Surname	StemUp Model Solution	Centre Number	Candidate Number
First name(s)			2

GCE AS

B400U20-1

Z22-B400U20-1

THURSDAY, 9JUNE 2022 – AFTERNOON

BIOLOGY – AS component 2
Biodiversity and Physiology of Body Systems

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	13	
2.	9	
3.	12	
4.	14	
5.	18	
6.	9	
Total	75	

B400U201
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ADDITIONAL MATERIALS

In addition to this paper you will require a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen. Do not use gel pen or correction fluid.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet. If you run out of space, use the additional page(s) at the back of the booklet, taking care to number the question(s) correctly.

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.

The assessment of quality of extended response (QER) will take place in question **6**.

The quality of written communication will affect the awarding of marks.

JUN22B400U20101

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Answer **all** questions.

1. (a) All organisms need to obtain nutrients from their environment to survive. Define the following terms: [3]

(i) Holozoic;

Food is ingested and then digested internally (inside a digestive system), then absorbed, with undigested waste egested.

(ii) Saprotrophic;

Extracellular digestion: enzymes are secreted onto dead or decaying material, digesting the food externally, and the products are absorbed.

(iii) Photoautotrophic.

Formation of organic molecules from inorganic molecules (CO_2 and water) using light energy.

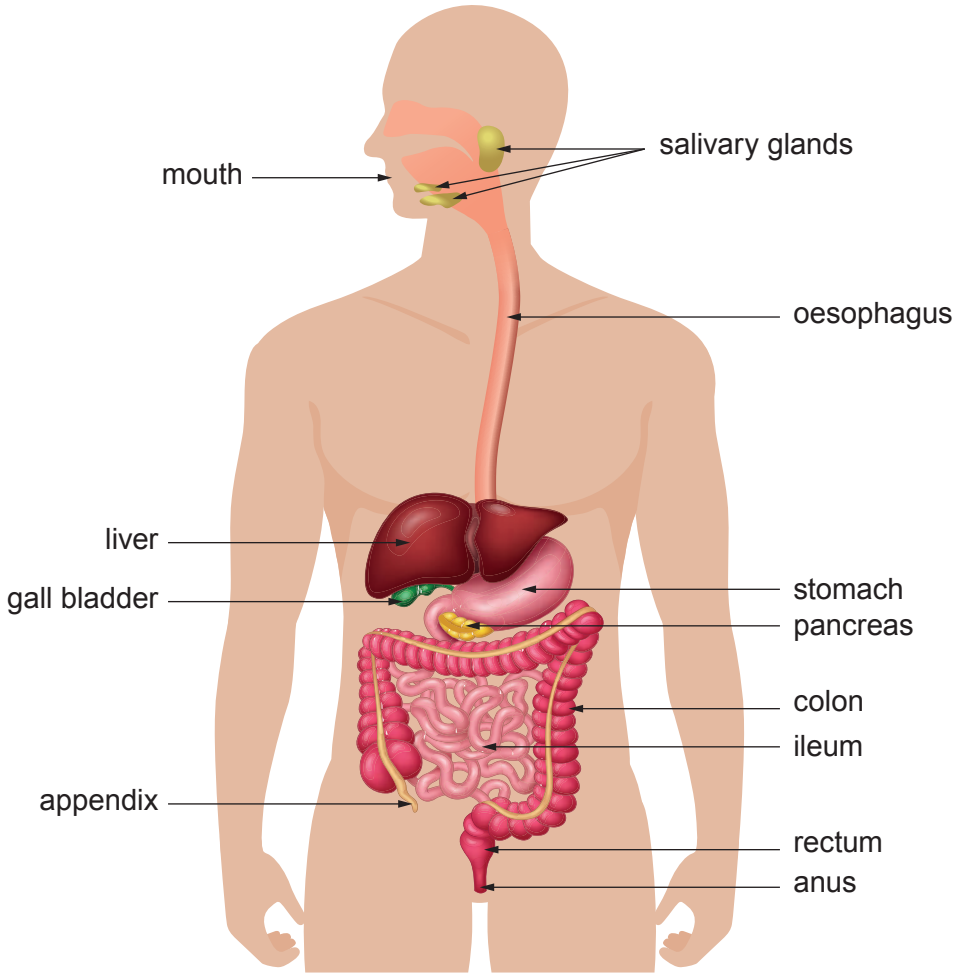
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(b) **Image 1.1** shows the human digestive system.

