / maintain concentration gradient high (1)		**(4)**

	Additional Guidance	Mark
ng: ncentrations (1) it / same locust (1) period (1) er / temperature / oxygen / light /	**ACCEPT** spiracle movements in stated time period	(6)

2(a)(i)	• appropriate line drawn (1)		• through thorax and abdomen • roughly horizontal • curved or straight • in lighter grey area **(1)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	• (so that the) {gas exchange system / respiratory system / trachea / air sacs / it} is clearly visible (1)	Accept {gas exchange system / respiratory system / trachea / air sacs / it} is easier to see Ignore refs to seeing tracheoles / spiracles Accept to stop it drying out Do not accept any incorrect reason	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(i)	An answer that includes the following: • A trachea (1) • B spiracle (1)	A accept tracheae B accept spiracles Accept phonetic spelling	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(b)(ii)	• tracheole(s) (1)	Accept tracheole fluid Accept phonetic spelling	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(b)(iii)	An answer that includes the following: • correct measurement of A or X (1) • correct diameter of X calculated to 2dp (1)	Sample calculation A = 5 (mm) accept 4.5 to 5.5mm X = 1 (mm) accept 0.5 to 1.5mm **0.18 mm** **Accept answer in range 0.08 to 0.30** Correct answer gains full marks	**(2)**

(Total for Question 2 = 7 marks)

swer	Additional Guidance
ver or between one (1)	

swer	Additional Guidance	Mark
		(1)

swer	Additional Guidance	Mark
		(1)

	Additional Guidance	Mark
rence to the following:	ALLOW converse	
surface area : mass ratio (1)		
ore oxygen (1)	IGNORE gas exchange	
cle contraction (1)		(3)

	Additional Guidance	Mark
		(2)

	Additional Guidance	Ma
		(3

Answer	Additional Guidance
ts are in m atio calculated / 99 (1)	Example of calculation 0.003054 m^3 = volume 0.102 ÷ 0.003054 = 33.4 : 1

Answer	Additional Guidance
ence to the following: volume ratio (1) / capillaries} / f {blood / capillaries} (1)	

	Additional Guidance	Mar
1017876 (2)	Example of calculation 180 ÷ 2 = 90mm = 0.09m 4 x 3.142 x $(0.09)^2$ 4 x 3.142 x 8100 = 101800.8 ÷ 1000000 = 0.1018008 4 x 3.14 x 8100 = 101736 ÷ 1000000 = 0.101736 Correct answer with no working gains full marks **ACCEPT** one mark for 0.102 expressed in different version eg. 1.02 OR 0.1018008 / 0.101736 expressed in different version eg. 101800.8 OR 1017876 expressed in different version	(2)

Number	Answer	Mark
2(a)(i)	**The only correct answer is A active transport** ***B*** *is not correct because it does not move substances against a concentration gradient* ***C*** *is not correct because it does not move substances against a concentration gradient* ***D*** *is not correct because it does not move substances against a concentration gradient*	**(1)**

Question Number	Answer	Mark
2(a)(ii)	**The only correct answer is A diffusion** ***B*** *is not correct because non-polar does not use facilitated diffusion* ***C*** *is not correct because non-polar does not use* osmosis ***D*** *is not correct because non-polar does not use transpiration*	**(1)**

Question Number	Answer	Mark
2(b)	**The only correct answer is A fatty acids** ***B*** *is not correct because it is not found in greater concentration in lymph* ***C*** *is not correct because it is not found in greater concentration in lymph* ***D*** *is not correct because it is not found in greater concentration in lymph*	**(1)**

Question Number	Answer	Mark
2(c)	**The only correct answer is B surface area to volume ratio decreases** ***A*** *is not correct because surface area increases* ***C*** *is not correct because surface area to volume ration does not increase* ***D*** *is not correct because surface area to volume ration does not stay constant*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2 (d)	An explanation that makes reference to four of the following points: • large surface area (1) • because of many tracheoles and alveoli (1) • short distance for diffusion (1) • because alveoli and tracheoles have thin walls (1) • moist to allow gases to dissolve (1)	IGNORE thin membranes ACCEPT because tracheoles penetrate tissue, alveoli close to blood capillaries	**(4)**

(Total for Question 2 = 8 marks)

1 (a)	A description that makes reference to the following: • enters through spiracles (1) • diffusion {in tracheae / in tracheoles / into cells} (1) • down concentration gradient (1)		**(3)**

Question Number	Answer	Additional Guidance	Mark
1 (b)(i)	{mm/cm/mm^3/cm^3} min^{-1} g^{-1}		**(1)**

Question Number	Answer	Additional Guidance	Mark
1 (b)(ii)	A description that makes reference to the following: • named factor (1) • how controlled (1)	e.g. temperature, {size / mass / age} of insect e.g. thermostatically controlled water bath / water bath set at a constant temperature / ac room choose equal { size / mass / age} of insect	**(2)**

Question Number	Answer	Additional Guidance	Mark
1 (b)(iii)	An explanation that makes reference to the following: • it has already absorbed the maximum amount of carbon dioxide / no more carbon dioxide can be absorbed (1) • (therefore) coloured liquid {would not move / would move less} / readings {are an underestimate / will not be valid} (1)	Accept it is able to absorb less carbon dioxide (for the second insect) Accept (it is replaced) so that coloured liquid will move / so that readings will be valid	**(2)**

Question Number	Answer	Mark
1(a)	**The only correct answer is D all statements are correct** *A is not correct because statement 3 and 4 are true* *B is not correct because statement 4 is true* *C is not correct because statement 3 is true*	**(1)**

Question Number	Answer	additional guidance	Mark
1(b)	An explanation that includes the following points: • larger organisms have smaller SA/ Vol ratio (1) • some cells far from surface (1) • so diffusion alone cannot supply deliver / transport (oxygen / glucose / nutrients to cells) (1)	**allow converse**	**(3)**

Question Number	Answer	Additional guidance	Mark
1(c)	An answer that makes reference to the following points **Similarities** • both have structures that increase surface area (1) • both have a short diffusion distance (1) • both have surfaces that allow oxygen and carbon dioxide to dissolve (1) **Differences up to three from** • fish live in aquatic environment so do not need to keep surfaces moist / insect air sacs are moist (1) • in insects gases delivered to / removed from cells directly but fish use circulation (1) • fish have gills / lamellae / filaments whilst insects have tracheae/ tracheoles / spiracles (1) • fish have counter current flow (1)	At least one similarity and one difference some insects pump air into and out of trachea some have air sacs which store air	**(4)**

(Total for Question 1 = 8 marks)

estion Number	Answer	Mark
2(a)	**The only correct answer is A lenticels** ***B** is not correct because stomata do not allow gases to enter stem* **C** *is not correct because waxy cuticle does not allow gases to enter stem* **D** *is not correct because xylem does not allow gases to enter stem*	**(1)**

	Additional guidanc
oles} by diffusion	Allow trachea

	Additional guidanc
of the following: t} (1) less surface area} (1) ble (1) is less oxygen in	

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	*Rhithrogena*	DO NOT ACCEPT *Rhithrogena germanica*	**(1)**

Question Number	Answer	Mark
3(a)(ii)	**The only correct answer is B** ***A*** *is not correct because Animalia is the kingdom* ***C*** *is not correct because Heptageniidae is the family* ***D*** *is not correct because Insecta is the class*	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to four of the following: • as temperature increases up to 10°C hatching increases and then decreases (1) • enzyme activity affects {hatching / development / growth} (1) • (below 10°C) increase in temperature increases {kinetic energy / enzyme-substrate complexes / successful collisions between enzyme} (1) • (above10°C) temperature too high denatures enzymes (1) • higher temperature results in less dissolved oxygen available (1)	Piece together **ACCEPT** converse **DO NOT ACCEPT** starts to denature **ACCEPT** shape of active site changed	**(4)**

Question Number	Answer	Additional Guidance	Mark
3(c)	An answer that makes reference to three of the following: **Similarities:** • large surface area (1) • thin exchange surface / small diffusion distances (1) **Differences:** • nymphs have gills and adults have trachea / spiracles (1) • the nymph has external system and the adult has internal system (1)	**DO NOT PIECE TOGETHER** **ACCEPT** both have tracheoles if not awarded as a difference **ACCEPT** tracheoles if not awarded as a similarity **ACCEPT** gills on the outside and {spiracles / trachea / tracheoles} are on the inside	**(3)**

Question Number	Answer	additional guidance	Mark
2(b)(i)	• measurement of sides and calculation of area in cm^2 • divided by magnification = actual size of area containing 6 stomata 6 stomata ÷ 0.105 = 57 (per cm^2)	Example of calculation 7.6 × 5.1 = 38.8 cm^2 **allow area from 37.5 to 40.0 (1)** area ÷ 370 **=** 0.105 cm^2 **area ÷370 (1) .101 – 0.108** =57 (per cm^2) **allow 55-59** Correct answer with no working gains full marks	**(3)**

Question Number	Answer	additional guidance	Mark
2(b)(ii)	Number of stomata = 57 x 130 (1) or 7410	**allow TE answer to 2bi ×130**	**(1)**

Question Number	Answer	Mark
2(b)(iii)	• Distribution of stomata may not be even / the same across leaf surface / only one sample taken / different parts of the leaf may have different number / rounded to whole number (1)	**(1)**

Question Number	Answer	Mark
2(b)(iv)	An explanation that refers to three of the following points • (plants need to keep stomata open) to absorb carbon dioxide (1) • during the day (1) • for photosynthesis (1) • however having stomata open leads to water loss / transpiration closing prevents water loss (1) • plants need to conserve water to maintain turgor (1)	**(3)** close at night

(Total for Question 2 = 9 marks)

Question Number	Answer	Additional guidance	Mark
4 (a)	An explanation that makes reference to three of the following: • {thin epithelium / capillary endothelium / single cell thick} for short diffusion path (1) • {capillaries / good blood supply} to maintain {diffusion / concentration} gradient (1) • {many alveoli / shape of alveoli} increases surface area for high (rate of) {diffusion / gas exchange} (1) • {fluid / water / moisture} to dissolve gases (1)	**Do not accept** cell walls **Accept** thin lining **Accept** thin wall **Accept** thin membrane	**(3)**

Question Number	Answer	Mark
4(b)	The only correct answer is **B** (1 and 3) *A is incorrect as adrenaline does not bind to transcription factors* *C is incorrect as adrenaline does not bind to transcription factors* *D is incorrect as adrenaline does not bind to transcription factors*	**(1)**

Question Number	Answer	Additional guidance	Mark
4(c)(i)	• correct tangent to the curve at 1 s (1) • division of volume by time (1)	**Accept** correct tangent **and** range between 0.7 to 0.9 for 2 marks	**(2)**

Question Number	Answer	Additional guidance	Mark
4 (c)(ii)	An explanation that makes reference to the following: • {exhalation / inhalation / ventilation} is more rapid / more air breathed {in / out} (in same time) (1) • to maintain a {diffusion / concentration} gradient (1) • so {fast / high / more} <u>diffusion</u> of oxygen into {blood / capillaries} (1)	**Accept** higher tidal volume **Accept** oxygen for air **Accept** maintains high <u>partial pressure</u> of oxygen in <u>alveoli</u> / high oxygen <u>concentration</u> in <u>alveoli</u> **Accept** steep diffusion gradient enables rapid movement into blood = mp2 and mp3	**(3)**

(Total for Question 4 = 9 marks)

Question Number	Indicative content	Mark
5 *(a)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Descriptions of Forest fires (F) (Graph 1)** • there is an increase in number of fires over time • but there is decrease in last few years • there are some years that do not fit the trend / fluctuations **Descriptions of changes in vegetation (S) (Graph 2)** • herbaceous plants decrease over time / are high after fires • species number decreases with age of forest • number of different species of all types decrease at 40 years • number of all species increases up to 7 years then decreases • (secondary) succession occurs after forest fires • (secondary succession) is due to presence of seeds / roots • many annual species at start that then decrease • after 40 years, climax community has developed • fewer species at climax community / dominated by a few species **Discussion ideas (D)** • forest fires may be due to other factors / human activity / forest fires may be natural events • climate change would dry out the forests so fires are more likely • no clear link between forest fires and climate change in the data – idea of correlation not causal • the carbon dioxide from fires will lead to more global warming / climate change • forest fires increase species diversity / are away of increasing species diversity / older forest is less diverse • idea that early stages in succession are more productive / remove more carbon • older woody trees shade the ground (reducing productivity) • older forests will have fewer niches • fires may reduce animal diversity / may affect other species, e.g. nesting sites / less food for animals / loss of habitat • other measures to reduce carbon emissions may be more effective • preventing forest fires may harm herbaceous plants / smaller plant species • the data is only about Europe / Europe has fewer forests / small sample size idea / European forests are not representative	**(6)**

Level 0	Marks	No awardable content
Level 1	1-2 (1-3)	Limited scientific judgement made with a focus on mainly just one method, with a few strengths/weaknesses identified. A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but with limited evidence to support the judgement being made. **1 mark (any one points from F, S, D)** **2 mark (any two points from F, S, D)**
Level 2	3-4 (4-6)	A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified. A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasional evidence to support the judgement being made. **3 marks (at least three from any two of F, S, D)** **4 marks (at least four from any two of F, S, D)**
Level 3	5-6 (7-9)	A scientific judgement is made which is supported throughout by sustained application of relevant evidence from the analysis and interpretation of the scientific information. A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding with evidence to support the judgement being made. **5 marks (at least four from all of F, S and D)** **6 marks (at least five from all of F, S and D)**

Question Number	Answer	Mark
5(a)(i)	**5(a)(i). The only correct answer is B** ***A*** *is not correct because chi squared test compares expected result to the actual result* ***C*** *is not correct because standard deviation measures scatter about the mean* ***D*** *is not correct because Student's t test compares the means of two sets of data*	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(a)(ii)	• $6\sum d^2$ calculated **(1)** • $n(n^2-1)$ calculated **(1)** • correct r_s value given **(1)**	Example of calculation 6 × 108 = 648 7(49-1) =336 1 - (648 ÷ 336) = -0.93 / 0.93 / -0.929 / 0.929 **Accept** ecf from $6\sum d^2$ and $n(n^2-1)$ calculations **Correct answer gains full marks, with no working shown**	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(a)(iii)	An explanation that makes reference to the following: • critical value found at {p = 0.05 / 95% level confidence level / 5% significance level} **(1)** • because if {calculated / r_s} value is greater than critical value there is a {strong / significant} {relationship / correlation} **(1)**	**Accept** 0.01 / 99 % **Accept** converse	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)	An explanation that makes reference to four of the following: • because 30 °C is an appropriate temperature for one species and provides enough oxygen for the other species **(1)** • because if the temperature was above {30 / 40} °C there would be less oxygen dissolved in it **(1)** • so there would not be enough oxygen for {respiration / metabolism / ATP production} **(1)** • because if the temperature was above {25 / 30} °C the enzymes would be denaturing **(1)** • because the temperature was below {25 / 30} °C the enzymes would not have enough {kinetic energy / collisions / enzyme substrate complexes} **(1)**	**Accept** because 30 °C satisfies the requirements of both fish **Do not accept** start to denature **Accept for 1 mark** 30 °C is close to the optimum temperature for the enzymes	**(4)**

Total for Question 5 = 10 MARKS

Question Number	Answer	Additional guidance	Mark
6(a)(i)	• flush out or remove gases from previous trial / allow locust to breathe normal air (1)	allow all locusts to start with same concentration of gases remove carbon dioxide increase oxygen	**(1)**

Question Number	Answer	Additional guidance	**Mark**
6(a)(ii)	• enable breathing (rate) of locust to {recover / return to resting value} (1)	allow return to normal, return to breathing rate in (normal) air	**(1)**

Question Number	Answer	Additional guidance	Mark
6(b)(i)	• $\Sigma (x - x)^2$ (1) • substitution and division (1) • square root to obtain SD (1)	Example of calculation 49 49÷3 =16.33 √16.3 = 4.04 using mean of 48 from table in QP allow 1 mark for dividing by 3 correct answer with no working gets full marks allow SD of 4.03 using mean of 48.25 allow 4.0 (to one dec place as matches other SD data in table)	**(3)**

Question Number	Answer	Additional guidance	Mark
6(b)(ii)	An explanation that makes reference to the following: • as range gets higher so does SD (1) • as both measure dispersal / spread (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
6(c)	An answer that makes reference to the following • as oxygen increases breathing rate fluctuates / no clear relationship (1) • lowest rate at 100% oxygen (1) • as carbon dioxide increases so does breathing rate / highest carbon dioxide breathing rate is highest (1) • carbon dioxide has a greater effect on breathing rate than oxygen (1)	allow converse	**(4)**

(Total for question 6 = 11 marks)

Answer	Additional Guidance	Mark
es reference to the following: / reservoir of} oxygen (1) occur in {large / active} locusts (1)		**(2)**

Answer	Additional Guidance	Mark
es reference to the following: rface area to volume ratio (1) sufficient (1)	**Accept** short diffusion distance	**(2)**

Answer	Additional Guidance
reference to the following: (1) er (1)	

Answer	Additional Guidance
eference to the five of the following: tmospheric air (1) [other gases / oxygen / moisture} (1) · which could affect breathing rate (1) ved to recover because led air / needs to return to normal} (1) de concentration tested (1) d be repeated to see if results are malous} (1)	**Accept** need to use a range of carbon dioxide

Indicative content
ing to candidates' deployment of knowledge and understanding of the material in relat in the generic mark scheme. ıot prescriptive and candidates are not required to include all the material which is l content included in the response must be scientific and relevant.
ex / alveolar expansion ıe highest level of improvement in Carrico index / more than natural surfactant 3 together are best to treat ARDS / increase the Carrico index ‹ more than A ıment is rapid and persists from 30 to 120 minutes
ıtural surfactant / control Carrico index as natural surfactant / control ıpared to natural surfactant / control een alveoli expansion and Carrico index ion results in improvement in blood oxygenation which improves Carrico index allow alveoli to expand, increasing surface area and oxygen diffusion into blood ex of 67 which is what A and B reach

Additional Guidance
CEPT more likely to collapse

	M

	Additional Guidance	M
	Example of calculation (67 x 0.21 =) 14	

of the following

974 **and**
er 1985 / 1989 (

between 1978 a

anic waste} cor

ores / create ne

Ansv

en

ot form between
rm between neig
s do not form be

e same way as humans to the compounds	
e with no surfactant	
attempted but with limited interpretation or analysis of the scientific information with a e piece of scientific information.	
ntain basic information with some attempt made to link knowledge and	
given with occasional evidence of analysis, interpretation and/or evaluation of both piec .	
some linkages and lines of scientific reasoning with some structure.	
which is supported throughout by sustained application of relevant evidence of analys valuation of both pieces of scientific information.	
a well-developed and sustained line of scientific reasoning which is clear and logically	

Question Number	Answer	Additional Guidance	Mark
8 (a)	An explanation that makes reference to three of the following: • larger organisms have a smaller SA to volume ratio (1) • many cells far from surface (1) • diffusion too slow to supply or remove gases (1) • metabolic demand may be higher (1)	**Accept** (gas exchange system) increases the animals SA to vol ratio	**(3)**

