Candidate Name	Centre Number					Candidate Number				

A LEVEL BIOLOGY

COMPONENT 3

Requirements for Life

SPECIMEN PAPER

2 hours

	For Examiner's use only		
	Question	**Maximum Mark**	**Mark Awarded**
Section A	**1.**	**13**	
	2.	**16**	
	3.	**10**	
	4.	**14**	
	5.	**10**	
	6.	**8**	
	7.	**9**	
Section B		**20**	
	Total	**100**	

ADDITIONAL MATERIALS

In addition to this examination paper, you will need a calculator and a ruler.

INSTRUCTIONS TO CANDIDATES

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

INFORMATION FOR CANDIDATES

The number of marks is given in brackets at the end of each question or part-question.
The assessment of the quality of extended response (QER) will take place in question 7.

SECTION A

*Answer **all** questions.*

1. Insects are a group of organisms that are mostly adapted to a terrestrial mode of life. Some aquatic organisms, in the same kingdom as insects, use gills for gas exchange but insects have evolved a different system.

(a) Name the kingdom to which insects belong and state the characteristics used by taxonomists to place them in this kingdom. [3]

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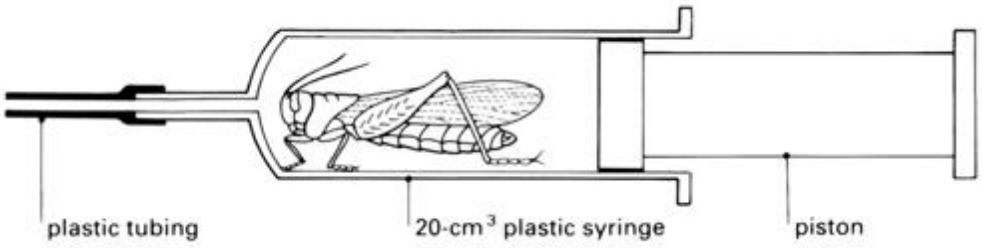
(b) Ventilation of the tracheal system involves contractions of the abdomen. These are called breathing movements. In an experiment to investigate ventilation in insects, a locust was placed in a syringe as shown in the diagram below.



The number of body breathing movements during 30 seconds was counted and the reading was repeated to give three sets of readings.
The air in the syringe was then replaced with gas mixtures of different percentage compositions of oxygen and carbon dioxide and the experiment repeated.

(i) Suggest why the student should have left the locust in the syringe for five minutes before they began the first count? [1]

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(ii) Suggest what step the student should have taken before changing the gas mixture in the syringe? [1]

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(iii) Suggest why ventilation in the locust involved movements of the whole body. [1]

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(iv) Describe how oxygen reaches the tissues in insecs. [2]

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The results of the experiment are shown below.

	Approximate percentage composition of the gas mixture		Number of body breathing movements in 30 s			Mean number of body breathing movements in 30 s
	oxygen	carbon dioxide				
Atmospheric air	21	0.04	26	29	26	27
Gas mixtures	83	17	54	49	46	50
	88	12	41	46	51	46
	94	6	48	42	46	45
	97	3	39	43	41	43
	100	0	7	7	10	8

(c) (i) Based on the results given in the table, which gas is having the greater effect on ventilation in the locust - oxygen or carbon dioxide? Use data from the table to explain how you reached your conclusion. [3]

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(ii) Air exhaled from the human lungs contains approximately 16% oxygen and 4% carbon dioxide. Estimate the mean number of body breathing movements in 30 s if the experiment were repeated using exhaled air. Justify how you reached this estimation. [2]

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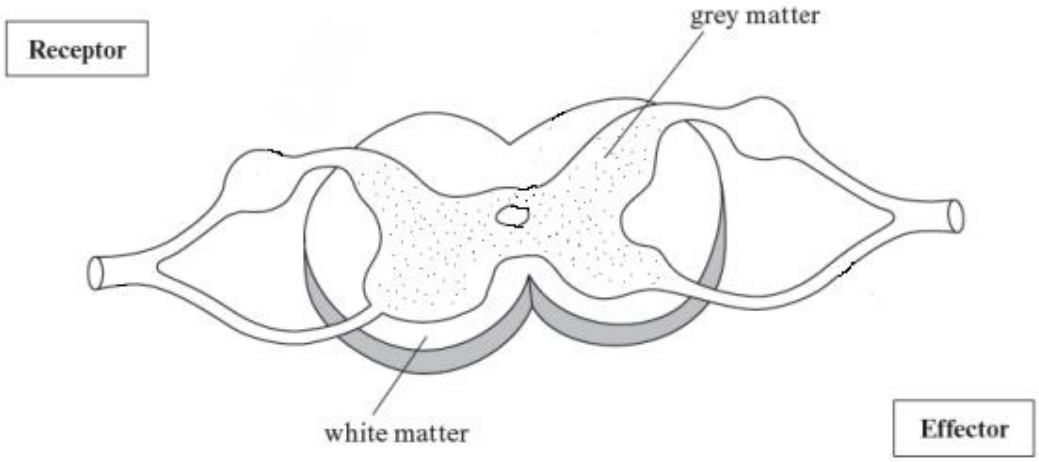
2. There are many reflex actions involving a sensory input to one side of the spinal cord which result in the contraction of an effector on the opposite side of the body. This is referred to as a crossed extensor reflex. An example of this is when one foot steps on a nail, the crossed extensor reflex shifts the body's weight onto the other foot, protecting and withdrawing the foot on the nail.