Image 1.1



Using **Image 1.1**, complete the table below to identify **one** structure where each process shown takes place. [2]

Structure	Process
Pancreas	secretes lipase
Liver	secretes bile
Mouth	site of mechanical digestion
Colon	absorption of water

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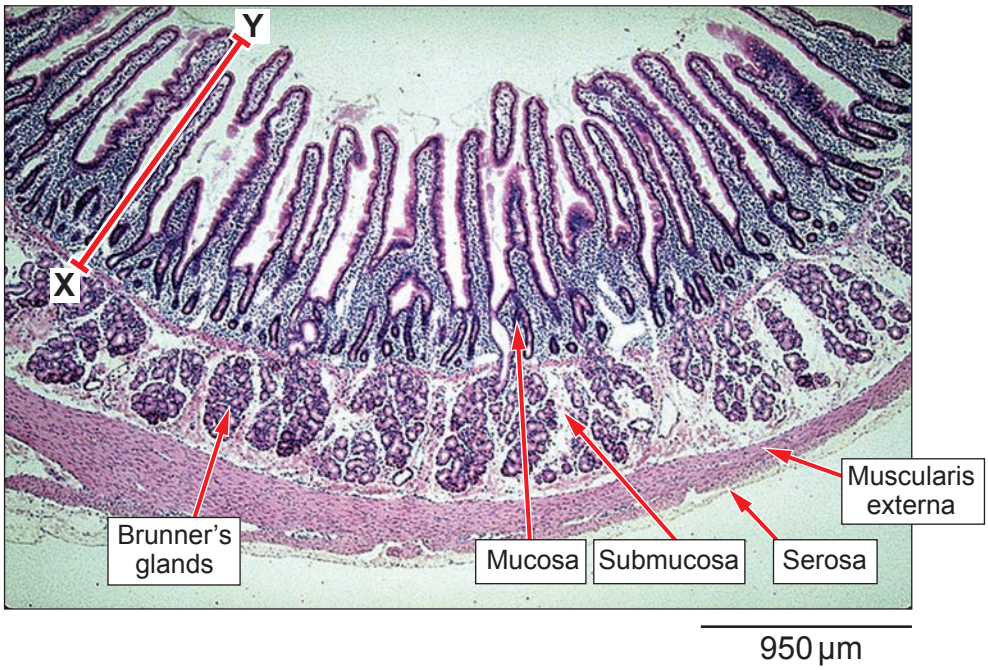
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(c) **Image 1.2** shows a photomicrograph of the wall of the duodenum. The duodenum tissue has been stained.

Image 1.2



(i) Explain why it was necessary to stain the tissue before it was viewed under the microscope. [1]

Staining shows more detail and gives more contrast between structures, so the different tissue layers can be distinguished.

(ii) Calculate the actual size of the villus along the line **X–Y**. [2]

X–Y = 37 mm, scale bar = 28 mm

actual size = (37 ÷ 28) × 950 = 1255 µm

Actual size = 1255 µm

(iii) State the function of the villi and how villi are adapted for their function. [1]

Villi absorb the products of digestion (nutrients); they are adapted by having a large surface area (folded with microvilli).

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(iv) Ions such as calcium and phosphate are absorbed into the blood in the ileum. State their roles as components of structures or biological molecules in the body. [2]

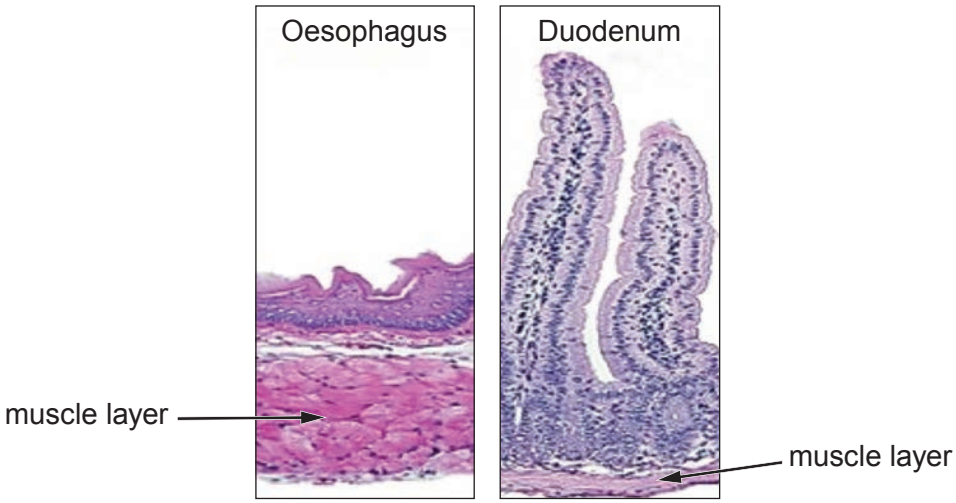
Calcium ions

Strengthen bones and teeth (component of calcium phosphate in bone).