Question Number	Answer	Additional Guidance	Mark
8 (b)	An answer makes reference to three of the following: Similarities (max two) • large surface area (1) • moist gas exchange surface (1) • thin gas exchange surface (1) • concentration gradient achieved by ventilation (1) Differences (max two) • transport (circulatory) system in mammals but not in insects (1) • the gas exchange / respiratory surface in mammals is the alveoli, in insects it is the junction between the tracheoles and the respiring tissues (1) • mammals have cartilage / insects have chitin (1) • Insects have air sacs to store air (1)	**max two from similarities or differences**	**(3)**

Question Number	Answer	Mark
8 (c)(i)	• {mixture/composition} of gas (1)	**(1)**

Question Number	Answer	Mark
8(c) (ii)	An answer that refers to four of the following • lowest in 100% pure oxygen (1) • highest rate in 4 and 17 % carbon dioxide (1) • carbon dioxide has greater effect than oxygen (1) • relatively small sample so high variability in results (1) • most variable at 88% oxygen and 12% carbon dioxide (1) • little increase in rate above 4% carbon dioxide (1) • correlation with carbon dioxide stronger than with oxygen (1) • no mention of other gas in mixtures 2 / 3 (1)	**(4)**

Question Number	Answer	Additional Guidance	Mark
8(c) (iii)	A description that refers to two of the following • keep oxygen / carbon dioxide constant (1) • vary temperature by placing syringe in water bath (1) • stated (at least) 5 temperatures between 5 and 40) (1)	**Accept** air composition/mixture of gases same **Accept** AC / temp controlled room / incubator / heater	**(2)**

(Total for Question 8 = 13 marks)

Number	Answer	Additional Guidance	Mark
6(a)	A description that makes reference to three of the following: • locate specimen by using {low power / medium power} objective lens (1) • (focus) using {low power / medium power} objective lens before the high power objective lens (1) • only use fine focus with high power lens (1)		(3)

Question Number	Answer	Additional Guidance	Mark
6(b)	• multiplication (1) • division (1)	3.142 x 0.2^2 / 3.142 x 0.04 = 0.126 / 0.1257 / 0.12568 18 ÷ 0.126 = 143 Allow one mark if answer is 142.857 / 143.198 / 143.220 Correct answer gains full marks, with no working shown	(2)

Question Number	Answer	Additional Guidance	Mark
6(c)	conversion of mm into µm conversion of µm into mm conversion of µm into cm (1) divide image size by actual size (1)	Correct answer gains full marks, with no working shown 27 mm = 27 000 µm / 20 ÷ 1000 = 0.02 mm / 20 ÷ 10 000 = 0.002 cm 27 000 ÷ 20 = (×) 1350 / 13.5 x 10^2 / 1.35 x 10^3	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(i)	• calculate sum of d^2 and divide (1) • calculate square root (1)	Correct answer gains full marks, with no working shown 68.8 ÷ 4 = 17.2 square root of 17.2 = 4.1 / 4.147 / 4.15 One mark for 17.2 / 68.8	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(ii)	A description that makes reference to two of the following: • leaves at {same height / same age} on stem (1) • sample at same stated position of leaf (1) • same surface of leaf (1)	**DO NOT ACCEPT** same location / same part / same place **DO NOT ACCEPT** same area / same part / same place	(2)

Question Number	Answer	Additional Guidance	Mark
6(d)(iii)	An answer that makes reference to three of the following: • (reduced growth) because less carbon dioxide absorbed (1) • therefore less {GP / GALP / glucose / sucrose} (1) • less transpiration so less mineral ions (1) • therefore less named product (1)	**ACCEPT** converse **ACCEPT** cellulose / amino acids / protein / chlorophyll / DNA **DO NOT ACCEPT** starch	(3)

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	An answer that makes reference to the following: • 200 μm converted into m (1) • surface area of one alveolus calculated (1) • total surface area of a pair of lungs (1) Value for π / Area of one alveolus (2) / Area of lung (2) / Area of two lungs (3 marks) 3 / 1.2×10^{-7} / 36 / 72 3.14 / 1.26×10^{-7} / 37.7 / 75.4	(200 ÷ 100 0000 =) 0.0002 (4 × 3 × 0.0001 × 0.0001=) 1.2×10^{-7} / 1.26×10^{-7} 2 × 300 million × 1.2×10^{-7} 72/75.36/75.4 Correct answer gains full marks 72/75.4 to wrong order of magnitude = 2 marks 36/37.7 to wrong order of magnitude = 1 mark 301.44 = 1 mark (diameter instead of radius) $0.0002/2 \times 10^{-4}$ = 1 mark	(3)

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	An explanation that makes reference to the following: • because gas exchange will be faster/increased rate of diffusion (of gases) (1) • supplying {sufficient/more} oxygen for respiration (1)	Ignore efficiently/more	(2)

Question Number	Answer	Additional Guidance	Mark
7(a)(iii)	An explanation that makes reference to two of the following: • (because fluid is needed) for {oxygen/gases} to dissolve in (before it can diffuse into the blood) (1) • because (fluid/surfactant) prevents the {lungs / alveoli} collapsing (1) • (because fluid is needed) to maintain the alveolar membrane (1)	Allow oxygen in solution So the alveoli don't stick together	(2)

Question Number	Answer	Additional Guidance	Mark
7(b)	An explanation that makes reference to three of the following: • has {ostia/gaps} to allow water to flow into the body to maintain concentration gradient (1) • single layer of cells lining the body cavity so that the gas {exchange surface is thin/shorter diffusion distance} (1) • cells possess flagella to {increase surface area/ keep the water flowing} (1) • the shape of cavity/sponge provides a large surface area (1)	Accept the unidirectional movement of water maintains concentration gradient Accept a description of the shape linked to SA	(3)

Question Number	Answer	Additional Guidance	Mark
7(c)	An explanation that makes reference to the following: • use of gills decreases as the tadpole develops into frog and breathing air(1) • use of lungs increases as the tadpole develops to frog and using oxygen in air(1) • the skin is used for gas exchange in all developmental stages of the frog (1) • the skin is used in the tadpole because it has a high surface area to volume ratio (1) • in the adult frog the skin is less important than the lungs in taking up oxygen but more important in releasing carbon dioxide (1)	Accept gills in tadpole as taking oxygen from the water Accept lungs are {not used/developed} when the tadpole lives in water Piece together Skin is most important at releasing carbon dioxide at all stages (piece together)	(4)

Question Number	Answer	Additional Guidance	Mark
9(a)(i)	**The only correct answer is B** **A** is incorrect because respiration takes place in the root **C** is incorrect because photosynthesis does not take place in the root **D** is incorrect because respiration takes place in the root		(1)

Question Number	Answer	Additional Guidance	Mark
9(a)(ii)	**The only correct answer is A** **B** is incorrect because pits are in the xylem **C** is incorrect because plasmodesmata are between cells **D** is incorrect because stomata are in the leaves		(1)

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	• insect weighed before and after investigation and the difference calculated (1)		(1)

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	• 42.86 (%)		(1)

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	An explanation that makes reference to two of the following: • as a standard for comparison (1) • to prevent {water loss / dehydration} (before the start of the investigation) (1) • as this is the highest humidity {they could tolerate / that could be produced} (1)	**ACCEPT** a description e.g. so that the effects of lower humidities can be seen **ACCEPT** reduce water loss so there will be water in the tracheoles **ACCEPT** higher humidities might be harmful	(2)

Question Number	Answer	Additional Guidance	Mark
9(b)(iv)	An explanation that makes reference to three of the following: • water loss increases with decrease in humidity as there is more room for water molecules (1) • less water loss at {low / 20% / 0%} humidity in air because spiracles close (1) • water loss is greater in air with higher levels of carbon dioxide as ventilation rate is faster (1) • and the spiracles stay open (1)	**ACCEPT** converse where appropriate **ACCEPT** fewer water molecules in air / down a (water vapour) concentration gradient (into air) **ACCEPT** breathing rate / gas exchange	(3)

Question Number	Answer	Additional Guidance	Mark
9(c)(i)	• 7.776×10^6 / 7.78×10^6 / 7.8×10^6 / 8×10^6		(1)

Question Number	Indicative content		Mark
***9(c)(ii)**	<u>Indicative content</u> Gill filaments: • active fish (generally) have a greater number of gill filaments than inactive fish • the exception is the heaviest inactive fish, *Tinca* • maybe a weak correlation between number of filaments and mass of active fish Lamellae: • active fish (generally) have more lamellae on each filament • but this does not correlate with the mass of the fish • *Tinca* is the inactive fish with the highest total number of gill filaments • 1.9×10^6 • which is way lower than *Thunnus* • and only slightly above the active fish with the least number Surface area: • active fish (generally) have a greater surface are of gills than inactive fish of similar mass • but no correlation with mass Diffusion distance: • very little data on diffusion distance • active fish seem to hoave a smaller diffusion distance • but no obvious correlation with activity or mass Explanations: • higher {number of filaments / lamellae / surface area} increases gas exchange • a smaller diffusion increases gas exchange • so more oxygen available for aerobic respiration • therefore more ATP can be generated • for the contraction of muscles (of the active fish) • more energy needed for movement of heavier fish	**Level 1:** 1 mark = one gill aspect commented on 2 marks = two gill aspects commented on **Level 2:** 3 marks = two gill aspects commented on with an explanation 4 marks = three gill aspects commented on with an explanation **Level 3:** 5 marks = four gill aspects commented on, with an explanation 6 marks = four gill aspects commented on, with an explanation linking to muscle contraction	6

Question Number	Answer	Mark
1(a)	**1(a). The only correct answer is A** ***B*** *is not correct because there are 5 monocytes and 8 neutrophils* ***C*** *is not correct because there are 3 lymphocytes, 5 monocytes and 8 neutrophils* ***D*** *is not correct because there are 3 lymphocytes*	**(1)**

Question Number	Answer	Mark
1(b)	**1(b). The only correct answer is C** ***A*** *is not correct because erythrocytes transport oxygen and platelets prevent entry of bacteria* ***B*** *is not correct because erythrocytes transport oxygen and platelets prevent entry of bacteria* ***D*** *is not correct because leucocytes are involved in defence*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(c)	An explanation that makes reference to two of the following: • (bone marrow / body / patient / person) produces more cells / more released into blood (1) • because patient has {an allergy / allergic inflammation} (1) • because patient has a parasitic infection e.g. worms (1)	**Accept any two from :** asthma /tropical pulmonary eosinophilia / Loeffler syndrome / Churg-Strauss syndrome / atopic dermatitis / eosinophilic oesophagitis / hypereosinophilic syndromes / some malignancies / adverse drug reactions / allergic rhinitis / atopic asthma / atopic dermatitis	**(2)**

Total for Question 1 = 4 MARKS

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>1(a)</td><td>
<table>
<tr><th rowspan="2">Statement about blood vessels</th><th colspan="4">Type of blood vessel</th></tr>
<tr><th>both capillaries and veins</th><th>capillaries only</th><th>veins only</th><th>neither capillaries nor veins</th></tr>
<tr><td>Endothelial cells</td><td>☒</td><td>☐</td><td>☐</td><td>☐</td></tr>
<tr><td>Valves</td><td>☐</td><td>☐</td><td>☒</td><td>☐</td></tr>
</table>
</td><td></td><td>(2)</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Answer</th><th>Additional Guidance</th><th>Mark</th></tr>
<tr><td>1(b)</td><td>An explanation that makes reference to two of the following:
• (blood) fluid is forced through capillary wall (1)
• due to high hydrostatic pressure (in arterial end) (1)
• due to narrowing of the arteries (1)</td><td>ACCEPT pores/gaps in the capillary</td><td>(2)</td></tr>
</table>

Question Number	Answer	Mark
1(a)(i)	**The only correct answer is A** ***B*** *is not correct because enzymes decrease reaction time* ***C*** *is not correct because enzymes decrease activation energy* ***D*** *is not correct because enzymes decrease activation energy and decrease reaction time*	**(1)**

Question Number	Answer	Mark
1(a)(ii)	**The only correct answer is D** ***A*** *is not correct because fibrin is not an enzyme* ***B*** *is not correct because fibrinogen is not an enzyme* ***C*** *is not correct because fibrinogen is not an enzyme*	**(1)**

Question Number	Answer	Additional Guidance	Mark
1(b)	A description that makes reference to two of the following: • {increasing mass / more} (snake venom) decreases clotting time (1) • {small mass / 0.002 µg} of snake venom has a shorter clotting time (than Xa) (1) • {larger masses / 0.004 µg and over / 0.02 and 0.04} has little effect on clotting time (1)	**ACCEPT** clotting time is faster converse **ACCEPT** takes less time / faster rate **ACCEPT** 0.004 µg has slight increase and 0.02 µg and 0.04 µg has slight decrease	**(2)**

Question Number	Answer	Additional Guidance	Mark
1(c)	form a {plug / mesh / scab / barrier / thrombus} to seal the {blood vessel / wound} / release {clotting factors / thromboplastin}	**ACCEPT** to stop bleeding / to prevent {infection / microorganisms entering} **DO NOT ACCEPT** prothrombin / thrombin / fibrinogen / fibrin	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(a)	• (high) hydrostatic pressure forces {fluid / plasma} out of the capillaries (at the arteriole end) (1)		(1)

Question Number	Answer	Additional Guidance	Mark
2(b)	An explanation that makes reference to the following: • blood plasma has higher protein content as the {plasma proteins / named plasma protein / some proteins} are too large to pass out of {capillary / blood} (1) • tissue fluid has less (dissolved) oxygen as it has {diffused into / respired by} the {cells / tissues} (1)	**ACCEPT** converse for tissue fluid **ACCEPT** converse for plasma	(2)

Question Number	Answer	Additional Guidance	Mark
2(c)	An answer that makes reference to the following: • tissue fluid enters the lymphatic (vessels / system) (1) • lymph returns to {the (subclavian) veins / blood} (1)		(2)

Question Number	Answer	Additional guidance	Mark
6(a)	An explanation that makes reference to three of the following: • the curve is {S-shaped / sigmoidal} (1) • because cooperative binding occurs (1) • when the first (molecule of) oxygen binds, the shape of subunits change / (1) • so (subsequent) oxygen molecules bind more easily / affinity increases as more oxygen binds (1) • oxygen binds when blood is in {alveoli / lungs} **and** oxygen is released in {tissues / muscles} (1)	**Accept** change shape (of haemoglobin) / conformational change / allosteric change occurs	**(3)**

Question Number	Answer	Additional guidance	Mark
6(b)	An explanation that makes reference to three of the following: • the haemoglobin is (already) saturated at 14 kPa (so adding more oxygen has no effect) (1) • **drug** does not affect oxygen saturation at {14 kPa / high partial pressures} (1) • drug shifts curve to right (1) • drug reduces the affinity (for oxygen at lower partial pressures) (1) • so more oxygen is {released / unloaded / dissociated} to tissues (1)	**Accept** Hb saturated at 12 kPa / increasing oxygen will not enable any more oxygen to bind **Accept** with drug saturation is similar (to without drug) at high partial pressures **Accept** has effect like Bohr shift	**(3)**

(Total for Question 6 = 6 marks)

	Additional Guidance	Ma
following:		
ıbin **and**	(1)	
erlap over	(1)	
) fibrin	(1)	
	(1) ACCEPT correct description of a clot	(4

	Additional Guidance	Ma
		(1

	Additional Guidance	Ma
ollowing:		
	(1) IGNORE kill REJECT produce antibodies	
ən / bacteria /	(1) ACCEPT correct references to lysosomes / phagosomes	(2

ɔur of the ınt is lowered) (1) elet count is ɛd blood cells	Ignore dizzy / faint	
ibiotics / bone ınt} (1) ɛts / (1) (therapy) /	Accept treatments if no symptoms given Allow any factor involved in blood clotting Ignore blood / iron / coagulant Ignore white cell transfusion	**(4)**

y correctly y correctly y correctly		**(1)**

	Additional guidance	Mar
y 100 to	<u>Example of calculation</u> 12 000 – 2500 = 9500 ÷ 12 000 x 100 = 79 % Accept 79.2 / 79.17 / 79.167 / 79.16 recurring Correct answer gains full marks, with no working shown.	**(2)**

Ignore to produce thrombin alone		(1)

	Additional guidance	Mark
g:	Allow converse for healthy dog	
ctivity) (1)		
in (1)	Accept prothrombin not converted to thrombin Ignore less thrombin alone	
	Ignore less fibrin alone	(3)

		(2)

	Additional guidance	Mark
ulant	Ignore thromboplastin / fibrinogen / fibrin	(1)

	Additional Guidance	Mark
	Accept any number between and including 127.6 and 130.4 beats per minute / bpm	(1)

	Additional Guidance	Mark
wing:		(4)
creases		
/ aorta		
ntre /	**Do not accept** signal / message	
ve /	**Do not accept** signal / message	
ode (1)	**Accept** adrenaline stimulates SA node	

	Additional Guidance	Mar
e and Z		
Z controls		
e and Y		(1)

	Additional Guidance	Ma
not closed		
, not closed		
not open		(1)

Number	Answer	Additional Guidance	Mark
1(a)	An explanation that makes reference to three of the following points: • an explanation related to presence or absence of nucleus (1) • an explanation related to cell shape (1) • an explanation related to cell contents (1)	• erythrocytes / red cells have no nucleus to carry more haemoglobin • monocytes have a nucleus to synthesize enzymes / proteins • erythrocytes / red cells have biconcave shape to increase surface area to absorb oxygen • monocytes are larger/ can change shape to engulf pathogens • erythrocytes small to pass through narrow capillaries • erythrocytes / red cells contain haemoglobin to transport oxygen	**(3)**

Question Number	Answer	Additional Guidance	Mark
1 b	An answer that makes reference to the following: • prevent entry of {pathogen / named pathogen} (1)	allow prevent infection	**(1)**

Question Number	Answer	Additional Guidance	Mark
1 c	An answer that makes reference to three of the following points: • PTT can be used to indicate liver disease (1) • difference in mean scores with liver disease takes longer to clot (1)	must state mean / average	**(3)**

	• no overlap between mean and standard deviation therefore significant difference between groups / not due to chance (1)	ACCEPT standard deviation is low for both groups	

(Total for Question 1 = 7 marks)

Question	Answer	Mark

Number	Answer	Additional Guidance	Mark
5 (a)	An answer that makes reference to similarities • contain {fluid medium / blood} and {pump / heart } and {tubes or vessels} (1) and two of the following differences • heart has 1 or 2 chambers, double circulation has 3 or 4 chambers (1) • blood passes {through the heart} once per circulation, double circulation blood passes {through the heart} twice (1) • oxygenated and deoxygenated blood not separated, double circulation they are separated (1)		**(3)**
	• pressure is lower (due to delicate nature of gills) in single circulation (1) • single circulation is less effective at {delivering oxygen / removing carbon dioxide} (1)		

Question Number	Answer	Additional Guidance	Mark
5 (b)	An answer that makes reference to four of the following: • choose 10 plus of each sex of {same age fitness level / mass / free from any heart condition} (1) • obtain (mean) resting rate for each person (1) • measure heart rate after exercise until heart rate returns to normal resting rate (1)		
	• record time taken in until heart is at resting rate (1) • standardisation of {type of exercise / duration of exercise / temperature of room / time of day} (as this might affect the heart rate) (1) • compare means (and standard deviations) (1)	**ALLOW compare averages**	**(4)**

(Total for question 5 = 7 marks)

Question	Answer	Additional Guidance	Mark

1(a)(i)	*B is incorrect as the valve has already closed* *C is incorrect as the valve is open* *D is incorrect as the valve is open*		**1**

Question Number	Answer	Additional Guidance	Mark
1(a)(ii)	D sinoatrial node, atrioventricular node, bundle of His *A is incorrect as the impulse starts at the* sinoatrial node *B is incorrect as the impulse starts at the* sinoatrial node *C is incorrect as the bundle of His is after the* atrioventricular node		**1**

Question Number	Answer	Additional Guidance	Mark
1(b)(i)	An explanation that makes reference to three of the following: • tissue fluid leaves the capillary through pores (1) • because the hydrostatic pressure is greater than the oncotic pressure (1) • plasma proteins are present in the blood but not in tissue fluid / more protein in blood plasma (1) • plasma proteins are too large to leave capillary (1)	**Allow** fenestrations / other terms for pore **Allow** oncotic pressure is lower than hydrostatic pressure	**3**

Question Number	Answer	Additional Guidance	Mark
1(b)(ii)	An explanation that makes reference to two from: • there is less protein in the blood plasma (1) • so that less tissue {fluid / water} enters blood (1) • because the oncotic pressure is less / there is less capillary length where oncotic pressure is greater than hydrostatic pressure (1)	**Allow** more fluid leaves than enters	**2**

Question Number	Answer	Additional guidance	Mark
1(a)	A calculation which shows: measurement of diameter • conversion of measurement to μm and division of diagram size by actual size • 8750 – 8800 (2)	One mark for correct measurement allow 63 mm or 6.3 cm Example of calculation 63 ×1000 63000÷7.20 = 8750, accept 8800 to 2 sig fig Correct answer with no working gains full marks	**(2)**

Question Number	Answer	Additional guidance	Mark
1(b)(i)	A calculation which shows: • correct substitution of values into formula (1) • calculation of volume (1) = 195.3 μm^3 to 195.5 μm^3 (2)	Example of calculation 4/3 ×3.142 x (3.6×3.6 ×3.6) 4/3 × 3.14 **× 46.656** **Allow 1 mark for** 4/3 × π **× 46.656** **Or 1 mark for 4/3 x 3.142 x 46.656** = 195.33 μm^3 4/3 × 3.143 × 46.656 = 195.52 μm^3 Lots of answers 195.43 Correct answer with no working gains full marks	**(2)**

Question Number	Answer	Additional guidance	Mark

1(b)(ii)	An explanation that makes reference to three of the following points: • lower volume (for same diameter) / flatter / stacked so (more) can fit through (small) capillaries (1) • higher surface area (/ vol ratio) of red cell so faster / greater / more absorption / diffusion (of oxygen / carbon dioxide / gases) (1) • due to biconcave nature of red cell (curving inwards) (1) • contains heamoglobin (so more able) to **absorb** / **combine / bind with** oxygen / carbon dioxide as (carbaminohaemoglobin or as HCO_3^- ions) (1)	**Smaller so can fit through capillaries** **absorption /diffusion**/ not just transport / carriage	**(3)**

(Total for Question 1 = 7 marks)

Question Number	Answer	Additional guidance	Mark

Question Number	Answer	Mark
3(a)	An answer that makes reference to one of the following: • prevents entry of pathogens / named pathogen (1) • prevents blood loss / bleeding (1)	**(1)**

Question Number	Answer	Mark
3(b)(i)	**The only correct answer is D 2, 3 and 4** ***A*** *is not correct because 1 increased levels of high-density lipoproteins does not increase plaque formation and atherosclerosis* ***B*** *is not correct because 1 increased levels of high-density lipoproteins does not increase plaque formation and atherosclerosis* ***C*** *is not correct because 1 increased levels of high-density lipoproteins does not increase plaque formation and atherosclerosis*	**(1)**

Question Number	Answer	Mark
3(b)(ii)	**The only correct answer is B develops in arteries because the blood pressure is higher** ***A*** *is not correct because blood flow is not slower* ***C*** *is not correct because it does not usually occur in veins* ***D*** *is not correct because it does not usually occur in veins*	**(1)**

Question Number	Answer	Mark
3(c)	An explanation that makes reference to four of the following: • so less oxygenated blood to body cells for aerobic respiration (1) • leg movement causes muscles to contract squeezing veins (1) • increases blood flow / allow venous return / blood goes back to heart / blood flow prevents clot developing (1) • if aspirin taken risk of bleeding higher than DVT formation (1) • side effects are worse than risk of DVT / benefits may outweigh the risk (1)	**(4)**

(Total for Question 3 = 7 marks)

al Guidance	Mark
tential decreases uid / water} is od / capillary}	(2)

	Additional Guidance	M
following:		
nped to lungs and) after going through	(1) IGNORE pumped to lungs and body without qualifying that it is separate	

	Additional Guidance	M
higher than the pressure		

	Additional Guidance	M
the following: na) proteins pumping /	(1) (1)	
is **higher** (than	(1) ALLOW converse statement	
is **lower**, fluid is	(1) ALLOW converse statement	

	of the following:		
	M		
	urs (1)		
	laque / atherosclerosis}		
	n reduces {blood flow /	Ignore blocked	
	sease / stroke} (1)		
	n leads to (further)		
	ck / stoke / angina / (1)		
ith			
			(4)

ows depolarisation of the atria	
ows depolarisation of the atria and the T wave represents	
presents repolarisation of the ventricles	

	Additional guidance
e of the following:	
ve stress (1)	Accept calculation of heart rates
sed heart rate (1)	Eg: exercise / drugs / smoking / BMI / fitness / diet / atherosclerosis
not be significant (1)	
osis (1)	

ver	Additional Guidance	Mark
of the following: nvolve depolarisation) wn}		(1)

	Mark
	(1)

	Mark
	(1)

ver	Additional Guidance	Mark
of the following: tion (1) eded for respiration /) diac output (1) / / exercise} (1) rt rate when resting (1)		(4)

	Mark
n *tation* *tation*	(1)

Question Number	Answer	Additional Guidance	Mark
4(a)(i)	**C** monocyte | eosinophil	**A** is incorrect because cell J is not an eosinophil and cell K is not a lymphocyte **B** is incorrect because cell J is not a lymphocyte and cell K is not a neutrophil **D** is incorrect because cell J is not a neutrophil and cell K is not a monocyte	(1)

Question Number	Answer	Additional Guidance	Mark
4(a)(ii)	**D** 50 : 3	**A** is incorrect because there are about 50 erythrocytes and 3 leukocytes **B** is incorrect because there are about 50 erythrocytes and 3 leukocytes ie the ratio is the wrong way round **C** is incorrect because there are 3 leucocytes	(1)

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that makes reference to the following: • because the numbers of erythrocytes to leucocytes can be determined (1) • and compared to the {normal / healthy / known CML} (smear) (1)	**ACCEPT** red blood cells to white blood cells named white blood cell	(2)

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to four of the following: • by epigenetic modification (1) • for example by {DNA methylation / histone methylation / histone acetylation} (1) • {house-keeping genes / genes needed in both cell types} remain switched on (1) • genes needed in {common lymphoid progenitor / lymphoid} cells become (permanently) switched off (1) • causing {proteins / named protein} to be made that are specific to the {cell type / named cell} (1)	**ACCEPT** descriptions / post-transcriptional modification transcription of genes switched on / no transcription of genes switched off **ACCEPT** converse **ACCEPT** converse credit a named example of a gene which may be switched {on / off} e.g. gene coding for cytokines in T lymphocytes **NB** genes become switched on or off = 1 mark, if no other marks awarded	(4)

Question Number	Indicative content
***5(a)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: • IgM produced early in response (D) • has multiple antigen-binding sites (D) • involved in agglutination of the viruses (R) • IgA produced early in response (D) • can bind two antigens (D) • so involved in agglutination of the viruses (R) • involved in opsonisation (R) • to enhance phagocytosis by phagocytes (R) • is present in {eyes / nasal passages} (D) • to prevent entry of pathogen through {eyes / nose} (R) • can provide passive immunity to newborn baby (R) • IgG persists in body for a few months (D) • providing immunity to virus (R) • has two antigen-binding sites (D) • involved in agglutination of the viruses (R) • involved in opsonisation (R) • to enhance phagocytosis (R) • can cross the placenta to provide passive immunity to the fetus (R) • IgD will be involved in B cell activation (R) • as it will bind virus to B cell (R) • activated B cells will differentiate into plasma cells that will produce antibody (R) • IgE not involved as Rubella infection {is not a parasitic infection / does not result in an allergic response} (R) **Level 1 :** 1 mark = description of antibodies from either the graph or the table 2 marks = description of antibodies from both the graph and the table / role of one class of antibody described **Level 2 :** 3 marks = role of two classes of antibody described 4 marks = role of three classes of antibody described **Level 3 :** 5 marks = role of four classes of antibody described 6 marks = role of all five classes of antibody described

Level	Marks	
0	0	No awardable content
1	1-2 (1-3)	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4 (4-6)	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	5-6 (7-9)	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Mark
4 (a)	An explanation that makes reference to the following: • if women smoked they would inhale smoke / would have effects of their own smoking / Co comes from their smoking (1) • so could not attribute changes in babies to effects of passive / separate effect of passive smoking / would not show only the effects of passive smoking / effects of passive smoking would be negligible / masked by own smoking (1)	**(2)**

Question Number	Indicative content
4(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Uses data from table** **reference to differences between groups** • (significant) difference in birth weight with higher mean for group not exposed to PS • (significant) difference in birth length with higher mean for group not exposed to PS **but no little difference / similarity in** • but no significant / less difference in head circumference • but no / little difference in apgar scores as much more variation within groups/ higher SD **Comments upon validity / problems with data from table**
	• large study so small differences may be significant • no information upon age / health / mass of mother • no information about how much exposure to PS • unclear pattern as some measures not affected no sig difference **Uses information about effects of CO on haemoglobin** • CO levels many times higher in smokers so also in PS group • as CO absorbed into blood • attaches to Haemoglobin less oxygen carried • oxygen not dissociated or given up in tissues **Effects on baby** • less oxygen available for respiration • less energy for growth • so smaller size **Comments upon problems with information on CO** • no direct physiological measures / oxygen CO levels on mother / baby • no information on effects of substances in PS • no information on persistence of CO in mother's or baby's blood

Level	Mark	Descriptor
	0	No awardable content
1	1-2	The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. *Gives one difference or similarity between groups from data in table or effect of CO =1* *Gives one difference or similarity between groups from data in table and one effect of CO = 2* ***or*** *Gives two difference or similarity between groups from data or two effects of CO =2*
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and / or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. ***and*** *one effect on baby = 3* ***and*** *two effects on baby = 4*
3	5-6	An explanation is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. ***and*** *one comment on validity of data or problem with CO information = 5* ***and*** *one comment on validity of data and problem with CO information = 6*

Total for Question 4 = 8 marks)

Number			
6 (a)	The only correct answer is **B** W and X A is incorrect because glucose passes out of the glomerulus C is incorrect because glucose is absorbed in the PCT D is incorrect because glucose is absorbed in the PCT		**(1)**

Question Number	Answer	Additional Guidance	Mark
6 (b)(i)	An explanation that makes reference to three of the following points: • there is more protein in plasma than tissue fluid (1) • because plasma proteins are too large to pass out of the capillary (1) • and **oncotic** pressure generated by (plasma) proteins (1) • (so fluid moves in) as {oncotic / osmotic} pressure is greater than hydrostatic pressure (1)	**Accept** converse **Accept** converse	**(3)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that makes reference to four of the following points: • sodium ions are not removed from the **ascending** limb (1) • so the water potential of medullary fluid is higher (1) • therefore less water is removed from the **descending** limb (1) • and less water is removed from the {collecting duct / distal tubule} (1) • (a higher volume of) {dilute / low concentration} urine is produced (1)	**Accept** less negative water potential **Accept** water potential gradient is lower **Accept** osmotic gradient is lower	**(4)**

2(a)(i)	16.7	Length of (X-Y on diagram in mm) ÷1.2mm 20 ÷ 1.2 = 16.7 Accept 17, 16.67, 16.6 with recurring dot	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(a) (ii)	An explanation that includes two of the following points: • artery has smaller lumen than vein / artery has thicker layer of smooth muscle and elastic fibers than a vein (1) • as artery needs to withstand higher pressure than vein / as artery need to have elastic recoil which the vein does not (1)	Comparative statements required for both marks **allow** converse for vein	**(2)**

Question Number	Answer	Mark
2(b)	**The only correct answer is D as M P Q N is the correct order** *A is not correct because M Q P N is not the correct order* *B is not correct because M N Q P is not the correct order* *D is not correct because N M Q P is not the correct order*	**(1)**

Question Number	Answer	Mark
2(c)(i)	• clot in arteries can stop blood reaching important organs such as {heart / brain / lungs} / arteries have narrower lumen so more likely to be blocked / clots in arteries can lead to increased blood pressure / prevent oxygenated blood reaching tissues (1)	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(c)(ii)	An explanation that includes three of the following: • **smoking** can damage the lining of arteries increasing plaque build-up / increasing blood pressure (1) • **lack of exercise** increases the build-up of plaques / increasing blood pressure (1) • **high LDL** increases likelihood of plaque build-up or lower HDL can increase of plaque build-up risk of atherosclerosis / increasing blood pressure (1) • **increased body mass** / leads to higher blood pressure / type II diabetes which increases damage to blood vessel walls (1) • **increased stress** releases cytokines increasing inflammatory response in blood vessels leading to plaque formation / increasing blood pressure (1) • **High saturated fat** in diet increases cholesterol in the blood (1) • **High salt in diet** can lead to increased blood pressure (1)	or balance of HDL and LDL	**(3)**

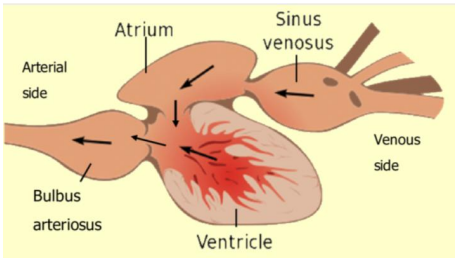
(Total for Question 2 = 8 marks)

Question Number	Answer	Mark
3(a)(i)	**The only correct answer is C as N receives oxygenated blood from the lungs** ***A*** *is not correct because L does not receive oxygenated blood from lungs* ***B*** *is not correct because M does not receive oxygenated blood from lungs* ***D*** *is not correct because S does not receive oxygenated blood from lungs*	**(1)**

Question Number	Answer	Mark
3(a)(ii)	**The only correct answer is B as O has the highest pressure during the cardiac cycle** ***A*** *is not correct because M does not have the highest pressure during the cardiac cycle* ***C*** *is not correct because Q does not have the highest pressure during the cardiac cycle* ***D*** *is not correct because R does not have the highest pressure during the cardiac cycle*	**(1)**

Question Number	Answer	Mark
3(a)(iii)	**The only correct answer is B as P is the septum** ***A*** *is not correct because O is not the septum* ***C*** *is not correct because Q is not the septum* ***D*** *is not correct because R is not the septum*	**(1)**

Question Number	Answer	Mark
3(b)(i)	**The only correct answer is D as Z is the atrium** ***A*** *is not correct because W is not the atrium* ***C*** *is not correct because X is not the atrium* ***D*** *is not correct because Y is not the atrium*	**(1)**

Question Number	Answer	Mark
3(b)(ii)	correct arrows (1) 	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)(iii)	An explanation that makes reference to three of the following: • fish has a single circulatory system whilst mammal has double (1) • blood passes through heart once in fish but twice in mammal (1) • fish heart only has two chambers not four (1) • therefore no separation of oxygenated and deoxygenated blood (1)	**Accept** one atrium in fish but two in mammals AND one ventricle in fish and two in mammals **Allow** converse	**(3)**

(Total for Question 3 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)	An explanation that makes reference to two of the following: • more men than women are affected and heart disease increases with age **(1)** • gender because {presence of oestrogen in women / more men than women smoke} **(1)** • age because {more time to develop atherosclerosis / less active lifestyle / higher blood pressure / less elastic arteries} **(1)**	**Accept** pieced together answer	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)	An explanation that makes reference to two of the following: • the { atheroma / plaque / (blood) clot} blocks the (coronary) artery **(1)** • therefore the heart {cells / muscle} are deprived of {oxygen / glucose} **(1)** • therefore respiration cannot take place **(1)**	**Accept** atherosclerosis results in the (coronary) artery being blocked **Accept** they (heart cells) are deprived of oxygen / less oxygen {reaches / transported to} the cells / ischaemia / reduction in flow of oxygenated blood	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(c)	An answer that makes reference to five of the following, including at least one similarity or one difference : <u>Similarities</u>: • both have the potential to divide indefinitely **(1)** • both have the potential to differentiate into a number of cell types **(1)** <u>Differences</u>: • iPS cells were {adult cells / named example of adult cell} but embryonic stem cells are cells taken from the {morula / inner cell mass} **(1)** • iPS have a {gene / named gene} added but embryonic cells do not **(1)** • there are {no / less / different} ethical issues surrounding the use of iPS cells **(1)** • iPS cells can form adult cells whereas embryonic cells form younger cells **(1)** • iPS cells will produce patient-matched cells but embryonic stem cells will be antigenic **(1)**	**NB** do not piece together **Accept** have no Hayflick limit **Accept** to specialise e.g. fibroblasts, keratinocytes, kidney epithelium, blood cells **Accept** blastomeres / early embryo (up to 14 days) e.g. Oct4, Sox2, cMyc, KIf4 **Accept** there will be rejection issues using embryonic stem cells but not using iPS cells	**(5)**

Total for Question 4 = 9 MARKS

Number			
4 (a)(i)	The only correct answer is: **D** Z *A is incorrect because W is the hypothalamus* *B is incorrect because X is the cerebrum* *C is incorrect because Y is the cerebellum*		**(1)**

Question	Answer	Additional Guidance	Mark

Number			
4 (a)(ii)	The only correct answer is: **C** release of noradrenaline by the sympathetic nervous system *A is incorrect because acetylcholine decreases the rate* *B is incorrect because acetylcholine decreases the rate* *D is incorrect because noradrenaline is released by the sympathetic nervous system*		**(1)**