Phosphate ions

Used to make phospholipids (cell membranes), ATP and nucleic acids (DNA nucleotides).

Image 1.3



(v) **Image 1.3** shows that the muscle layer of the wall of the oesophagus is thicker than that of the duodenum. Suggest an explanation for this. [2]

Food in the oesophagus is more solid (a bolus) than the liquid chyme in the duodenum.

So a stronger contraction of the circular and longitudinal muscles (more forceful peristalsis) is needed to push food along the oesophagus.

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05

13

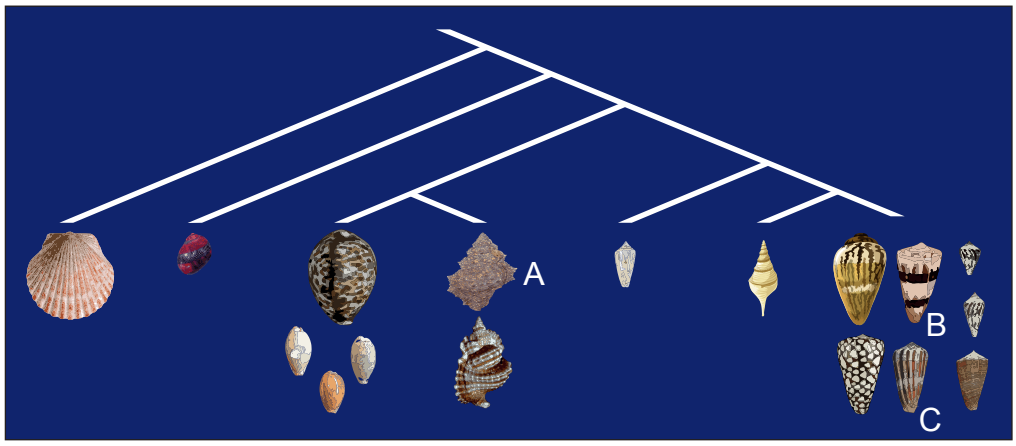
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2. Cone snails are venomous, predatory marine snails. There are approximately 10 000 species of cone snails identified mainly by the shape, colour and banding patterns of the shell. **Image 2.1** shows some of these organisms.

Image 2.1



Organism	Binomial name	Common name
A	*Bursa nobilis*	The Noble Frog Shell
B	*Conus capitaneus*	The Captain's Cone
C	*Conus omaria*	Omaria Cone

(a) State the name given to the type of diagram shown in **Image 2.1** and explain how the diagram shows the relatedness of the cone snails. [2]

Phylogenetic tree.

The more recent the branching point, the more closely related the cone snails are; snails sharing a recent common ancestor are closest.

(b) **Image 2.1** also shows the binomial names and common names of some of the snails. With reference to organism **A**, explain what is meant by the binomial system and the reasons for scientists using this rather than the common names. [3]

A binomial name has two parts, genus then species: for A, Bursa is the genus and nobilis is the species.

Common names vary regionally and in different languages, causing confusion when identifying species.

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(c) Classification of the cone snails is based upon the shell morphology. Explain how DNA analysis could be used to determine the position of organisms in **Image 2.1**. [2]

Carry out DNA base sequencing (or DNA hybridisation) on each species and compare the base sequences.

The more similar the base sequences, the more closely related the snails are, so the closer their positions on the tree.

(d) There are over 10 000 different species of cone snails which indicates there is a high level of biodiversity. State how the genetic diversity within **one species** of cone snail could be assessed. [1]

Analyse the proportion of polymorphic loci across the genome, or count the number of alleles for a particular gene in the population.

(e) Cone snails **B** and **C** from **Image 2.1** were kept together in a tank. They interbred and produced offspring which were infertile. Explain why the offspring were infertile. [1]

B and C are different species (Conus capitaneus and Conus omaria), so the hybrid's chromosomes cannot pair in meiosis and it cannot form gametes.