Question Number	Answer	Additional Guidance	Mark
4 (b) (i)	• correct identification of pressure when the valve closes (1) • conversion of cm^2 into m^2 (1) • correct calculation of force (1)	Example of calculation: 0.8 kPa **Accept** reading between 0.6 – 0.8 **(one mark)** 0.00035 m^2 or 3.5×10^{-4} **(one mark)** **0.00028 N (three marks)** **Accept** final answer between **0.00021 – 0.00028** **Accept** correct standard form 2.1×10^{-4} to 2.8×10^{-4} Correct answer with no working gains full marks **ECF for mp 3** if either or both wrong graph reading / wrong area conversion	**(3)**

Question Number	Answer	Additional Guidance	Mark

4 (b)(ii)	An explanation that makes reference to four of the following points: • pressure rises in the atrium during contraction (of ventricle) (1) • (because) blood is flowing back into the **atrium** (1) • lower pressure in aorta / lower pressure in ventricle / lower pressure in systemic (circulatory system) (1) • therefore less oxygenated blood flows to muscles / slower flow of oxygen to muscles (1) • so there is less respiration (in muscles) (1)	**Accept** pressure in atrium rises during systole **Accept** valve prevents backflow into **atrium** **Accept** less / slower (deoxygenated) blood to lungs **Accept** less ATP produced / more anaerobic respiration	**(4)**

Question Number	Answer	Additional Guidance	Mark
	The only correct answer is:		

Question Number	Answer	Mark
5(a)(i)	**The only correct answer is D T** ***A*** *is not correct because Q is not involved in clotting* ***B*** *is not correct because R is not involved in clotting* ***C*** *is not correct because S is not involved in clotting*	**(1)**

Question Number	Answer	Mark
5(a) (ii)	**The only correct answer is D U and V** ***A*** *is not correct because P and Q are not both involved in the immune response* ***B*** *is not correct because S and T are not both involved in the immune response* ***C*** *is not correct because T and U are not both involved in the immune response*	**(1)**

Question Number	Answer	Mark
5(a) (iii)	**The only correct answer is D U** ***A*** *is not correct because P is not a* lymphocyte ***B*** *is not correct because R is not a* lymphocyte ***C*** *is not correct because T is not a* lymphocyte	**(1)**

Question Number	Indicative content
5(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Reference to changes in number of blood cells** • Condition A too few • Condition B too many • Condition C too few • Condition D too many • notes that normal range is very wide • small change can lead to condition being diagnosed **Reference to symptoms** • Condition A cannot prevent /defend against infection as too few antibodies produced • Condition B causing swelling as overproduction of lymphocytes and antibodies • Condition C unable to produce (nonspecific) immune response so less phagocytosis /bacteria in gut body mouth not destroyed engulfed • Condition D too many phagocytes produced in response to infection

	Advice • Condition A avoid infection as few antibodies produced / have vaccinations to boost antibody production • Condition B check overproduction not due to blood cancer / leukemia • Condition C avoid infections lack of cells may be due to chemotherapy killing fast growing cells • Condition D too many normally not an issue but check overproduction not due to blood cancer / leukemia • Advice depends upon age as cell numbers change with age

(Total for Question 5 = 9 marks)

Level	Mark	Descriptor
	0	No awardable content
1	1-2	The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. ***Makes one or two reference to number of white cells =1*** ***Makes reference to at least one change in number of cells and refers to symptoms or advice = 2***
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. ***Makes reference to change in number of cells and a link to symptom / advice =3*** ***Makes reference to increase and decrease in number of cells and links each to symptoms or advice =4***
3	5-6	An explanation is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured. ***Makes reference to increase and decrease in number of cells and links each to symptoms and medical advice =5*** ***Makes reference to increase and decrease in number of cells and links each to symptoms and explains medical advice =6***

Number	Answer	Additional Guidance	Mark
3(a)	• multiplication and conversion to dm^3	19.2	(1)

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to the following: • {heart rate / beats per minute} increases cardiac output (1) • stroke volume stays the same at 120 (cm^3) / stroke volume stays the same after 100 bpm / stroke volume stops increasing / stroke volume reaches maximum / stroke volume less important than heart rate (1)	**IGNORE** stroke volume stays the same	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)(i)	An explanation that that makes reference to three of the following: • {more} (frequent) impulses (1) • from SAN to AVN to bundle of His / Purkyne fibres (1) • therefore more of the ventricles contract / greater contraction of ventricles / stronger contraction of the ventricles (1)	**IGNORE** frequency of contraction	(3)

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	An explanation that that makes reference to four of the following: • more heart muscle / thicker ventricle walls (1) • therefore stroke volume increases / more blood per contraction (1) • therefore same {cardiac output} with fewer beats (1) • therefore sufficient supply {oxygen / glucose} (1) • allows respiration in cells (1)	**IGNORE** bigger hearts / stronger	(4)

Number	Answer	Additional Guidance	Mark
4(a)	An explanation that that makes reference to three of the following: • (haemoglobin) {saturated / high affinity / associates} at high ppO_2 OR (haemoglobin) {less saturated / low affinity / dissociates} at low ppO_2 (1) • binding of the first oxygen molecule is difficult (1) • changes shape of haemoglobin molecule (1) • therefore facilitates binding of other oxygen molecules (1)	**IGNORE** concentration of oxygen	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(b)	• correct values read from graphs (1) • subtraction for cat and for mouse (1) • difference calculated (1)	**example of calculation** cat 95 and 50 mouse 80 and 31 cat 45% mouse 49% 49 – 45 = 4 **ACCEPT** 2 marks if incorrect values read from graph	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that that makes reference to three of the following: • mouse (haemoglobin) {releases more oxygen / lower affinity / dissociates more / is less saturated} at the same ppO_2 / mouse (haemoglobin) is saturated at a higher ppO_2 (1) • mice {cells / tissues} need more oxygen / mice have higher {respiration rate / metabolic rate} (1) • because mice have larger surface area to volume ratio (1) • therefore mice lose more heat (1)	**ACCEPT** converse for all Mps	**(3)**

Question Number	Answer	Additional Guidance	Mark
4(d)	• curve drawn to the left of the horse curve		**(1)**

Question Number	Answer	Mark
7(a)(i)	**The only correct answer is A Bohr effect** **B** is not correct because it is not the chloride shift **C** is not correct because it is not the dissociation curve **D** is not correct because it is not the oxygen debt	**(1)**

Question Number	Answer	Additional guidance	Mark
7(a)(ii)	An explanation that makes reference to two of the following: • binding of the first oxygen molecule to haemoglobin changes the shape of haemoglobin molecule (1) • therefore facilitates binding of other oxygen molecules (1)	allow easier faster binding	**(2)**

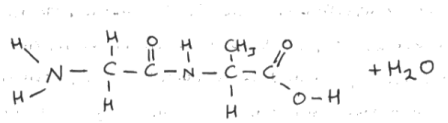
Question Number	Answer	Additional guidance	Mark
7(a)(iii)	• reading values of graph (1) • calculation (1) 71-51=20%	low carbon dioxide 95-44=51 allow readings 94 or 95 and 44 or 45 so subtraction 49, 50 or 51 high carbon dioxide 87 -16 = 71 allow readings 87 and 16 or 17 so subtraction 70, 71 allow answer 19 or 20 or 21 allow TE for mp 2	**(2)**

Question Number	Answer	Additional guidance	Mark
7(a)(iv)	An explanation that makes reference to three of the following: • as these respiring cells / tissues are releasing are releasing CO_2 (1) • so that haemoglobin has a lower affinity for oxygen (1) • so it unloads its oxygen / dissociates at higher partial pressure of oxygen (1) • thus, more oxygen is released to be used in aerobic respiration (1)	allow haemoglobin is less saturated	**(3)**

Question Number	Answer	Additional guidance	Mark
7(b)	An explanation that makes reference to the following • curve lies to left of normal (1) • therefore haemoglobin has to have a higher affinity for oxygen at lower partial pressures (1)	allow heamoglobin has a higher saturation at lower partial pressures	**(2)**

(Total for question 7 = 10 marks)

3(a)(i)	*B is incorrect because it is the carboxylic acid group* *C is incorrect because it is not the R group* *Dis incorrect because it is the amino group*		**1**

Question Number	Answer	Additional Guidance	Mark
3 (a)(ii)	*An answer that makes reference to:* • correct peptide bond between the amino acids (1) • a water molecule (1)		**2**

Question Number	Answer	Additional Guidance	Mark
3(a)(iii)	*An answer that makes reference to three from:* • three polypeptide chains (1) • that are (left hand) helices joined together (1) • (helices are held together) by hydrogen bonds (1) • many tropocollagen molecules / triple helices joined together (1)	**Allow** repeating sequences of amino acids / every third amino acid is glycine / lots of proline **Allow** triple helix	**3**

Question Number	Answer	Additional Guidance	Mark
3(b)(i)	• 1.3 N (1)		**1**

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	An explanation that makes reference to three of the following: • arteries stretch more / (have weaker collagen which means that) less force produces a longer extension (1) • because the elastic constant is lower (1) • and (blood in arteries) has high pressure (1) • and less force is required to break the artery (1)	**Allow** less elasticity in arteries **Allow** arterial blood has high hydrostatic pressure	**3**

Question	Answer	Additional Guidance	Mark

Question Number			
5(a)	An answer that includes four of the following **Similarities** • both haemoglobin and myoglobin are globular proteins (1) • myoglobin and subunits / single chain of haemoglobin have similar secondary and tertiary structure (1) • both contain the oxygen-binding haem / heme (as their prosthetic group). (1) **Differences** • haemoglobin found in red blood cells / myoglobin found in muscle (1) • myoglobin has a higher affinity for oxygen so becomes saturated at lower partial pressures (1) • myoglobin single peptide chain / single haem/ heme chain / haemoglobin 4 peptide chains /4 haem / heme chains / different tertiary / quaternary structure (1)	At least one similarity and one difference	**(4)**

Question Number	Indicative content
5(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Factor 1 mass of myoglobin in mg g^{-1}** • greater myoglobin longer dive time / less myoglobin shorter dive time • *example of organism from data eg harbour seal has highest myoglobin and longest dive time* **Factor 2 mass** • larger mass organisms do not have relatively longer dive time • *example from data eg larger grey seal has shorter dive time than harbour seal* • as more myoglobin in harbour seal • *water shrew has longest dive time if data adjusted for mass* **Factor 3 habitat** • aquatic organisms have longer dive time / terrestrial have lowest • *example seals have longer dive time* **Factor 4 Relationship between factors habitat and myoglobin** • aquatic organisms have higher myoglobin • *example shrew higher than rat* **Reference to other factors**

	• other named factor such as lung function / evolution / adaptation • *example rat has a relatively long dive time compared to human* • when allowing for body mass **Biological explanation** • more myoglobin allows more storage of oxygen • therefore more aerobic respiration

Level	Mark	Descriptor
	0	No awardable content
1	1-2	The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. ***Makes reference one or two factors =1*** ***Makes reference to at least one example organism linked to factor = 2***
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of the scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. ***Makes reference to two factors and includes linked example organism for each =3*** ***Makes reference to three factors and includes linked example organism for each=4***
3	5-6	An explanation is given which is supported throughout by evidence from the analysis, interpretation and/or evaluation of the scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear, coherent and logically structured. ***Makes reference to three factors, examples and includes ref to myoglobin as oxygen store =5*** ***Makes reference to biological explanation link between myoglobin and respiration=6***

(Total for Question 5 = 10 marks)

Question Number	Answer	Mark
5(a)	• Lama (1)	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b) (i)	An explanation that includes two of the following: • because of the co-operative binding of oxygen to the 4 polypeptide chains (1) • binding of the first oxygen molecule changes the shape of haemoglobin molecule (1) • therefore facilitates binding of other oxygen molecules (1)	**Accept** Increases affinity/easier for other oxygen molecules	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	54%	6kPa = 94% 2kPa = 40% 94-40 **Allow** range of 52-54	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b) (iii)	An explanation that includes two of the following: • vicuna curve is to left of horse / moves up (1) • so has higher affinity for oxygen at same partial pressure (1) • therefore vicuna hemoglobin is more saturated (at lower partial pressure) than horse / vicuna can absorb more oxygen at lower partial pressure (1)	**allow** converse for horse **ignore** reference to Bohr shift / steepness	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An explanation that includes two of the following: • llama hemoglobin more saturated / saturated at lower partial pressure than horse (1) • lower partial pressures of oxygen at higher altitude (1) • so more oxygen is taken up (1) • more oxygen available to muscles (1)	allow converse for horse **accept** higher affinity for oxygen at lower partial pressures **accept** llama's haemoglobin has a higher affinity to oxygen than the horse / curve to the left of the horse **Accept** oxygen density is lower as atmosphere is thinner	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(d)	An answer which includes one of the following: • mouse is smaller so has larger SA/Vol (so curve is to right of horse) (1) • mouse has a higher respiration rate (so curve is to right of horse) (1)	**Allow** converse for both marking points **Accept** metabolic rate for respiration rate	**(1)**

(Total for Question 5 = 10 marks)

Question Number	Answer	Mark
3 (a)(i)	The only correct answer is B *A is incorrect as this is atrial systole* *C is incorrect as this is diastole* *D is incorrect as this is diastole*	**1**

Question Number	Answer	Additional guidance	Mark
3(a)(ii)	A description that makes reference to three of the following: • {sinoatrial node / SAN} initiates {depolarisation / electrical wave / wave of excitation} action potential} (1) • (depolarisation) causes {atria to contract / atrial systole} (1) • AVN {has a delay / pauses} (1) • (AVN) transmits (depolarisation) down {bundle of His / Purkinje fibres} (1) • depolarisation passes {from apex / up ventricle walls} stimulating (ventricle) **contraction** (1)	**Allow** impulses / action potential **Allow** SAN depolarises . **Allow** ventricles contract from {base / apex} upwards	**3**

Question Number	Answer	Additional guidance	Mark
3(b)(i)	• calculation of mean heart rate (1) • calculation of blood volume, conversion to dm^3 (1)	Example of calculation 75 75 x 0.15 = 11 dm^3 **if anomaly included, then** **11 = 2 marks** **One mark for** 11.25 / 11.3 / 11.2 **OR** 75 in working **(if anomaly not included)** **10 = 2 marks** **One mark for** 10.125 / 10.12 / 10.13 / 10.1 **OR** 67.5 **correct answer gets all marks**	**2**

Question Number	Answer	Additional guidance	Mark
3(b)(ii)	An answer that makes reference to four of the following: 1. drug binds to (noradrenaline) receptors / prevents {noradrenaline / adrenaline} binding (to receptor) / acts as a competitive inhibitor (for adrenaline / noradrenaline) (1) **and three from** 2. heart rate increases after fright with **and** without drug (1) 3. heart rate is lower with drug (1) 4. heart rate **increases less** with the drug (after fright) (1) 5. heart rate increase is {**less / decreases}** with repeated frights without drug (1) 6. {fright number 4 with drug / 105} is {anomalous / does not fit pattern / is an outlier} (1)	**Allow** blocks receptors (for noradrenaline) **Allow** converse **Allow** heart rate **increases more** without drug (after fright) **Allow** is too high compared with others	**4**

(Total for Question 3 = 10 marks)

Question Number	Answer	Mark
4 (a)(i)	The only correct answer is B (hydrogen) *A is incorrect as disulfide bonds do not form secondary structure* *C is incorrect as ionic bonds do not form secondary structure* *D is incorrect as peptide bonds do not form secondary structure*	**1**

Question Number	Answer	Mark
4 (a)(ii)	The only correct answer is C (substitution) *A is incorrect as no bases are deleted* *B is incorrect as no bases are added* *D is incorrect as no chromosome sections are moved*	**1**

Question Number	Answer	Additional guidance	Mark
4(a)(iii)	An explanation that makes reference to two of the following: • {valine / new amino acid} is {non-polar / not charged} (1) • so valine is hydrophobic (1) • so the **haemoglobin** (molecules) are {less soluble in water} / so the **haemoglobin** (molecules) {form fewer hydrogen bonds with water / **haemoglobin** (molecules) associates with {fewer water molecules} (1)	**Allow** glutamate is hydrophilic **Allow** is less able to dissolve in water **Allow** haemoglobin molecules are less able to associate with water	**2**

Question Number	Answer	Additional guidance	Mark
4(b)(i)	An answer that makes reference to two of the following: Similarities (**max 1**) 1. both have {S-shaped / sigmoidal} curve (1) 2. both have cooperative binding (1) Differences (**max 1**) 3. affected haemoglobin has a lower affinity for oxygen (1) 4. affected haemoglobin has {lower saturation of oxygen / never reaches 100 % saturation} (1) 5. there is a wider {variation / range / spread / variability} in affinity (for haemoglobin) from people with sickle cell anaemia (1)	**One similarity and one difference.** **Allow** converse for unaffected	**2**

Question Number	Answer	Additional guidance	Mark
4(b)(ii)	• there is a {wide / large} {variation / range} (1)		**1**

Question Number	Answer	Additional guidance	Mark
4(b)(iii)	An explanation that makes reference to three of the following: • (haemoglobin has a) low(er) **affinity** for oxygen (1) • haemoglobin never becomes fully saturated / less oxygen will {bind to / load on} haemoglobin (1) • so that less oxygen is available for **respiration** (in muscles) / less **aerobic respiration** / more **anaerobic respiration** (1) • so that less **ATP** is produced for **muscle contraction** / more **lactic acid** formation (in muscles) (1)	**Allow** sickle cell haemoglobin needs higher partial pressure of oxygen to saturate **Allow** sickle cell haemoglobin is less saturated with oxygen / carries less oxygen	**3**

(Total for Question 4 = 10 marks)

Number	Answer	Additional Guidance	Mark
5(a)(i)	time of cardiac cycle read from graph and divided into 60	60 ÷ 0.8 = 75 (beats per minute)	(1)

Question Number	Answer	Mark
5(a)(ii)	**The only correct answer is C** ***A*** *is not correct because the aortic pressure is higher than the ventricular pressure* ***B*** *is not correct because the aortic pressure is higher than the ventricular pressure between 0.10 s to 0.13 s* ***D*** *is not correct because the aortic pressure is higher than the ventricular pressure between 0.37 s and 0.43 s*	**(1)**

Question Number	Answer	Mark
5(a)(iii)	**The only correct answer is A** ***B*** *is not correct because 0.13 s is when the semi-lunar valve opens* ***C*** *is not correct because 0.37 s is when the semi-lunar valve closes* ***D*** *is not correct because 0.43 s is when the atrio-ventricular valve opens*	**(1)**

Question Number	Answer	Additional Guidance	Mark
5(b)	A description that makes reference to five of the following: • (myogenic means) no external nerve impulses / doesn't require nerve impulse / no stimulation from brain / generated from within heart (1) • (contraction initiated by) SAN (1) • {depolarisation / wave of excitation} causes {atria to contract / atrial systole} (1) • delay at the AVN (1) • (depolarisation) through the {bundle of His / Purkyne fibres} (1) • (depolarisation) causing {ventricle to contract / ventricular systole} from base/apex of heart (1)	**ACCEPT** no outside stimulation (needed to contract heart) **ACCEPT** impulses	**(5)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An explanation that makes reference to three of the following: • the heart rate is slower (1) • because noradrenaline and beta blocker are similar {shapes / structures} (1) • so beta blocker binds to noradrenaline receptors (1) • therefore {prevents / blocks} binding of noradrenaline (to receptors) (1)	**DO NOT ACCEPT** same shape	**(3)**