B400U201 07

9

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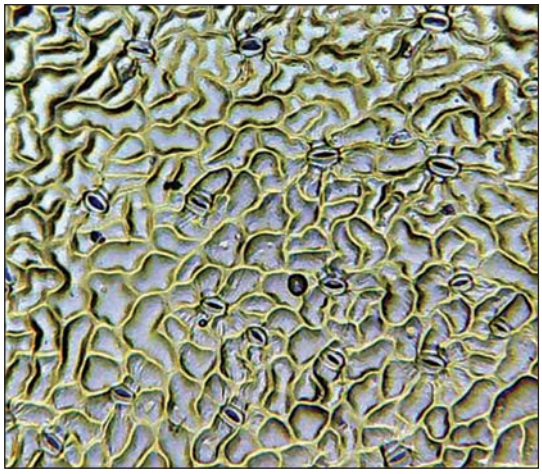
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3. (a) Stomata on the surface of leaves are the main site of gas exchange in plants.

Stomatal density can be measured by applying nail varnish to the under-surface of the leaf to create an impression of the leaf surface. **Image 3.1** shows an impression of part of the leaf surface of a mesophyte leaf measuring 0.2 mm × 0.2 mm.

Image 3.1



(i) Using a light microscope, **21** stomata were counted in the area. Use this number to calculate the number of stomata per mm^2. [2]

area = 0.2 × 0.2 = 0.04 mm^2

21 ÷ 0.04 = 525

Number of stomata = 525 per mm^2

(ii) Some of the stomata shown in **Image 3.1** are open. Explain the mechanism of stomatal opening which allows gas exchange to take place. [4]

In the light, K^+ ions are actively pumped into the guard cells (using ATP).

Starch in the guard cells is converted to malate ions.

This lowers the water potential inside the guard cells.

Water moves into the guard cells by osmosis from the surrounding epidermal cells.

The guard cells become turgid and, as the inner cell wall is thicker and less elastic, they bend unevenly so the stoma opens.

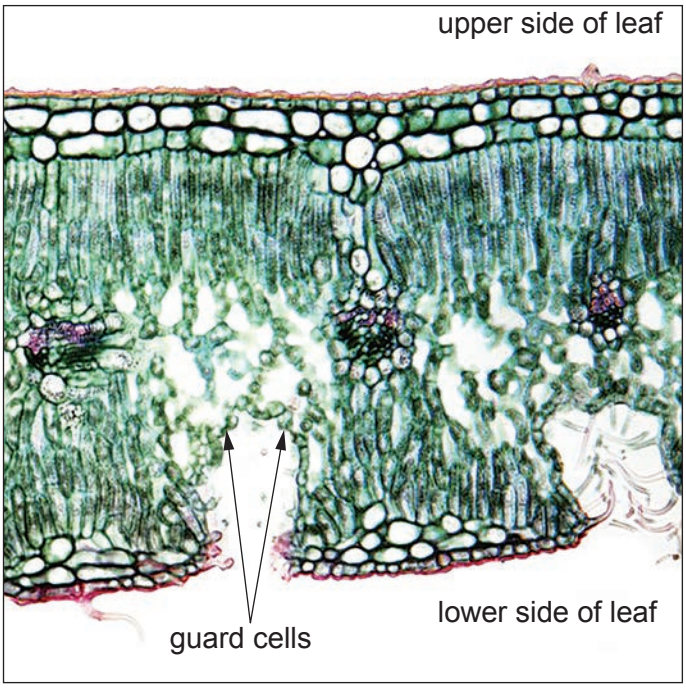
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(b) When the stomata are open, loss of water vapour also occurs. **Image 3.2** shows a section of a leaf from a plant which has adaptations to reduce this loss of water vapour from its leaves.

Image 3.2



(i) Identify the **type** of plant which has the type of adaptations shown in **Image 3.2**. Describe **and** explain **three** adaptations shown in **Image 3.2** which reduce the loss of water vapour. [4]

Xerophyte.

Sunken stomata in pits: humid air is trapped, with less air movement, reducing the water vapour gradient.

Hairs (trichomes) trap water vapour, reducing the diffusion gradient between the leaf and the air.

A thick waxy cuticle and epidermis on the upper surface reduce evaporation from the leaf surface.

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09

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(ii) Suggest why the method used to obtain the impression in **Image 3.1** would not be a suitable technique to measure stomatal density in the leaf shown in **Image 3.2**. [1]

The stomata are sunken in pits (hidden by hairs), not on the surface, so the varnish would not take an impression of them.