	Additional Guidance	Mark
	ACCEPT other valid medical conditions for all Mps	
oking} (1)		
ancer} (1)	**ACCEPT** adult 1 lives at altitude	
/ anaemia /		**(2)**

	Additional Guidance	Mark
		(1)

	Additional Guidance
	ACCEPT converse for all Mps
hils / lymphocytes	
lets} (1)	
nonocytes / white	**ACCEPT** adult 1 has 2 neutrophils while adult 2 has 4

Additional Guidance	Mark
e of calculation	
= 10 000 µm	
÷ 20 = 500	
: answer with no working ull marks	
one mark for 9mm / 10mm / 12mm / 0.9cm / 1.0cm / 1.1cm / working	**(2)**

Additional Guidance	

Question Number			
7(a)	An explanation that makes reference to the following: • because {cholesterol / fatty acids} are hydrophobic (so cannot be carried in bloodstream) (1) • phospholipid tails are hydrophobic so {cholesterol / fatty acids} can be carried inside lipoprotein (1) • {protein / phospholipid heads} in lipoprotein are hydrophilic (enabling transport in bloodstream) (1)	**ACCEPT** non-polar **ACCEPT** non-polar **ACCEPT** polar	

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	• substitution of values into equation • answer given to 3 or 4 sig figs	4/3 × π × 11 × 11× 11 / 5572.453 5570 / 5572 **ACCEPT** 5580 / 5575 for 1 mark	

Question Number	Answer		Mark
7(b)(ii)	An explanation that makes reference to two of the following: • because (in the LDL) there is less protein (contained in a larger volume) (1) • because the protein is denser than the phospholipid (in the LDL) (1) • (the LDL has) {a larger hole in the middle / fewer molecules in relation to its size} (1)	**ACCEPT** converse statements for HDL **ACCEPT** types of protein in HDL are denser than the types in LDL	

Question Number	Answer	Additional Guidance	Mark
7(b)(iii)	An explanation that makes reference to four of the following: • because cholesterol is a risk factor (1) • (because of raised LDLs) more cholesterol in the blood (1)		
	• {cholesterol / plaque / atheroma} builds up in (walls of) artery (1) • reducing the flow of blood to the heart {tissue / cells} (1) • therefore lack of oxygen for (aerobic) respiration (in heart cells) (1)		

Number	Answer	Additional Guidance	Mark
3(a)	9 / 90		(1)

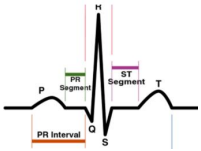
Question Number	Answer	Additional Guidance	Mark
3(b)(i)	• calculation of volume (1) • calculation of cardiac output (1) • conversion to $dm^3\ min^{-1}$ (1) OR • change units for radius (1) • calculation of volume (1) • calculation of cardiac output (1)	= $\frac{4}{3}$ x 3.142 x 0.001 = 0.004189 x 200 = 0.0000008379 ($dm^3\ min^{-1}$) **Accept** 8×10^{-7} / 8.4×10^{-7} / 8.38×10^{-7} / 8.379×10^{-7} / 0.0000008 / 0.00000084 / 0.000000838 Correct answer gains full marks, with no working shown. 8 / 8.4 / 8.38 / 8.379 to wrong power of 10 gets 2 marks Ecf if diameter used instead of radius 0.1mm = 0.001 dm = $\frac{4}{3}$ x 3.142 x 0.001 = 4.189×10^{-9} x 200 ($dm^3\ min^{-1}$) = 8.38×10^{-7} **Accept** 8×10^{-7} / 8.4×10^{-7} / 8.379×10^{-7} / 0.0000008 / 0.00000084 / 0.000000838 / 0.0000008379	(3)

Question Number	Answer	Additional Guidance	Mark
3(b)(ii)	more cells that need supply of {glucose / oxygen} (1)		(1)

Question Number	Answer	Additional Guidance	Mark
3(c)(i)	• calculate sum of d^2 and divide (1) • calculate square root (1)	50 ÷ 2 = 25 5.0 Correct answer gains full marks, with no working shown.	(2)

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	An answer that makes reference to the following: • one axis labelled mean heart rate with units, linear scale starting at 0 (not broken scale), bars labelled and covers at least half the grid (1) • accurate plot and standard deviations (1)		(2)

Question Number	Answer	Additional Guidance	Mark
3(c)(iii)	An answer that makes reference to two of the following: • for valid comparison / to get a valid result (1) **and any one from the following**: • temperature because {water fleas are ectotherms / affects heart rate} (1) • {carbon dioxide / pH} affects heart rate (1) • time of measuring because water fleas may fatigue (1) • acclimatisation to allow equal time for substances to take effect (1)	Accept to ensure the treatment is the only factor affecting heartrate	**(2)**

Question Number	Answer	Additional guidance	Mark
7 (a)(i)	An answer that includes • correctly shaped ECG wave and labelled (1) • aligned correct position with cardiac cycle (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
7 (a)(ii)	rate = 60 ÷ 0.8 = 75 cycles per minute allow	allow 75-78	**(1)**

Question Number	Answer	Additional guidance	Mark
7 (b)	An explanation that makes reference to the following points: • A atrioventricular valve closes because pressure in ventricle becomes higher than pressure in atrium (1) • B semilunar valve / aortic valve opens because pressure in ventricle becomes higher than pressure in aorta (1) • C semilunar valve closes because pressure in aorta exceeds pressure in ventricle (1) • D atrioventricular valve opens because ventricular pressure falls below pressure in atrium (1)	**Accept** converse Must have valve change and pressure change	**(4)**

Question Number	Answer	Additional guidance	Mark
7 (c)	A description that makes reference to **four** of the following: • SAN acts as pacemaker (1) • impulse travels through heart (muscle / fibres) cause atrial contraction (1) • AVN delays transmission of impulse so contraction of ventricle after atria (1) • impulse spreads through Purkinje / Purkyne fibres via bundle of His (1) • impulse travels from apex of the ventricles (1)	**Accept** initiates depolarisation / depolarisation starts at SAN	**(4)**

(Total for Question 7 = 11 marks)

oncotic pressure cannot be lower at Y than it is at X hydrostatic pressures are not the same at X and Y hydrostatic and oncotic pressure at Y cannot be the same	**(1)**

nswer	Additional guidance	Mark
nce to the following:) g to move fluid (1) movement} in vein (1) {glands / neck} in lymph (1)	Allow converse where appropriate	**(2)**

e following: ids / fatty acids / salts / hormones} (1) in synthesis} can occur (1) soned} (1)	Ignore waste	**(2)**

	Additional guidance	Mark
)	Example of calculation 16 ÷ 100 x 80 = 12.8 x 1000 = 12 800 Correct answer gains full marks, with no working shown.	**(2)**

	d does not have turgor d does not have turgor ıe water would not leave the blood	(1)

Answer	Additional guidance	Mark
;e to four of the following: / quantified} reduction (1) :inues for many years} (1) as {some still remain in year 6 / / ıd beyond six years} (1) ɔ {mosquito nets / repellent / mosquitoes / drug resistant worms} (1)	Ignore immune	(4)

Number	Answer	Additional Guidance	Mark
8(a)	*The only correct answer is:* **B** correlation coefficient *A is incorrect because chi squared compares frequencies* *C is incorrect as standard deviation is a measure of dispersion* *D is incorrect as t-test compares mean values*		**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)	An explanation that makes reference to five of the following points: • {pioneer species / mosses / lichens arrive} (after glaciers melt and colonise bare rock) (1) • {decomposition /decay} increases the soil depth / humus content / minerals / nutrients (1) • therefore (larger) plants can grow (due to soil depth / minerals / nutrients) (1) • leaf litter increases after 40 / 100 years as more herbaceous plants / shrubs / trees are present (1) • (steep) increase in nitrate after 40 / 100 years as more leaves / plants / animals / faeces (1) • leaf litter falls (towards the end / from 150 – 250 years) as climax community has emerged (1)	**Accept** animals arrive / increased niches **Accept** larger plants **Accept** increase from 12.8 to 277 as equivalent to 40/100 **Accept** increase from 5.3 to 21.8 as equivalent to 40 / 100 **Accept** nitrate continues to increase due to presence of animals / faeces (as leaf litter falls)	**(5)**

Question Number	Answer	Additional Guidance	Mark
8(c)(i)	An explanation that makes reference to three of the following points: • (leghaemoglobin / myoglobin) is not S shaped / is linear / is a straight line (1) • because (leghaemoglobin / myoglobin) affinity for oxygen does not alter (1) • because (with leghaemoglobin) there is no cooperative binding (1) • (leghaemoglobin) binds to one molecule (of oxygen) (1)	**Accept** converse for haemoglobin **Accept** converse for haemoglobin **Accept** converse for haemoglobin **Accept** shape change to subunits / conformation change **Accept** (leghaemoglobin / myoglobin) has only one oxygen binding site **Accept** haemoglobin has four binding sites / binds to four molecules of oxygen	**(3)**

Question Number	Answer	Additional Guidance	Mark

8(c)(ii)	An explanation that makes reference to three of the following points: • (waterlogged soil has) little / low / less / no oxygen (1) • (leghaemoglobin) provides oxygen for **respiration** (1) • which enables active uptake of mineral ions / named mineral ion (1) • such as (calcium) to make calcium pectate / (nitrate) to make amino acids / (magnesium) to make chlorophyll (1)	**Accept** binds to / stores oxygen for respiration **Accept** other correct active processes e.g. synthesis of amino acids / protein synthesis / mitosis **Accept** other correct examples of minerals with functions	**(3)**

Question	Answer	Additional Guidance	Mark

Number	Answer	Additional Guidance	Mark
8(a)(i)	• 1.52×10^7		(1)

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	A description that makes reference to three of the following: • damage to {endothelium} caused by {high blood pressure / toxins / smoking} (1) • inflammatory response and arrival of {macrophages / white blood cells} (1) • deposits of {cholesterol / calcium} (1) • formation of {atheroma / plaque} (1)	**DO NOT ACCEPT** fat / lipid	**(3)**

Question Number	Indicative content
*8(b)	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Candidates are expected to reach a decision/conclusion on whether the Hardy Weinberg equation could be used to predict the number of people in the future who would need treatment in the UK for health disorders. **Lifestyle (L)** • HW only predicts genetic disorders • many health disorders are not genetic / caused by lifestyle • example of a lifestyle disease **Formula and Assumptions (A)** • assumes frequency of alleles remains constant / $p + q = 1$ refers to allele frequency • assumes frequency of genotypes remains constant / $p^2 + 2pq + q^2 = 1$ refers to genotype frequency • p^2 = homozygous dominant / $2pq$ = heterozygotes / q^2 = homozygous recessive • assumes no selection / random mating • assumes no mutation • assumes no migration • assumes large population / no genetic drift **Problems (P)** • recognises assumptions invalid • explain why assumptions are invalid • understands that countries have different population sizes • people unwilling to have a genetic test / risks with genetic tests / tests need to be done • genetic testing is expensive • cannot test for all alleles • understands that environment can affect gene expression

Level	Marks	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. **1 to 3 from L A or P (only one of L A or P)**
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure. **4 to 6 from L A or P (from at least two of L A or P)**
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **7 plus from L and A and P**

Question Number	Answer	Mark
7 (a)(i)	• separate oxygenated blood from deoxygenated / left side generates a higher pressure for systemic circulation	**(1)**

Question Number	Answer	Mark
7 (a)(ii)	• ventricles have to generate more pressure / pump blood all around body or to the lungs whilst atria collect blood from body / lungs and pump it into ventricles	**(1)**

Question Number	Answer	Mark
7(b)(i)	**The only correct answer is** **A P is the vena cava** B is not correct as Q is pulmonary artery C is not correct because R is the aorta D is not correct because S is the pulmonary vein.	**(1)**

Question Number	Answer	Mark
7(b)(ii)	**The only correct answer is** **B Y closed and Z open** A is not correct as Z is not closed C is not correct as Y is not open D is not correct as Y is not open	**(1)**

Question Number	Answer	Additional guidance	Mark
7(c)	A description that makes reference to **three** of the following: • R / aorta thicker (walls) (1) • R / aorta has a narrower / smaller lumen (1) • R / aorta contains more muscle / elastic tissue (1) • R / aorta contains (semi lunar) valves (1)	allow converse for descriptions of S pulmonary vein. Thicker muscular walls scores mp 1 and 3 allow R more elastic / elasticity	**(3)**

Question Number	Answer	Additional guidance	Mark
7(d) (i)	An answer that makes reference to four from: similarities • both have hearts (1) • both have valves (1) differences • mammals closed system / has blood vessels (1) • mammal have a separate pulmonary circulation system (in insects, exchange of oxygen and carbon dioxide occurs in the tracheal system) (1) • mammal is a double circulatory system and insect is single (1)	accept converse for insect	**(4)**

Question Number	Answer	Additional guidance	Mark
7(d)(ii)	An answer that includes two of the following points : • glucose / amino acids / proteins / mineral ions / lipids / hormones (2)	https://genent.cals.ncsu.edu/bug-bytes/nutrition/ allow named carbohydrate / named amino acid / named mineral ion	**(2)**

(Total for question 7 = 13 marks)

Question Number	Answer	Additional guidance	Mark
8(a)	An explanation that makes reference to the following: • {fast transport of / more} **oxygen** for **respiration** / so that **oxygen** for **respiration** is delivered (to tissues) at a high rate (1) **and one from** • keeps oxygenated and deoxygenated blood separate (1) • maintains high pressure to body / maintains lower pressure to lungs (1) • pulmonary (lungs) and systemic circulatory (body) systems are separate (1)		**2**

Question Number	Answer	Additional guidance	Mark
8(b)(i)	• correct reading from graph for duration of one heart cycle • correct division of 60 seconds by the duration of one heart cycle	0.80 – 0.86 (s) **or** 60 ÷ duration of one beat **= one mark** 70 – 75 (bpm) **(2)** **Correct answer with no working gains both marks**	**2**

Question Number	Answer	Additional guidance	Mark
8(b)(ii)	An explanation that makes reference to three of the following: • there is a long(er) gap between the P and QRS waves / extended PQ time (1) • delay between atrial systole and ventricular systole / ventricular systole is delayed (1) • (may be damage to) bundle of His / Purkinje fibres (1)	**Allow** contraction **Allow** takes longer to pass through Purkinje fibres / bundle of His	**2**

Question Number	Answer	Additional guidance	Mark
8(b)(iii)	An explanation that makes reference to three of the following: • acetylcholine is released from the parasympathetic neurones / nervous system (1) • acetylcholine slows heart rate / reduces frequency of depolarisation (1) • atropine binds / blocks (acetylcholine) receptors (1) • at SAN (1) • stops / prevents / reduces acetylcholine binding (to receptor) (1)	**Allow** atropine stops acetylcholine inhibiting depolarisations **Allow** impulses **Allow** competes for receptor	**3**

Question Number	Answer	Additional guidance	Mark
8(b)(iv)	A description that makes reference to four of the following: • (increased) respiration rate so blood {carbon dioxide (concentration) increases / oxygen (concentration) decreases} • **blood** {pH decreases / acidity increases} (1) • detected by chemoreceptors (1) • {baroreceptors / stretch receptors} detect (changes in) blood pressure (1) • (chemoreceptors in) {aorta / carotid artery / medulla} (1) • impulses (from neurones of peripheral receptors) sent to {medulla / cardiac centre / cardio-acceleratory centre}(1)	**Allow** carbonic acid **Allow** aortic body / aortic arch / carotid body / carotid sinus **Allow** baroreceptors in {aorta / carotid artery / carotid body / carotid sinus / aortic body / aortic arch} **Do not accept** signals / messages / pulses	**4**

Number	Answer	Additional Guidance	Mark
9(a)	An explanation including four of the following: • {plaque / clot / atheroma} forms in (coronary) artery (1) • causing {narrowing / blockage} of the **coronary** artery (1) • therefore reducing the blood supply to {cardiac / heart} {muscle / tissue / cells} (1) • so {cardiac / heart} muscle dies (1) • heart (muscle) stops contracting (if enough cardiac muscle cells die) (1) • so oxygen not supplied to brain cells (causing death) (1)	Accept cholesterol build up in artery Accept less {oxygen / glucose} reaches {cardiac / heart} {muscle / tissue / cells} Accept {heart attack / myocardial infarction / MI / cardiac arrest / heart failure} Accept heart stops pumping (blood around body)	**(4)**

Question 9b

Level	**Marks**	
0	0	No awardable content
1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Additional Guidance	Mark
9(b)	**Indicative content** **Lifestyle choices (L points) – likely to reduce risk of death** • increased exercise (intensity or duration) reduces risk • diet detail eg more {fruit / vegetables / antioxidants} decrease risk • some lifestyle choices increase risk • diet high in {saturated fat / cholesterol} / high salt • {poor diet / lack of exercise} increases risk of {obesity / high BMI} • smoking increases risk of atherosclerosis • alcohol consumption • lifestyle changes may not have been the only reason for decrease in deaths * • credit other factors likely to reduce death **Confounding factors (C points)** • different age groups have different risk / older people more at risk as more likely to have atherosclerosis • different sexes have different risk / males more at risk • ethnicity – different ethnic backgrounds have different risk • genetic predisposition to factors increasing risk • eg high blood pressure / high cholesterol / type 1 & 2 diabetes as more likely to have atherosclerosis • detail of damage eg. high blood sugar leads to damage to lining of blood vessels • credit other factors which will prevent deaths reaching zero • credit idea that any of these could stop deaths (in UK) reaching zero* **Data points (D points)** • death rate declines over the period (in all countries except Montenegro) • relevant comparison of data between UK and other European countries		

	• manipulation of data • graph appears to be plateauing • suggestion of why number of deaths in other countries may not have fallen • comment on percentage change compared to absolute change • comment on table refers to male and female, graph refers to males only – same pattern • comment on gradual decline, not a single event causing decline • incomplete data eg only 1990 and 2019 / no ages of people • no data on incidence of CHD, only death from CHD • no evidence that lifestyle choices have changed* • correct suggestion of why aspects of data collection not valid*		
	L1 : 1 mark one point, 2 marks any 2 points, 3 marks any 3 points **L2 points from at least 2 areas, including data** 4 marks 4 points 5 marks 5 points 6 marks 6 points **L3 points from 3 areas, with comment on validity*** 7 marks 7 points 8 marks 8 points 9 marks 9 points, includes a reasoned argument assessing validity		

(Total for Question 9 = 13 marks)

wer	Additional Guidance	Mark
al (1)	Example of calculation: 400 x 207 = 82800 cm^3 **Accept** calculation of total haemoglobin per cm^3 kg^{-1} blood: 207 × 216 = 44712 **Accept** calculation of concentration of haemoglobin in one seal: 216 × 400 = 86400	
$^{-3}$ (1)	216 ÷ 1000 = 0.216 g cm^{-3}	
concentration of haemoglobin (1)	0.216 x 82800 = 17885 g Correct answer with no working gains full marks **Accept** for two marks a correct answer with no units / wrong units **Accept** for three marks: 17884.8 g / 17880 g / 17890 g / 17900/ 18000 g / 17.8848 kg / 17.885 kg / 17.89 kg / 17.9 kg / 18 kg	**(3)**

nal Guidance	Mark
	(1)

	Additional Guidance	M
the g / sale / trade / (1) red species (1)		

	Additional Guidance	M
of the e pool / ns) (1) rmful	**Accept** small / restricted gene pool	

	Indicative content
biological knowledge and understanding to the given context with	ing to candidates' deployment of knowledge and understanding of the material i ls outlined in the generic mark scheme.
ormation with some attempt made to link knowledge and	not prescriptive and candidates are not required to include all the material whic nal content included in the response must be scientific and relevant.
terns from at least one of A or B	
and understanding by selecting and applying some relevant	en maximum depth and maximum time holding breath etween mass of animal and depth maximum time holding breath and mass of mammal uires larger oxygen storage as can't breathe underwater s oxygen to release energy
s and lines of scientific reasoning with some structure.	
with explanation from at least one of A or B	
ledge and understanding by selecting and applying relevant ots.	en volume of oxygen in body and maximum depth en concentration of haemoglobin in blood and maximum depth ygen stored in muscle and maximum depth sess myoglobin acting as an oxygen store in muscle bour seal have more oxygen stored in lungs / Weddell seal and Northern ygen stored in lungs ults in more buoyancy so deeper diving mammals have less stored in lungs od volume and haemoglobin concentration results in very high blood oxygen
ped and sustained line of scientific reasoning which is clear and	od so higher haemoglobin concentration and blood volume in animals that dive
l explanation of patterns from both A and B with	s of oxygen stored in muscle
	ıpport explanation . to support explanation, for example, determining total haemoglobin als.