(iii) Suggest how the method used to obtain the impression of the stomata in **Image 3.1** may need to be modified if using a **hydrophyte** leaf. [1]

Apply the nail varnish to the upper surface of the leaf, as hydrophyte stomata are on the upper surface.

12

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4. (a) The head of a bony fish was dissected to remove its gills as shown in **Image 4.1**.

Image 4.1



(i) Complete the risk assessment below for the **main** hazard in the fish head dissection. [2]

Hazard	Risk	Control measure
Dissecting instruments, e.g. scalpel, are sharp	Skin could be cut or pierced when using the scalpel	Cut onto a white tile, cutting away from the body

(ii) Explain **four** ways in which the gills are adapted for gas exchange. [4]

Many gill filaments and gill plates (lamellae), increasing the surface area for gas exchange.

A rich blood supply to the gill plates, which maintains the concentration gradient for oxygen.

Countercurrent flow of blood and water, which maintains a concentration gradient along the whole gill plate.

A thin epithelium, one cell thick, giving a short diffusion distance.

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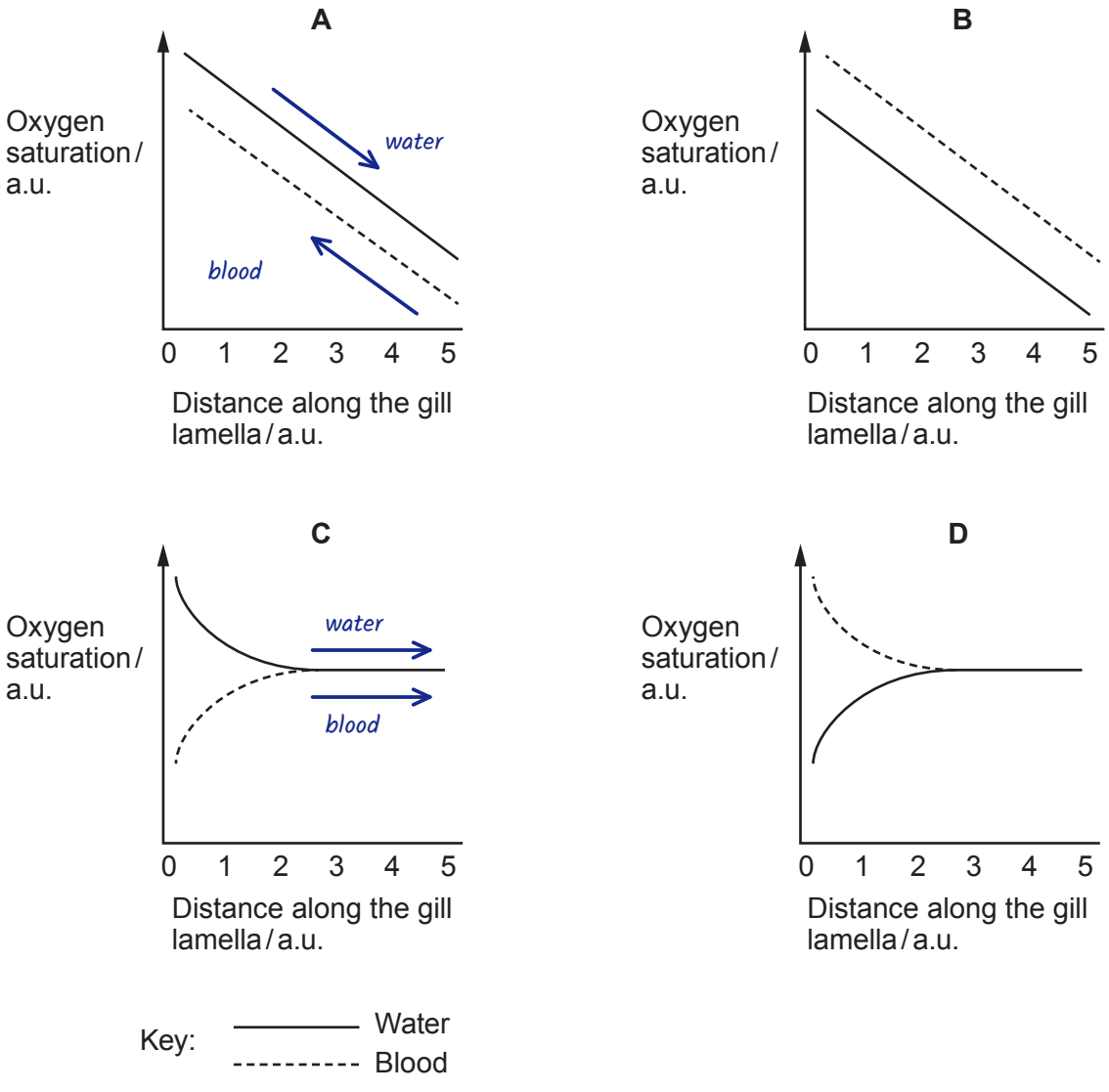
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(b) **Table 4.2** shows the effect of the different anatomical arrangement of blood vessels in a bony fish (salmon) and a cartilaginous fish (shark).

Table 4.2

Distance along the gill lamella / mm	Oxygen concentration / a.u.			
	Salmon		Shark	
	Water	Blood	Water	Blood
1	5.00	4.43	5.00	1.82
2	4.23	3.97	4.42	3.45
3	3.57	3.42	3.58	3.58
4	2.98	2.54	3.58	3.58
5	2.01	1.97	3.58	3.58

Graph 4.3



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(i) Using evidence from **Table 4.2**, identify which graph **(A – D)** shows blood and water flow in the: [1]

Salmon ..A..

Shark ..C..

(ii) **Add arrows to the two graphs chosen** in (b)(i) to identify the direction of blood and water flow. [1]

(iii) Explain why the salmon is more efficient than the shark in absorbing oxygen from the water passing over the gills. [3]

In the salmon, blood and water flow in opposite directions across the gill plate (countercurrent flow).

So a concentration gradient is maintained and diffusion occurs along the whole gill plate; equilibrium is never reached.

This gives a higher oxygen concentration in the salmon's blood, 4.43 a.u., compared with 3.58 a.u. in the shark.

(c) The ventilation rate in salmon can be determined by counting the number of times the operculum opens and closes per minute. In one experiment, the ventilation rate in polluted water (low oxygen concentration) was compared to the ventilation rate in unpolluted water (higher oxygen concentration). The mean ventilation rate of salmon in polluted water was found to be 15 per minute, whereas in salmon from unpolluted water, the mean ventilation rate was 6 per minute.

Suggest and explain the reason for this difference in ventilation rate. [3]

Polluted water has less oxygen, so the salmon increases its ventilation rate to move more water across the gills per minute.

This allows it to get the same (sufficient) volume of oxygen into the blood.

This meets its metabolic needs, supplying enough oxygen for aerobic respiration (its oxygen demand).

14

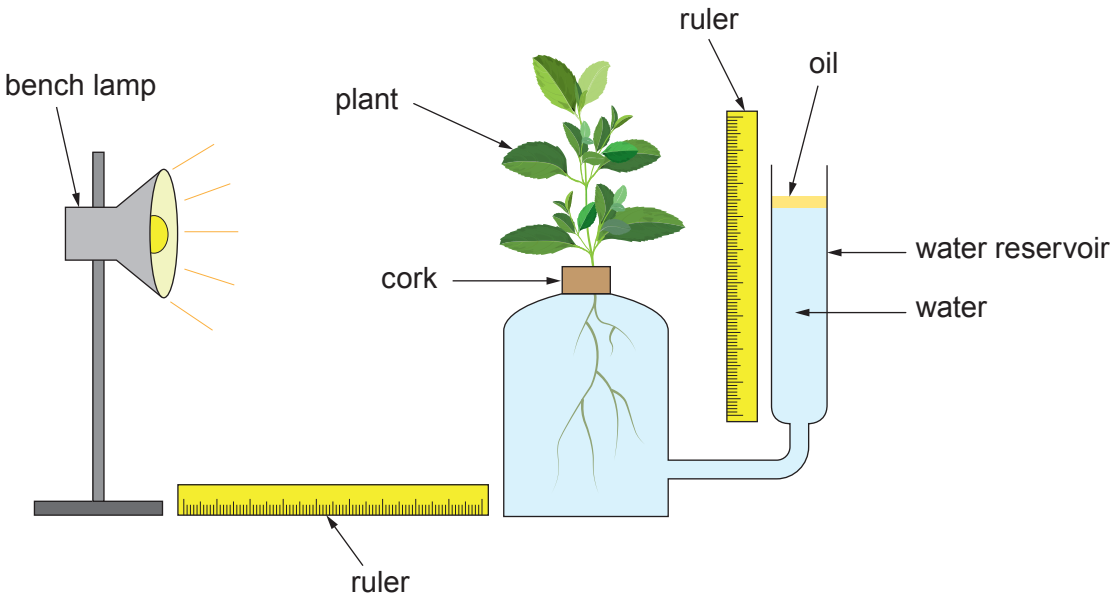
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5. (a) A potometer can be used to measure the uptake of water by a plant. **Image 5.1** shows one type of potometer.