Number	Answer	Additional Guidance	Mark
7(a)(i)	An explanation that makes reference to four of the following: • damage to endothelium / lining (1) • therefore inflammatory response occurs (1) • therefore formation of {atheroma / plaque } in arteries (1) • therefore arteries are narrowed which reduces {blood flow / oxygen supply / glucose supply} • leads to (further) increase in blood pressure (1)	must mention arteries once Ignore blocked	(4)

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	An answer that makes reference to three of the following: • smoking damages arteries lining (1) • type 2 diabetes increases blood pressure (1) • high cholesterol / LDL levels increase therefore formation of {atheroma / plaque } in arteries (1) • lack of exercise / high fat diet (leads to obesity) (1) • inherited alleles from parents who had cvd (1)	ALLOW Sex / sex hormones / men more likely to develop arthrosclerosis ALLOW Age older more likely to develop arthrosclerosis	(3)

Question Number	Answer	Additional Guidance	Mark
7(a)(iii)	• mean of percentages calculated (1) • number of deaths calculated (1)	8.77 ÷ 2 = 4.385 (4.385×12 000)÷100 = 526 correct answer gains full marks allow one mark for x 12000 ÷100 or for x 6000 ÷ 100 or 4.29 % of 6000 = 257.4 and 4.48 % of 6000 = 268.8 = 526	(2)

Question Number	Answer	Additional Guidance	Mark
7(b)	An answer that makes reference to four of the following yes as • 100 mg a high enough dose to benefit from reduced heart disease (1) • large study (1) • long time frame (1) no as • is 100 mg a low enough dose to prevent intestinal bleeding / may cause bleeding (1) • little difference between death rate between groups risk decreases by 2 in 1000 ie 0.2% (1) • but twice the levels of (gastrointestinal) bleeding (so no benefit) (1) • no effect on incidence of strokes (1) • no other lifestyle information provided / different patients had different risk factors (1)	at least one from yes / and no	**(5)**
	• no information on cause of death (1)		

(Total for question 7 = 14 marks)

Question	Answer	Additional Guidance	Mark

Question Number	Answer	Additional guidance	Mark
5(a)(i)	• **A** atrium (1) • **B** ventricle (1)	allow auricle	**(2)**

Question Number	Answer	Additional guidance	Mark
5(a)(ii)	An answer that makes reference to **three** of the following At least one similarity and one difference Similarities • both have 2 atria (1) • both have AV valves (1) • heart divided into upper and lower chambers / have atria and ventricle (1) Differences • frog has 1 ventricle / undivided whilst mammal has 2 ventricles / has septum (1) • frog has 3 chambers whilst mammal has 4 (1) • frog has no valves in arteries (1)		**(3)**

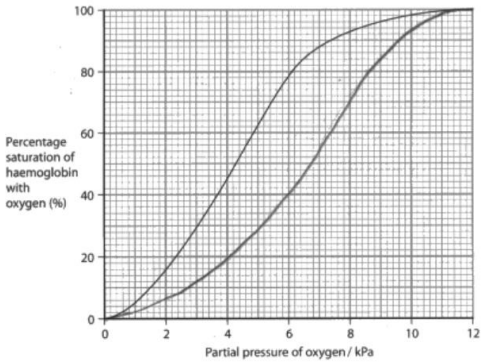
Question Number	Answer	Additional guidance	Mark
5(b)(i)	• frog systemic circulation contains oxygenated blood from both lungs and skin / in frog blood from ventricle goes to lungs and body (1)		**(1)**

Question Number	Answer	Additional guidance	Mark
5(b)(ii)	An explanation that makes reference to the following: • low metabolic rate so require less oxygen / lungs allow frogs to be more active on land (1) • so mixing of blood in ventricle not limiting (1) • but blood has to go to two gas exchange surfaces (1) • moist skin allows oxygen to dissolve / skin provides large surface area for gas exchange (1)		**(4)**

Question Number	Answer	Additional guidance	Mark
5 (c)	An explanation that makes reference to **four** of the following: • SAN acts as pacemaker (1) • impulse travels through heart muscle / fibres cause atrial contraction (1) • AVN delays transmission of impulse {to coordinate contraction of ventricle after atria} (1) • impulse spreads through Purkinje / Purkyne fibres via bundle of His (1) • ventricle contracts from apex (1)	initiates depolarization / depolarization starts at SAN	**(4)**

(Total for question 5 = 14 marks)

Number	Answer	Additional Guidance	Mark
8(a)(i)	An explanation that includes three of the following • four {polypeptide chains / subunits / haem groups / Fe^{2+}} (1) • haem groups {combine / bind} (reversibly) with oxygen (molecules) (1) • so can pick up four molecules of oxygen (1) • co-operative binding occurs (1) • because after first molecule of oxygen binds, the (3D) shape of the molecule changes (1)	Accept 2 alpha and 2 beta chains / subunits Accept iron {combines / binds} with oxygen Accept description eg after first molecule of oxygen binds {other oxygen molecules can be picked up more easily / there is a higher affinity for oxygen}	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	• curve drawn lower and to the right of existing curve with same start and end point (1)	Sample graph 	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(a)(iii)	An explanation including two of the following: • oxygen more likely to be released (from Hb) at {respiring tissues / muscle} (1) • because {partial pressure / concentration} of carbon dioxide is {high / higher} in {respiring / muscle} tissues (1) • {Bohr shift occurs / the affinity of haemoglobin for oxygen is reduced} when {partial pressure / concentration} of carbon dioxide is {high / higher} (1)	Accept haemoglobin gives up oxygen more easily when {partial pressure / concentration} of carbon dioxide is {high / higher} Accept when carbon dioxide concentration is high, carbonic acid (releases H^+ which) causes quaternary structure of Hb to change	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(b) (i)	0.25	Accept 25% / ¼ / one in four / 1:3 Do not accept 1:4 / 3:1	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b) (ii)	An explanation that includes the following • (heterozygotes have) one {dominant / non-mutated} copy of the allele (1) • so {beta globin / the protein} can still be made (1)	 Accept in heterozygotes the dominant allele is always expressed Accept both alleles must be recessive for the symptoms to be shown Ignore reference to carrier	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(c)(i)	An answer including the following: • value for q^2 identified (1) • value for q or p calculated (1) • value for 2pq calculated to 2sf (1)	Example calculation 0.28 q = 0.53 / 0.529 or p = 0.47 / 0.471 (this gains mp1 & 2 if 0.28 not seen) 0.50 / 50% Correct answer with no working gains full marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(c)(ii)	An answer including two of the following: • migration may occur (1) • mating may not be random (1) • population (on island) may be small (1) • {selection may occur / beta thalassaemia may affect fertility} (1) • mutation may occur (1)	 Accept population {is / may not be} isolated Accept may not be an equal chance of reproduction Accept population size {is not infinite / should be large} Accept genetic drift occurs Accept description of heterozygous advantage leading to higher number of heterozygotes	**(2)**

(Total for Question 8 = 14 marks)

	Additional Guidance	Mar
1)	**DO NOT ACCEPT** calculate mean / SD / use statistics **ACCEPT** 10 mins	**(4)**

	Additional Guidance	Mar
	tre} (1) ial (1) on} which increase	**DO NOT ACCEPT** message / signals **(4)**

itional Guidance	Mark
culation 0.833 77 / 0.773 78 / 0.783 gains full marks, with no	**(2)**

	Additional Guidance	M
g: s at SAN / pacemaker (1) ntract (1) ds (1) atrial contraction} / ction} (1)	**DO NOT ACCEPT** signal / message	

Indicative content	Mark
ing to candidate's deployment of knowledge and understanding of material in relation to t ıe generic mark scheme. ıot prescriptive and candidates are not required to include all the material which is indica ncluded in the response must be scientific and relevant.	
aped e left than frog curves tadpole ght in frog ıer than frog curves e % ONCE	(3)
rated / as ppO_2 increases saturation increases ted / as ppO_2 decreases saturation decreases ver ppO_2 change in $pp0_2$ than frog ty than blood	
ɔinding easier	

	Additional Guidance
	DO NOT ACCEPT Animalia eukaryotes

	Additional guidance
;	
ɔn (1)	
	DO NOT ACCEPT thin membranes
1)	

change in ppO_2 causes large change in percentage saturation
iation in gills or lungs
situation in tissues

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lated elements of biological knowledge and understanding to the given context with
nents made.

related to consequences are made with limited linkage to a range of scientific ideas,
ques and procedures.

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ncepts.

/ ppO_2 in water lower than ppO_2 in air
ble to obtain oxygen from polluted water
release oxygen to tissues during exercise / activity / movement
to survive
land

ge to a range of scientific idea

which is clear and logically

Number	Answer	Additional Guidance	Mark
8 (a)(i)	• correct value from graph (1) • correct calculation of oxygen in 1 g of haemoglobin (1) • correct calculation of oxygen in 100 cm^3 of blood (1)	72 % 72 / 100 X 1.36 = 0.9792 1.47 / 1.469 / 1.4688 cm^3 Correct answer gains full marks	3

Question Number	Answer	Additional Guidance	Mark
8 (a)(ii)	An explanation that makes reference to four of the following: • myoglobin (is on the left because) has a higher affinity for oxygen / binds more tightly to oxygen (1) • therefore it acts as a store for oxygen / only releases oxygen when oxygen is low (1) • haemoglobin is sigmoidal / S shaped / myoglobin is not S shaped (1) • as oxygen binds cooperatively (1) • so that the affinity varies depending on how much oxygen is bound (1)	**Accept** converse for oxygen e.g. haemoglobin releases oxygen more easily **Accept** correct description	4

Question Number	Answer	Additional Guidance	Mark
8(b)	An answer that makes reference to four of the following: • the (Tibetan haemoglobin) has a higher affinity for oxygen (1) • so that it is more saturated at lower pressures of oxygen (1) • with high carbon dioxide, the Tibetan haemoglobin has a lower affinity for oxygen (than Europeans) (1) • because it has a {more pronounced / bigger} Bohr shift / shift to the right (1) • so that it will release oxygen more easily (1)	**Accept** converse **Accept** oxygen concentrations **Accept** can bind oxygen at low pressures /can bind oxygen when at altitude where there is less partial pressure of oxygen **Accept** with higher carbon dioxide, Tibetan haemoglobin is less saturated (than European haemoglobin)	4

Question Number	Answer	Additional Guidance	Mark
8 (c) (i)	• calculation of q (1) • calculation of p (1) • calculation of number of heterozygotes (1)	Correct answer: 516 **Accept** answers with range of 517 and 528 with incorrect rounding for two marks Correct answer gains full marks **Accept** ECF for mp3 for 2pq x 2500	**3**

Question Number	Answer	Additional Guidance	Mark
8 (c)(ii)	An explanation that makes reference to the following: • only Tibetans and Denisovans have the allele (1) • so (the presence of the allele) suggests that Denisovans and Tibetans must have interbred (1) • and produced fertile offspring (1)	**Accept** Allele is present in Tibetans and Denisovans	**2**

Question Number	Answer	Additional Guidance	Mark
9(a)	An answer that makes reference to four of the following: • as the length of the dive increases and the depth of the dive increases, the percentage decreases (1) • appropriate conclusion about percentage and length of dive (1) • no information about how long the longest dive lasts (1) • appropriate conclusion about depth of dive (1) • no information on the length of time that dives at different depths last (1)	**NB** piece together **e.g.** most dives last less than 16 to 20 minutes some dives can last as long an hour **e.g.** most dives are up to 100 to 200 metres some dives may be as deep as 600 metres	(4)

Question Number	Answer		**Additional Guidance**	Mark
9(b)(i)	**The only correct answer is A** ***B** is incorrect because the haemoglobin would have a higher affinity for oxygen* ***C** is incorrect because the curve would be to the left* ***D** is incorrect because the curve would be to the left*			(1)

Question Number	Indicative content	
***9(b)(ii)**	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. **Indicative content** • less oxygen stored in seal's lungs • so that more is delivered to the body • reduces buoyancy • cannot be replenished as diving • lungs of seal must be able to diffuse oxygen into blood faster • therefore {larger surface area / faster blood flow} • blood of seal carries more oxygen • because their haemoglobin has a higher affinity for oxygen • blood of seal carries more oxygen because they release erythrocytes from the spleen • therefore can supply more oxygen to muscles for aerobic respiration • to release ATP for muscle contraction • muscles of seal have more myoglobin • therefore can store more oxygen until oxygen tensions are very low • so that aerobic respiration can take place • to release ATP for muscle contraction • anaerobic respiration would not supply enough ATP for muscle contraction • body fluids store the same level of oxygen • because they do not have a role in storing oxygen • small concentrations in body fluids, as oxygen is dissolved in it for diffusion into cells	**Level 1:** 1 mark = 1 comparison 2 marks = 3 comparisons **Level 2:** 3 marks = 1 set of data simply explained 4 marks = 2 sets of data simply explained **Level 3:** 5 marks = 3 sets of data explained with links to diving and muscles 6 marks = 4 sets of data explained with links to diving and muscles

Question Number	Answer	Additional Guidance	Mark
9(c)	An answer that makes reference to four of the following: • oxygen in blood decreases as it moves into {muscles / cells / named cell} for (aerobic) respiration (1) • blood retains some oxygen (even though the muscles are depleted) (1) • this is to supply oxygen to the brain so that the cells do not die (1) • oxygen decreases in muscles as it is used to generate ATP for muscle <u>contraction</u> (1)	**ACCEPT** energy	(3)

Question Number	Answer	Additional Guidance	Mark
9(d)	An explanation that makes reference to three of the following: • lactic acid (accumulation) in the muscles is toxic (1) • therefore it passes from the muscles into the blood (1) • lactic acid is taken from the muscles to the liver by the blood (1) • drop in pH (caused by lactic acid) will denature enzymes (in the cells / blood) (1)		(3)

nswer	Additional Guidance	M

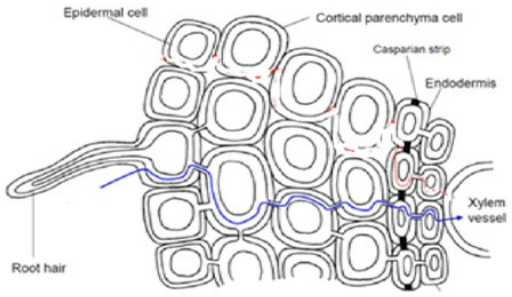
nswer	Additional Guidance	M
(1)	Example of Calculation 200 ÷ 1.79 = 111.73 ACCEPT 111.7	

nswer	Additional Guidance	Ma
erence to four of the	ACCEPT converse statements	
{no / little effect} in	(1) ACCEPT no oxygen / not in air	
air increases rate of	(1) ACCEPT translocation is faster / time taken is less	
s enzyme activity / olecules)	(1)	
ransport	(1) ACCEPT lack of **oxygen** reduces rate of transport	
g of sucrose / translocation} iires respiration}	(1)	(4

Number	Answer	Additional Guidance	Mark
1 (a)(i)	An answer that makes reference to the following: • one cell drawn with correct shape / proportion (1) • clear lines used to represent correct shape of cell, with no shading of any feature (1)	Must be a drawing not a diagram	**(2)**

Question Number	Answer	Additional Guidance	Mark
1 (a)(ii)	An explanation that makes reference to three of the following: • companion cells for ATP production (1) • because sieve tubes are for transport of organic molecules (1) • because energy is needed for transport (both up and down the stem) (1) • sieve tubes have no organelles, so less barriers to transport (1)	Allow named organic molecule eg {sugar / sucrose} Allow energy needed for active transport (of sugars) Allow sieve tubes have {sieve plates / plasmodesmata} so less barriers to transport	**(3)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that makes reference to the following: • so that some organelles are clearly visible (1)	**Accept** converse Allow named organelles	**(1)**

Question Number	Answer	Additional guidance	Mark
2(a)(i)	two marks from • passes from cell cytoplasm to cell cytoplasm (1) • via plasmodesmata of cells (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
2(a)(ii)	• conversion of measurement in mm to µm (x 1000) (1) • and division by 100 (1)	Example of calculation 60 x 1000 ÷ 100 = 600µm Correct answer with no working gains full marks allow 1 mark for 60 x 1000 or ÷ 100	**(2)**

Question Number	Answer	Additional guidance	Mark
2(b)	An explanation that makes reference to **four** of the following: • water is {evaporated / lost / transpired / diffused} from {leaves / stomata} (1) • therefore (leaf) cells have a low water potential / water potential gradient created (1) • because of cohesion of water molecules that {are polar / form hydrogen bonds} (1) • adhesion of water molecules to xylem walls (1)	allow water enters root hair down water potential gradient (1)	**(4)**

(Total for Question 2 = 8 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)			(2)

Molecule	Mineral ions used			
	nitrate ions only	phosphate ions only	both nitrate and phosphate ions	neither nitrate nor phosphate ions
amino acid	X	☐	☐	☐
DNA	☐	☐	X	☐

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	**The only correct answer is C** **A** is incorrect because 31 460 would be rounded up to 3.15×10^4 **B** is incorrect because 314 600 would be rounded up to 3.15×10^5 **D** is incorrect because 3 139 000 would be rounded up to 3.14×10^6		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	**The only correct answer is C** **A** is incorrect because symplast pathway does not go through cell walls **B** is incorrect because it shows the pathways the wrong way round **D** is incorrect because it shows apoplastic going through the cytoplasm		(1)

Question Number	Answer	Additional Guidance	Mark
4(b)(iii)	**The only correct answer is B** *A is incorrect because water moves from a dilute solution to a more concentrated one* *B is incorrect because water moves from a high water potential to a lower one* *D is incorrect because water moves from a high water potential to a lower one*		(1)

Question Number	Answer	Additional Guidance	Mark
4(c)	An explanation that makes reference to the three of the following: • water has a (small) positively charged {hydrogen / end} and a (small) negatively charged {oxygen / end} (1) • therefore hydrogen bonds form (between water molecules) (1) • therefore water moved due to {cohesion / cohesive forces} (between water molecules) (1) • (because of) {adhesion / adhesive forces} between water and xylem (1)	**ACCEPT** cohesive properties **ACCEPT** adhesive properties water moves due to adhesive and cohesive forces = 1 mark if no other mark awarded	(3)

Number	Answer	Additional Guidance	Mark
2(a)	An explanation that makes reference to two of the following: • dry leaves / do not put leaves under water (1) • because wet leaves reduce diffusion (1) or • {seal / use stem that fits} rubber connection (1) • therefore prevent loss of water from apparatus / maintain cohesion between water molecules (1) or • do not cut in air / cut under water (1) • prevents blocking xylem / prevent air getting into xylem / maintain {transpiration stream / water column / cohesion between water molecules} (1)	**ACCEPT** stem same size as capillary tube **DO NOT ACCEPT** entry of air	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(b)	A explanation that makes reference to the following: • attach syringe / reservoir and (3-way) tap (1) • to return bubble to scale / reset bubble (1) or • use longer capillary tube / longer scale (1) • bubble on scale for longer (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
2(c)(i)	An explanation that makes reference to the following: • multiply cross-sectional area by distance moved by bubble / $\pi r^2 \times d$ / $\pi r^2 \times h$ (1) • divide by total area of leaves (1) • divide by 5 (1)		**(3)**

Question Number	Answer	Additional Guidance	Mark
2(c)(ii)	An explanation that makes reference to two of the following: • moving air moves {water molecules / droplets} away (from leaf) (1) • therefore increases concentration gradient / diffusion gradient / water potential gradient (1) • difference is significant because SDs do not overlap (1)	**ACCEPT** converse **ACCEPT** wind	**(2)**

Number	Answer	Additional Guidance	Mark
3 (a)	• ***Ammophila*** (1)	reject Ammophila arenaria	**(1)**

Question Number	Answer	Additional Guidance	Mark
3 (b)(i)	• measurements of line AB and correct units (1) • calculation of magnification (1)	= 51 mm allow 50-52 mm ÷ 4mm = allow 12.75 allow range 12.5 -13 Correct answer gains full marks	**(2)**
		allow 1 mark for dividing by 4	

Question Number	Answer	Additional Guidance	Mark
3 (b)(ii)	An explanation that makes reference to two of the following points: • curved leaves so stomata are on inside of leaf {decrease concentration gradient /increase humidity} (1) • hairs reduce air movement (1) • stomata in pits to {increase humidity / decrease concentration gradient} (1)	ACCEPT reduces transpiration rate	**(2)**

	• (thick) waxy cuticle reduces water evaporation/ loss (from outer surface)(1)		

Question Number	Answer	Additional Guidance	Mark
3 (b)(iii)	An explanation that makes reference to two of the following points: • because it transports minerals (to the cells) (1) • because it transports water (to the cells) (1) • to support leaves to absorb light (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
3 (c)	An explanation that makes reference to two of the following points: • the water potential in soil solution will be higher (1) • so that water can be taken up from the sand / water not lost from roots {down a water potential gradient / by osmosis} (1)	IGNORE references to water concentration	**(2)**

(Total for Question 3 = 9 marks)

Number	Answer	Additional Guidance	Mark
5 (a)	An explanation that makes reference to five of the following: • carbon dioxide is absorbed through the stomata and water is lost (1) • recognition of two patterns of stomatal distribution (1) Trees (beech, oak, sycamore) plus pea & sunflower • plants {with leaves lying flat / have most stomata on the lower surface} to reduce water loss from direct sunlight (1) Frogbit • {upper surface in contact with air, lower surface with water / (therefore the) frogbit has all the stomata on the upper surface because it is not short of water} (1) Daffodil & maize • leaves are {upright / exposed to equal amounts of light} so have stomata on both surfaces (1)	Allow {more on upper / more on lower / equal distribution} Allow stomata on lower surface allow {carbon dioxide to enter / gas exchange} Allow it needs to absorb carbon dioxide from the air	**(5)**

Question Number	Answer	Additional Guidance	Mark
5 (b)(i)	An answer that makes reference to the following: • rate at low light intensity and high light intensity estimated (1) • percentage increase calculated (1)	Acceptable range of rates 1.2 to 1.5 4.5 to 5.5 Acceptable range = 200 – 358% Correct answer with no working gains full marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
5 (b)(ii)	An explanation that makes reference to the following: • temperature because it affects the rate of transpiration (1) • humidity because it affects the rate of transpiration (1)	accept other relevant factors eg. windspeed availability of water	**(2)**

Question Number			
3(a)	• (a group of similar) cells that perform a similar function (1)		(1)

Question Number	Answer	Mark
3(b)		(3)

Statement	Type of tissue			
	both xylem and phloem	xylem only	phloem only	neither xylem nor phloem
Contain sieve plates	☐	☐	X	☐
Have cellulose in the cell walls	X	☐	☐	☐
Has mitochondria	☐	☐	X	☐

Question Number	Answer	Mark
3(c)(i)	**The only correct answer is D** ***A** is incorrect because fructose is a monosaccharide* ***B** is incorrect because glucose is a monosaccharide* ***C** is incorrect because lactose is not found in plants*	(1)

Question Number	Answer	Additional Guidance	Mark
3(c)(ii)	• 14 / 14.3 / 14.29 (cm hr^{-1})		(1)

Question Number	Answer	Additional Guidance	Mark
3(c)(iii)	A description that makes reference to three of the following: • by mass flow / as a solution (flowing through the phloem) (1) • {sugars / sucrose} {loaded / pumped / actively transported} into phloem {in the leaf / at the source} (1) • {sugars / sucrose} {move out / diffuse} (out of phloem) into {sink tissues / roots / storage sites / named storage site} (1) • description of how water enters phloem at source **and** leaves at sink (1) • (sugars / contents) move to region of lower hydrostatic pressure (in the phloem) (1)	**ACCEPT** mass transport / dissolved in water **IGNORE** hypothesis **DO NOT ACCEPT** cohesion / adhesion / osmosis / active transport / diffusion / apoplast / symplast **DO NOT ACCEPT** glucose **DO NOT ACCEPT** glucose, but only penalise once pumped out / by active transport **DO NOT ACCEPT** diffusion **DO NOT ACCEPT** diffusion	(3)

Question Number	Answer	Mark
2(a)(i)	**The only correct answer is C T** **A** *is not correct because R is the epidermis* **B** *is not correct because S is the cambium* **D** *is not correct because U is the parenchyma*	**(1)**

Question Number	Answer		Mark
2(a)(ii)	• measurement in mm allow 57-59 • and division by 12 = 4.7 – 4.9 (2)	Example of calculation 58mm ÷ 12 =4.7 – 4.9 (2) Correct answer with no working gains full marks allow 1 mark correct measurement **or** dividing by 12	**(2)**

Question Number	Answer	Mark
2(b)(i)	**The only correct answer is** **B transport mineral ions from roots to growing regions** **A** *is not correct the xylem does not transport amino acids to growing regions* **C** *is not correct because xylem does not transport sucrose from leaves to growing regions* **D** *is not correct because xylem does not transport water from leaves to stem*	**(1)**

Question Number	Answer	Mark
2(b)(ii)	**The only correct answer is** **D the movement of substances is upwards and downwards** **A** *is not correct the movement of substances is not downwards only* **B** *is not correct the movement of substances is not a passive process* **C** *is not correct the movement of substances is not upwards only*	**(1)**

Question Number	Answer	Additional Guidance	Mark
2(c)	An answer that makes reference to **four** of the following Similarities • vertical arrangement of cells / contain fibres / vascular tissue (1) • contain cellulose cell walls (1) • contain parenchyma cells (1) Differences • Xylem mainly made up of lignified / cell walls contain lignin / secondary thickening / xylem has pits (1) • xylem cell walls break down / no <u>end</u> walls in xylem / xylem continuous tube (1) • phloem contains sieve tubes / sieve plates / companion cells (1)	At least one similarity and one difference **Accept** converse for phloem Not 'no cell walls'	**(4)**

(Total for Question 2 = 9 marks)

Question Number	Answer	Additional Guidance	Mark
4(a)	An answer that makes reference to the following: • all cells drawn with no extra details (1) • in correct proportions and twice as big (at least 4.4 cm) (1) • visible nuclei shown in correct positions (1)	No shading/feathered lines	**(3)**

Question Number	Indicative content	
***4(b)**	**Indicative content:** **1. Method for soaking stomata in potassium ions:** • leaf / leaf sections / epidermal strips taken • kept in dark (until all stomata are closed) • soaked in potassium ions/solution containing K^+ • of at least {five different concentrations / four different concentrations + water control) • left for a period of time • several leaf samples used /repeats, at each concentration **2. Control variables:** • leaves from same plant/same species of plant • all, kept in dark / exposed to same light intensity • other control variable, such as temperature / CO_2 concentration / windspeed / humidity / other (named) ions • same period of time **3. Visualising stomata:** • use a (light) microscope / description indicating microscope use • use, leaves / section/ strip, thin enough for light to penetrate through • use a, stain / named stain, to show stomata • nail varnish peel method • suitable plant leaf type eg: Tradescantia **4. Measurements made:** • use of an eye piece graticule • measure width of stomata • several stomata measured • eye piece graticule calibrated • using a stage micrometer **5. Data handling:** • calculate means • standard deviation / statistical analysis • graph plotted of width of stomata against potassium ion concentration	**Level 1** 1 mark : one relevant comment made 2 marks : Any 2 comments made from any aspect **Level 2 :** 3 marks : 3 comments made from at least two aspects 4 marks : 4 comments made from at least three aspects **Level 3 :** 5 marks : 4 comments made from at least four aspects 6 marks : at least 5 comments made from all aspects ACCEPT use of correlation coefficient test

	Additional Guidance	Mark
(1)	ACCEPT oxygen	
(1)	IGNORE phloem Needs to be in appropriate context of transport	**(2)**

	Additional Guidance	Mark
		(1)

	Additional Guidance	Mark
		(1)

Indicative content
·ding to candidates' deployment of knowledge and understanding of the material skills outlined in the generic mark scheme.
s not prescriptive and candidates are not required to include all the material . Additional content included in the response must be scientific and relevant.
:reases in the day ·anspiration could be due to environmental changes (wind speed / rain / humidity tion) lem diameter follows the same trend as change in transpiration
open ıcreases kinetic energy ases concentration gradient ıcreased / maintains concentration gradient s reduces water potential in the leaves
lar ogen bonding between water molecules er tension as water evaporates ssure to decrease, narrowing the xylem

nt
be attempted but with limited interpretation or analysis of the scientific information. contain basic information with some attempt made to link knowledge and understanding to the
be given with occasional evidence of analysis ad interpretation of two pieces of evidence.
, which is supported throughout by sustained application of relevant evidence of analysis, and information. ws a well-developed and sustained line of scientific reasoning which is clear and logically structured

Additional guidance	Mark
Accept osmotic potential	(3)

	Mark
s down a concentration gradient on happens down a concentration gradient are not moving in bulk	(1)

	Mark
lso involved t and symplast are involved lso involved	(1)

Ignore 7:497 or 28:1988 or 1/71	(1)

dditional guidance	Mar
dark room	
water bath / incubator /	
plastic bag	(2)

ts for wind and for still air n rate in wind (1)	Example of calculation Wind = (5.0 ÷ 20) = 0.25 Still air = (2.6 ÷ 20) = 0.13 (5.0 – 2.6) ÷ 20 = 0.12 0.25 – 0.13 = 0.12 Allow calculations based on other times eg 1.9 ÷ 7.5 = 0.25 1 ÷ 7.5 = 0.13 0.25 – 0.13 = 0.12 or 1.9 ÷ 7.5 = 0.253 1 ÷ 7.5 = 0.133 0.253 – 0.133 = 0.116 Allow one mark for calculation of one rate if answer incorrect Correct answer gains full marks, with no working shown.
	(2)

	Additional Guidance	Mark
	ACCEPT change fan speed / use fan at different distances	(

	Additional Guidance	Mark
	eats} /	(4)

		Mark
r		(1)

		Mark
r	s rate	(1)

Question Number	Answer	Additional guidance	Mark
3 (a)(i)	An explanation that makes reference to **two** of the following: • keep air-tight so as to not allow any air bubbles to enter (1) • so that continuous column of water to connect leaves to water in potometer (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
3 (a)(ii)	An explanation that makes reference to **two** of the following • as water on leaves will prevent transpiration / diffusion / evaporation (1) • as no (diffusion / concentration) gradient (1) • as stomata are covered / occluded (by water) (1)		**(2)**

Question Number	Answer	Additional guidance	Mark
3 (b)(i)	An explanation that makes reference to **four** of the following points: • take several readings (at each light intensity) after {stated time period} calculate mean / average (1) • reset using syringe between readings (1) • control named abiotic variable such as temperature / wind / humidity (1) • at 5 different light intensities (1) • vary light intensity by {moving light source away from potometer using light dimmer / rheostat} (1)		**(4)**

Question Number	Answer	Additional guidance	Mark
3 (b)(ii)	An explanation that makes reference to the following: • some water used in photosynthesis (1) • to maintain turgor (1)		**(2)**

(Total for Question 3 = 10 marks)

Question Number	Answer	Additional guidance	Mark
3(a)(i)	• (removing) roots affects water loss (1)	**Accept** null hypothesis or question	**(1)**

Question Number	Answer	Additional guidance	Mark
3(a)(ii)	An explanation that refers to two of the following • same <u>species</u> / same <u>surface area</u> of leaves / size of leaves (1) • so same density / number of stomata (1) • therefore same rate of transpiration / water loss (1)	Not type of plant / size of plant / number of leaves	**(2)**

Question Number	Answer	Mark
3(a) (iii)	• prevent <u>evaporation</u> / water loss from surface of water / surface of beaker	**(1)**

Question Number	Answer	Additional Guidance	Mark
3(b)	An explanation that makes reference to two of the following: • water loss is less than water uptake / water uptake is greater than water loss (1) • because some water used in photosynthesis (1) • to maintain turgor (1)	not all water taken up is evaporated	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(c)	A description that includes to the following • use seedlings all with roots / all seedlings without roots (1) • method of changing humidity (1) • control named abiotic variable (1) • repeat to calculate mean (1) • for <u>stated</u> time / change in mass per unit time (1)	E.g. using plastic bag/ moist air spray/ in greenhouse E.g. temperature / light / wind	**(4)** **ACCEPT** other methods

(Total for Question 3 = 10 marks)

Number	Answer	Additional Guidance	Mark
7 (a)	A is correct *apoplastic pathway* *B is incorrect as this is an incorrect term* *C is incorrect as the water passes through cell walls* *D is incorrect as the water passes through cell walls*		**1**

Question Number	Answer	Additional Guidance	Mark
7 (b)	An answer that makes reference to four from the following: • sugars are loaded / pumped / transferred into phloem / sieve tubes in leaf (1) • lowering water potential so that water enters phloem (1) • pressure in phloem increases (moving sugars) (1) • sugars are converted to (insoluble) starch in root cells / low sugar concentration in root cells (1) • increasing the water potential, so water moves out (1)		**4**

Question Number	Indicative content
7 (c)*	Answers will be credited according to candidate's deployment of knowledge and understanding of material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. • mistletoe lowers the NPP of apple trees over time (D) • NPP of trees without mistletoe shows an upward trend over 20 years (D) • NPP of trees with mistletoe shows an downward trend over 20 years (D) • mistletoe decreases the transpiration rate of the trees (D) • mistletoe has a higher transpiration rate than the apple tree (D) • higher transpiration rate of mistletoe diverts transpiration stream to mistletoe rather than apple tree / mistletoe takes the water from apple tree (E) • so less minerals are given to the apple tree (E) • less water for photosynthesis (E) • nitrogen content of apple trees is lower (D) • less amino acid / protein synthesis occurs (E) • less enzyme production so less photosynthesis (E) • lowering NPP (due to less enzymes) (E) • less nucleic acid synthesis (E) • less chlorophyll synthesis (E) • calcium content of the apple trees is lower (D) • so there is less production of cell walls / calcium pectate (E)

	Level 1: one or two D or E **Level 2: three or four from both D and E** **Level 3: five or six from both D and E, must explain effect of either low nitrogen / calcium and have no major errors**

Level	Marks	
Level	Marks	
0	0	No awardable content
1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.
2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure.
3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Mark
4 (a)(i)	The only correct answer is B (high high low) *A is incorrect as high humidity would reduce transpiration rate* *C is incorrect as low wind speed would reduce transpiration rate* *D is incorrect as low temperature would reduce transpiration rate*	**1**

Question Number	Answer	Additional guidance	Mark
4(a)(ii)	An explanation that makes reference to four the following: • {reduced leaf surface area / smaller leaves} so {less transpiration / evaporation / reduces water loss} (1) • {thick epidermis / waxy cuticle} {reduces evaporation / reduce water loss} (1) • stem used as photosynthetic organ / palisade cells (in stem) used for photosynthesis (1) • (when submerged) air spaces provide {oxygen for respiration / carbon dioxide for photosynthesis} (1) • high salt concentration (in cells) {lowers water potential / maintains water potential gradient} (1) • so less water loss by **osmosis** / water can enter by **osmosis** (1)		**4**

Question Number	Answer	Additional guidance	Mark
4(b)(i)	A description that makes reference to two of the following: • not quantitative / it is qualitative / not numerical (1) • cannot do statistical tests (1) • difficult to standardise / subjective (1)	 **Allow** scales are different for different species **Allow** different people make different estimates	**2**

Question Number	Answer	Additional guidance	Mark
4(b)(ii)	An explanation that makes reference to four of the following: • succession (has occurred) (1) • samphire is a {pioneer (species) / coloniser} (1) • samphire roots bind the silt / stabilises soil / stabilises substrate (1) • more {organic matter / humus} (in silt) due to {death / decomposition} (of plants) / more {nutrients / minerals / named nutrients} in soil (for other plant species) (1) • competition from {sea lavender / scurvy grass} results in less samphire (1) • abiotic factors change further in from sea / more sheltered further from sea (1)	**Allow** Samphire is only species that can live close to water / only samphire has adaptations to live by water **Allow** increased soil depth due to decomposition **Allow** decay **Allow** plants have different niches **Allow** competition between scurvy grass and sea lavender **Allow** named factors e.g. less wind / less salt / less exposed / less often flooded	**4**