Image 5.1



(i) The potometer was used to investigate the effect of changing light intensity on the uptake of water by the roots.

State the following for this investigation: [2]

I. the independent variable;

The distance of the lamp from the plant.

II. the dependent variable.

The distance the water level dropped in the reservoir.

(ii) Suggest and explain why oil was added to the surface of the water in the reservoir before the investigation started. [2]

Oil prevents water evaporating from the surface of the reservoir.

So the only route for water loss is uptake through the roots, then transpiration.

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(iii) Other factors apart from light intensity can also affect the uptake of water by a plant. Complete the table below to identify **two** other factors which could affect the water loss from the plant used in this experiment. Justify why each of these factors needs to be controlled. [3]

Factor	Justification
Temperature	Higher temperature would increase evaporation and transpiration
Humidity	Higher humidity would decrease the water vapour gradient, reducing transpiration

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(b) **Table 5.2** shows the results from the experiment shown in **Image 5.1**.

Table 5.2

	Distance the water had moved in one hour / mm			
Distance of lamp from plant / cm	Trial 1	Trial 2	Trial 3	Mean
10	6	5	8	6.33
20	4	4	6	4.67
30	3	3	3	3.00
40	2	2	2	2.00
50	1	0	0	0.33

(i) Calculate the mean distance the water had moved for a distance of 20 cm. **Express your answer to 3 significant figures. Write your answer in Table 5.2.** [2]

(4 + 4 + 6) ÷ 3 = 14 ÷ 3 = 4.666

(ii) Calculate the volume of water taken up by the roots per minute when the lamp was 30 cm from the plant, using the formula $\pi r^2 h$. [3]

The diameter of the water reservoir was 8 mm.

π = 3.14

h = distance moved by water in the reservoir

r = 8 ÷ 2 = 4 mm; V = 3.14 × 4² × 3 = 150.72 mm³ per hour

per minute: 150.72 ÷ 60 = 2.512

Volume = *2.51* ..... $mm^3\ min^{-1}$

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(iii) Suggest how the method could be modified to investigate the effect of wind speed on water uptake by the roots. [2]

Replace the lamp with a fan, keeping the light intensity constant.

Use a range of 5 wind speeds (fan speeds or distances of the fan) and measure the water moved at each.

(iv) A potometer is normally used to give an indication of transpiration rate. However, the rate of water uptake by the roots is not equal to the rate of water vapour loss from the leaves. Suggest why. [1]

Some water taken up is used in photosynthesis and other reactions (hydrolysis) and in maintaining turgidity, so is not lost.

(v) Most potometers are used with a cut shoot rather than a whole plant. Describe **one** precaution that should be taken when preparing the cut shoot, in order to not affect the movement of water in the xylem. Explain why this is necessary. [3]

Cut the shoot under water (and assemble the potometer under water). This prevents air bubbles entering the xylem.

Air would break the cohesion between water molecules, breaking the transpiration stream, so water could not continue to move up the xylem.

18

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6. The electrical activity of the heart can be measured and analysed using an electrocardiogram (ECG). **Image 6.1** shows an ECG trace from a healthy individual. **Image 6.2** shows an ECG trace from a patient with a heart defect.

Image 6.1 An ECG trace from a healthy individual

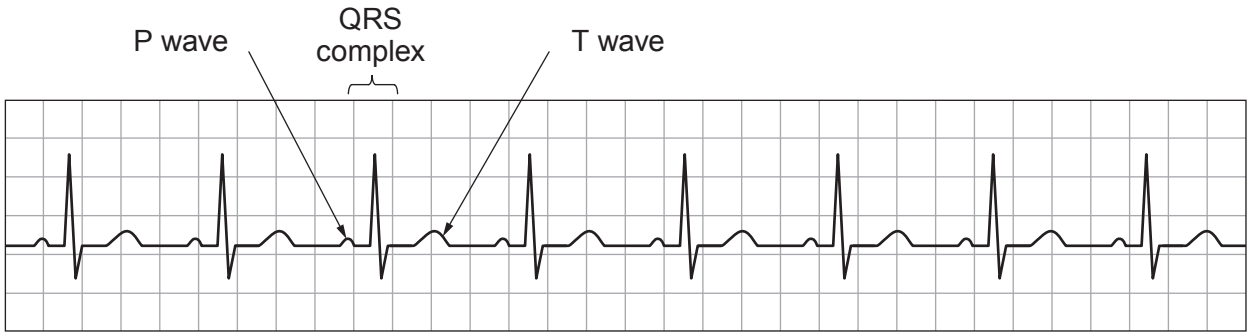
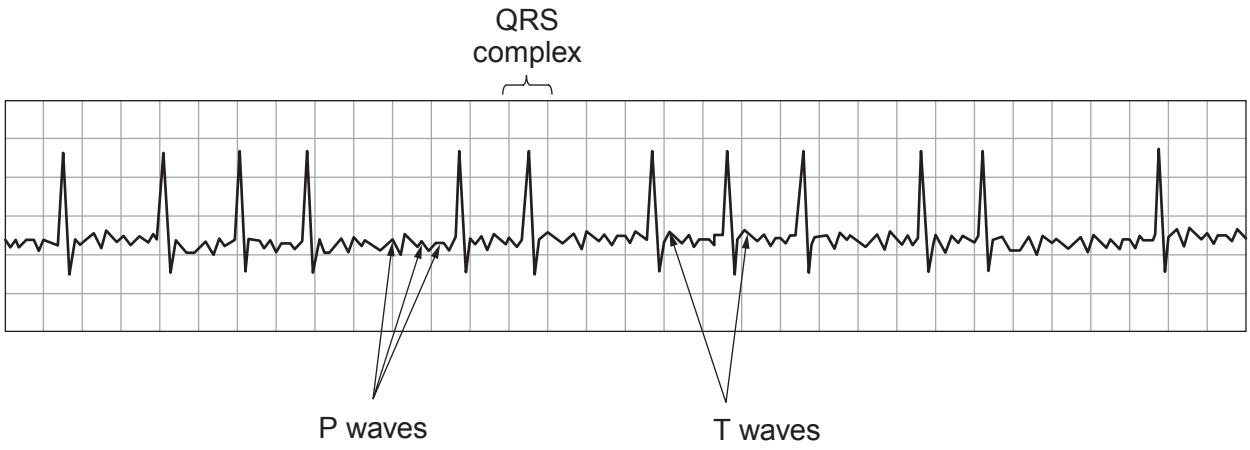


Image 6.2 ECG trace from a patient with a heart defect



Explain how the normal ECG relates to the electrical control of the cardiac cycle. Compare the ECG traces shown in **Images 6.1** and **6.2**. Using **Image 6.2**, suggest how the cardiac cycle would be affected in a patient with this heart defect. [9 QER]

The heart is myogenic. The pacemaker, the sinoatrial node (SAN) in the wall of the right atrium, sends a wave of excitation (impulse) across the walls of both atria. This depolarisation of the atria is shown by the P wave and causes the atria to contract (atrial systole).

The impulse cannot pass directly to the ventricles because of a layer of non-conducting tissue, so it passes to the atrioventricular node (AVN), where

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it is delayed. This delay allows the atria to finish emptying blood into the ventricles before the ventricles contract.

The impulse then passes down the bundle of His fibres in the septum to the apex of the heart. It travels up the Purkinje fibres in the ventricle walls, causing depolarisation throughout the ventricles. This is the QRS complex, and it is followed by ventricular systole, with the ventricles contracting from the base (apex) upwards, forcing blood into the arteries.

The T wave shows repolarisation of the ventricles, which corresponds to the start of ventricular diastole, when the heart muscle relaxes and the chambers refill.

Comparison: in the healthy trace (Image 6.1) there is one P wave before each QRS complex, but in the patient (Image 6.2) there are many P waves between QRS complexes. The shape of the QRS complex and the T wave is the same in both traces. In the normal ECG the QRS complexes occur at regular intervals, whereas in the patient they occur at irregular intervals. The patient's trace has more QRS spikes, so more cycles (beats) per minute, a faster heart rate, than the normal ECG, which has fewer beats per minute.

Effect on the cardiac cycle: the many P waves suggest that the SAN is firing too rapidly or irregularly, so the atria are not contracting normally but are quivering. This is an arrhythmia called atrial fibrillation.

As a result the atria are not able to fill or empty fully, so not enough blood passes into the ventricles. The ventricles contract irregularly and rapidly, so they have less time to fill, so less blood is pumped out at each beat (reduced stroke volume) and the cardiac output is less efficient.

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9

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