Question Number	Answer	Mark
7 (a)	• the loss of water (vapour) by evaporation from the leaf (and the stem) (1)	**(1)**

Question Number	Answer	Mark
7(b)(i)	An explanation that makes reference to three of the following points: • during the day transpiration increases from early morning (until midday) then decreases (1) • due to increase in light causing more stomata to open or stomata to open wider / stomata close as light reduces in afternoon (1) • temperature also increases kinetic energy of water molecules (1) • increasing rate of evaporation (1)	**(3)**

Question Number	Answer	Mark
7(b)(ii)	An answer that makes reference to four of the following points: • as soil temperature increases so does transpiration rate (1) • across all air temperatures and all relative humidities (1) • relative humidity has little effect / has inconsistent effect (1) • air temperature increases the rate at soil temp of 25°C but not at other temperatures (1) • relative humidity and air temperature had least / little effect when soil temperature was low (1) • soil temperature is the major factor at determining transpiration rate in this experiment (1)	**(4)**

Question Number	Answer	Additional Guidance	Mark
7(c)	A description that makes reference to three of the following points: • use a bubble / weight potometer and leafy shoot (1) • measure change in position of bubble / change in mass over a stated time period (1) • how light intensity is varied to achieve different levels (1) • repeat readings at least three times and calculate mean (1) • method to control temperature / humidity / stated abiotic variable (1)	**Accept** detailed description of potometer using the shoot **Accept** stated distances	**(3)**

(Total for Question 7 = 11 marks)

	Additional Guidance	Mark
	DO NOT ACCEPT burning	**(3)**

	Additional Guidance	Mark
	Eg: number of squares occupied / point frame	**(3)**

…er	Additional Guidance	Ma…
…e following: …ater line (1) 116 m (1) …ater line / … line / …d / …or elder / …rram grass / …ange is 85 m (1) …m is greater than elder / …maximum is 30% (1)	**DO NOT ACCEPT** description of data	**(2**

…ce	M…

Mark	
	(3)
	ticle} (1)

Number	Answer	Additional Guidance	Mark
8(a)	A description that that makes reference to the following: • apoplastic non-living (1) • apoplastic uses cell walls / intercellular spaces (1) • apoplastic {faster / less resistance} (1) • apoplastic by diffusion / passive (1) • apoplastic blocked by Casparian strip (1)	symplastic living symplastic uses protoplast / cytoplasm / cell membrane / plasmodesmata symplastic {slower / more resistance} symplastic by osmosis / active / affected by metabolism / cytoplasmic streaming symplastic does not have to cross Casparian strip	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	An explanation that makes reference to three of the following: • small (non-polar / polar) via {phospholipid / lipid bilayer} membrane (1) • large non-polar / lipid soluble via {phospholipid / lipid bilayer} membrane (1) • large / polar / ionic / charged / water soluble via protein channels (1) • large (polar) / ionic / charged use facilitated diffusion / active transport (1) • small (non-polar / polar) use diffusion (1)		**(3)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that that makes reference to two of the following: • into roots by diffusion / active transport (1) • transport in xylem due to transpiration (stream) (1) • in phloem by {mass flow / translocation} (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation that that makes reference to four the following: • summer is warmer / lighter (1) • therefore (more) evaporation / transpiration (1) • stomata open longer / open wider (1) • water molecules have more kinetic energy (1) • more leaf (area) (1)	**ACCEPT** converse for spring	**(5)**

Question Number	Answer	Mark
6(a) (i)	• potometer (1)	**(1)**

Question Number	Answer	Mark
6 (a)(ii)	An explanation that makes reference to a pair of the following: • cut shoot (at an angle) under water (1)	**(2)**
	• so that no air enters xylem (1) or • ensure no air is left in capillary tube • so that bubble can move (1) or • seal using petroleum jelly (1) • so that no air leaks into system / make airtight (1) or • move the air bubble to the zero / record the starting position of the air bubble (1) • so that water lost can be accurately measured (1)	

Question Number	Answer	Mark
6 (a)(iii)	An explanation that makes reference to two of the following: • not all water taken up by shoot is lost in transpiration / may absorb more water than it transpires (1) • because some used in photosynthesis / some used in cell expansion / elongation / keep cells turgid (1)	**(2)**

Question Number	Answer	Mark
6 (b)	An answer that makes reference to two of the following: • removing half of the leaves (1)	**(2)**
	• greatest change as decreases by 8 (mm per min) / decreases from 19 to 11 (1)	

Question Number	Answer	Mark
6 (c)(i)	• by putting (transparent) plastic bag / use humidifier / water spray / fan / hairdryer (1)	**(1)**

Question Number	Answer	Additional guidance	Mark
6 (c)(ii)	• change the temperature of the room or use a heater (without affecting other variables) (1)	Not water bath or heat lamp or oven	**(1)**

Question Number	Answer	Additional guidance	Mark
6(c)(iii)	A description that makes reference to the following: • use syringe to deliver (known) volume of water (1) • note how much bubble moves in mm (on scale) (1)	**Allow** note volume of water required (1) to move bubble certain distance (1)	**(2)**

Question Number	Answer	Mark
6(d)	An explanation that makes reference to two of the following points : • increased humidity increases the amount of water (molecules) in the air surrounding stomata (1) • so reduces diffusion gradient / concentration gradient (of water molecules) (1) • so less water loss / transpiration/ less diffusion therefore less water uptake (1)	**(2)**

(Total for Question 6 = 13 marks)

Number	Answer	Additional Guidance	Mark
9(a)	An answer including at least one similarity • both tissues contain tubes (1) • both have cell walls containing cellulose (1) **and** at least one difference • xylem vessels contain lignin, but phloem does not (1) • in xylem, end walls of cells break down completely (to leave hollow tubes), but in phloem there are sieve plates (1) • phloem (sieve tubes) have companion cells, but xylem does not (1) • phloem (sieve tubes) contains cytoplasm, but xylem does not (1)	Accept both have vessels which are cylindrical Accept xylem has thicker walls / xylem vessels have pits in (side) walls and phloem does not Accept phloem has sieve plates, but xylem does not Accept phloem contains plasmodesmata but xylem does not / phloem contains organelles but xylem does not	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	A calculation that shows the following stages • manipulation of units (to mm) (1) • calculation of volume of cylinder (1) • rate per minute calculated to 2sf (1)	Example of calculation: eg mean is 64 (mm) 4.522 / 4.524 (this gets mp1 and 2 if 64 not seen) 0.90 Correct answer with no working gains 3 marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An explanation that includes three of the following • {water uptake / transpiration} is fastest in moving air in the light (1) • {water uptake / transpiration} {is very slow / stops / decreases} in the dark as stomata close (1) • {water uptake / transpiration} is faster in moving air (than still air) as the diffusion gradient is {maintained / steeper} (1) • comment on decline in rate (of transpiration / water uptake) as trials continue in darkness with explanation (1) • effect of light is greater than effect of moving air (1)	Accept {water uptake / transpiration} is slowest in still air in the dark Accept concentration gradient / water potential gradient / diffusion shells around stomata or leaf Accept converse Accept stomata do not close completely until trial 3	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	A description that includes four of the following: • cover one surface of leaves with {petroleum jelly / clear tape} (to prevent transpiration) • measure {rate / distance moved in 5 mins / volume of water taken up in 5 mins} (1) • ensure that covering is fully removed or use another shoot with same surface area (1) • repeat for other surface of leaves (and compare results) (1) • {**method of control of** one named variable / monitoring named variable which cannot be controlled} (1) • repeats for each set up and calculate standard deviation (1)	Accept clear nail varnish / clear wax / clingfilm Accept other times Accept time how long it takes to move a set distance Accept same number of leaves / similar surface area Accept calculate (rate of) water loss per unit area Accept eg. temperature – AC room / room temperature humidity - clear bag over plant light intensity – distance from lamp air movement - distance from fan Accept repeat and carry out appropriate stats test eg t-test, 95% confidence limits, Mann Whitney U test	**(4)**

Total for question 9 = 13 marks

Number	Answer	Additional Guidance	Mark
9(a)	An explanation that includes two of the following: • (vessels) {are empty tubes / do not contain cytoplasm or organelles} (1) • allowing free water movement / for a continuous column of water (1) Or • (walls contain) lignin (1) • so they are {strong / waterproof} (1) Or • lumen of vessel is narrow (1) • so that capillary forces are strong (1) Or • walls contain pits (1) • for lateral movement of water (1)	Accept hollow / no end {walls / plates} Ignore dead Ignore efficient Accept to withstand pressure Accept so water cannot escape Ignore support Accept sideways	**(2)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	An answer that includes the following: • correct rate determined from graph to 1dp (1)	Example calculation $\frac{\text{Rate at 13 hours – rate at 5 hours}}{8}$ = **25.3** (g m^{-2} $hour^{-1}$) Accept answers in range 25.0 to 25.6 Correct answer with no working gains full marks	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An explanation that includes three of the following: • transpiration is slow between {1-5 / 21-23} hours because {it is dark / no light available} (1) • because (most) stomata are closed (at night / in the dark / between {1-5 / 21-23} hours}) (1) • (rate of) transpiration increases between {3 / 5} and 13 hours as {{temperature / light intensity} increases / as stomata open} (1) • (rate of) transpiration is at a maximum at 13 hours as {light intensity / temperature} is {high / highest} (1) • (rate of) transpiration decreases after 13 hours as {light intensity / temperature} decreases (1)	Allow at night for time Allow up to 5 hours / any 2 values between 1 and 5 / any 2 values between 21 and 23 Allow after {3 / 5} hours transpiration increases as.....	**(3)**

Question Number		Additional Guidance	Mark
9(c)	An answer that includes five of the following: Answers may be expressed in various ways • Potometer B directly measures {water loss / transpiration} / Potometer A measures water uptake (1) • some water is used in photosynthesis (1) • {Potometer A uses cut shoot but Potometer B uses whole plant (with roots) / Potometer B (with roots) is more like the real situation} (1) • Potometer A can only be used for a short time, but B can be used over several days (1) • Potometer A – change in temperature can affect position of air bubble (1) • Potometer A – more likely to have errors in reading of results (1)	Accept water uptake in Potometer A may be affected by {cutting the shoot / air bubbles in xylem} Accept can get repeatable results (more quickly) with a Potometer A / can repeat (easily) Potometer B – loss of leaves / flowers / seeds from plant will affect mass Ignore mass due to {water on leaves / O_2 or CO_2 loss}	**(5)**

Question Number	Answer	Additional Guidance	Mark
9(d)(i)	An answer that includes the following: • **only** phloem shaded (1)	Allow one or more areas of phloem shaded	**(1)**

Question Number	Answer	Additional Guidance	Mark
9(d)(ii)	An answer that includes the following: • sucrose (1)	Ignore radioactive Ignore formula if given	**(1)**

(Total for question 9 = 13 marks)

Question Number	Answer	Mark
7(a)(i)	**The only correct answer is D** ***A*** *is not correct because xylem carries water and mineral ions and the sucrose is in solution in the phloem* ***B*** *is not correct because xylem carries water and mineral ions* ***C*** *is not correct because the sucrose is in solution in the phloem*	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	A description that makes reference to **three** of the following: • xylem cell walls contain {cellulose and lignin / lignin} but phloem cell walls contain {only cellulose / no lignin} (1) • xylem is {hollow / no end walls} but phloem has {cell contents / sieve plates} (1) • xylem has pits but phloem does not (1) • xylem {does not have companion cells / is dead} but phloem has companion cells (1)	**Do not piece together unless points are clearly paired in adjacent sentences** **ACCEPT** xylem has thick cell walls but phloem has thinner cell walls {xylem is / xylem cells are} lignified **ACCEPT** {modified / enlarged} plasmodesmata	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	A description that makes reference to the following: • as the pressure gradient increases there is (a linear) increase in the velocity (for all three radii) (1) • as the radius of the xylem increases the velocity increases (1)	**ACCEPT converse for both points** **ACCEPT** higher the pressure gradient the higher the velocity **ACCEPT** greater the radius the higher the velocity	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	• velocities read from graph (1) • correct percentage calculated (1)	156 / 157 and 61 / 62 (156 - 61) x 100 ÷ 61 = 155.73 / 155.7 / 156 % (156 - 62) × 100 ÷ 62 = 151.61 / 151.6 / 152 % (157 - 61) x 100 ÷ 61 = 157.38 / 157.4 / 157 % (157 - 62) × 100 ÷ 62 = 153.23 / 153.2 / 153 % CE applies if 155 / 158 and / or 63 given as values from graph (155 – 61) ×100 ÷ 61 = 154.1 / 154 % (155 – 62) ×100 ÷ 62 = 150 % (155 – 63) ×100 ÷ 63 = 146.03 / 146 % (156 - 63) x 100 ÷ 63 = 147.62 / 147.6 / 148 % (157 - 63) x 100 ÷ 63 = 149.21 / 149.2 / 149 % (158 – 61) ×100 ÷ 61 = 159.02 / 159 % (158 – 62) ×100 ÷ 62 = 154.84 / 154.8 / 155 % (158 – 63) ×100 ÷ 63 = 150.79 / 150.8 / 151 %	**(2)**

Question Number	Indicative content
*7(c)	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant. Indicative content: • male gamete fertilise female gamete to produce embryo • one male gamete fuses with {both polar nuclei / (diploid) endosperm nucleus} to form a triploid endosperm nucleus • endosperm is a store of {starch / protein / oils} • ovules will become the seeds inside the berries • xylem transports the water needed for berry formation shown in graph 1 • xylem transports the water needed for hydrolysis of food stores • xylem transports mineral ions for berry formation • phloem transports the sucrose needed for berry formation and ripening in graph 2 • more sucrose is transported from the leaves when berries are present in graph 2 • ^{14}C incorporated into glucose during photosynthesis • glucose converted into sucrose for transport in the phloem

Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context. **2 or 3 comments made which may include description of graphs and / or explanations**
Level 2	**3-4**	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages and lines of scientific reasoning with some structure. **4 of 5 comments that include explanations with reference to at least two components**
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. **6 or 7 comments that include explanations with reference to all three components**

Question Number	Answer	Additional Guidance	Mark
8(a)(i)	• length of scale line given in µm • magnification calculated	1.7 × 10000 / 17000 1.7×10^{3} / 0.0017×10^{6}	

Question Number	Answer	Additional Guidance	Mark
8(a)(ii)	width of GM aperture divided by width of non-modified aperture	In the range of 1.3 to {4 / 4.0} to no more than 1 decimal place **DO NOT ACCEPT** with units or %	

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	A description that makes reference to the following: • (µmol) carbon dioxide used / {oxygen / GP / GALP / glucose} made (1) • (m^{-2}) is the area of the {leaf / open stomata} (1) • (s^{-1}) in one second (1)	**ACCEPT** example e.g. measure for 120 seconds and divide by 120	

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to three of the following: • increase in light intensity increases photosynthesis (1) • increase is greater in GM plants because the wider aperture will result in a more {gas exchange / uptake of carbon dioxide} (1) • therefore {light-independent reactions / Calvin cycle / carbon fixation} is faster (1) • rate levels off when {another factor / carbon dioxide concentration / temperature} becomes rate limiting (1)	**ACCEPT** GM plants photosynthesise faster than non-GM **ACCEPT** carbon dioxide not limiting the rate of {light-independent reactions / Calvin cycle / carbon fixation}	

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation that makes reference to three of the following: • because (faster photosynthesis will result in) more {GALP / glucose} produced (1) • to form a named plant molecule (1) • because transpiration stream will be faster (1) • therefore more mineral ions for named product (1)	**ACCEPT** biomass / other organic molecules more {oxygen / glucose} for ATP production **e.g.** Mg^{++} for chlorophyll, nitrates for protein	

Question Number	Answer	Additional Guidance	Mark
8(d)(i)	**D** ATP is broken down into ADP and phosphate ions by a hydrolysis reaction	**A** is incorrect because ATP is broken down **B** is incorrect because ATP is broken down **C** is incorrect because condensation reactions form bonds	

Question Number	Answer	Additional Guidance	Mark
8(d)(ii)	**A** malate lowers the water potential of the cytoplasm	**B** is incorrect because increase in solute concentration raises water potential so water would leave the cells **C** is incorrect because starch has no osmotic effect **D** is incorrect because starch has no osmotic effect	

Question Number	Answer	Additional Guidance	Mark
8(d)(iii)	**D** The guard cells become larger and the inner wall of the guard cell is less flexible than the outer wall	**A** is incorrect because entry of water would make the cell more larger **B** is incorrect because entry of water would make the cell more larger **C** is incorrect because the stoma would not form if the inner wall was flexible	

Question Number	Answer	Mark
8 (a)	An answer that makes reference to the following: • can reset bubble on scale (1)	**(1)**

Question Number	Answer	Mark
8 (b)	An explanation that makes reference to two of the following: • increasing fan speed blows away saturated air from stomata / no still air surrounding stomata (1) • so transpiration and water uptake increased as greater/ steeper diffusion / concentration gradient (1) • maximum reached / no further increase from medium to high as all moist air blown away no further increase in gradient (1)	**(2)**

Question Number	Answer	additional guidance	Mark
8 (c)(i)	An explanation that makes reference to two the following: • If leaves are wet (1) • so increases water uptake is lower / transpiration is slower / reduces diffusion gradient (1) or • temperature (increases / decreases) (1) • Increases / decreases kinetic energy of water molecules / water evaporated / water uptake / water loss / transpiration (1) or • cut damages vascular tissue (1) • so less water taken up / lost (1) or • light intensity (increases / decreases) (1) • so stomata open / stomata close (1)	**ignore humidity**	**(2)**

Question Number	Answer	additional guidance	Mark
8 (c)(ii)	An explanation that makes reference to the following: • the lack of an airtight seal (1) • will slow air bubble movement and may stop transpiration / water uptake (1) or • if scale is not read at eye level / read at angle (1) • parallax error in reading bubble on scale (1) or • wider capillary (1) • less distance moved by bubble (1)		**(2)**

Question Number	Answer	additional guidance	Mark
8 (d)(i)	• radius = 0.5 v = 80 • substitute values in formula and calculation • answer given to 2 sig figs = 62 or 63 (3)	full marks for correct answer no working 1 mark for $\times 0.5^2$ or $\times 0.25$ or 1 mark for $\times 80$ if use π as 3.1 = 62 if use π as 3.14= 63 if or 62.8 or 62.84 or 62.832 scores 2	**(3)**

Question Number	Answer	additional guidance	Mark
8 (d)(ii)	An answer that includes • method to measure leaf surface e.g using graph paper (1) • divide water uptake by surface area (1)		**(2)**

Question Number	Answer	additional guidance	Mark
8 (e)	A description that makes reference to three of the following • use at least 5 different temperatures (1) • measure distance moved by bubble in one minute / stated time (1) • repeat for each temperature and calculate mean (1) • use same plant species and size (1) • reference to named control variable light / humidity / wind speed (1)		**(3)**

(Total for Question 8 = 15 marks)