(a) Complete the diagram above to show the neurones involved in transmitting a nerve impulse from a receptor to result in a response from an effector on the opposite side of the spinal cord. Label all structures involved. [4]

(b) The higher centres of the brain can override a reflex action by using an inhibitory synapse. This synapse results in the transport of chloride ions (Cl^-) and potassium ions (K^+) across the post-synaptic membrane. Suggest how this could inhibit the generation of an action potential in the post-synaptic neurone. [3]

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(c) An experiment was carried out to investigate the distance travelled by an action potential in a **non-myelinated** neurone following the application of a strong stimulus.

distance from the stimulus (mm)	**time (ms)**
0.5	1.1
1.0	2.3
1.5	3.2
2.0	4.5
2.5	5.7

Calculate the speed of transmission of the action potential in this axon in mm ms^{-1}. Give your answer to three significant figures. Show your workings. [3]

Answer …… mm ms^{-1}

(d) In this experiment the value of the action potential was the same at all distances tested from the stimulus.

(i) Describe and explain how an action potential was generated in the neurone above. [4]

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(ii) Explain why the value for the action potential was the same at all distances from the stimulus. [2]

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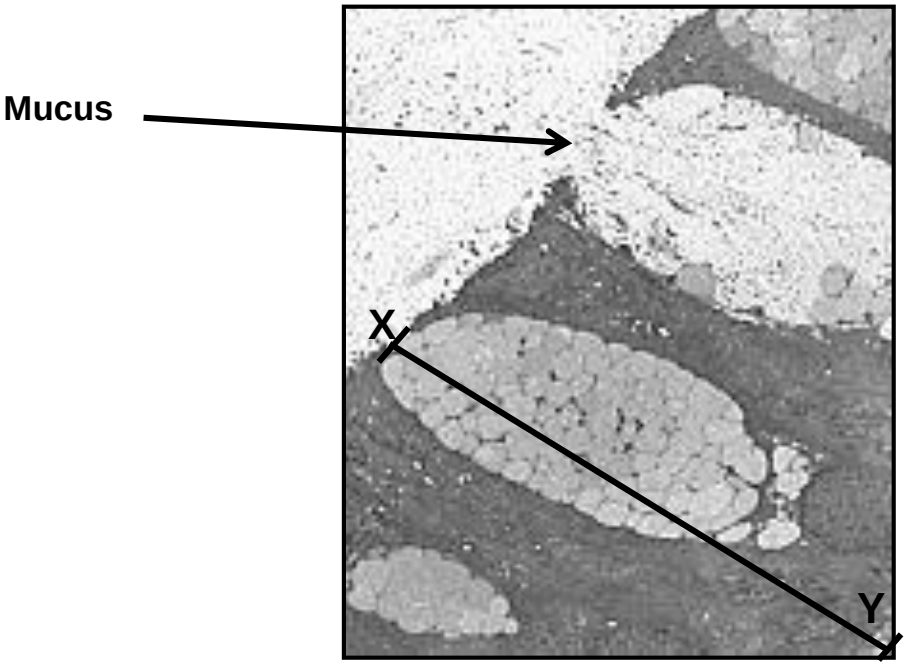
3. (a) Passage of food through the gut is aided by the production of mucus. The electron micrograph below shows some goblet cells that produce and secrete mucus in the small intestine.



Magnification = x 3700

(i) The height of one of the goblet cells is shown by the line labelled **XY**. Calculate the actual size of the cell, showing how you carried out your calculation. Give your answer using an appropriate unit. [2]

Answer = ……

(ii) State the method by which mucus is secreted from the goblet cells. [1]

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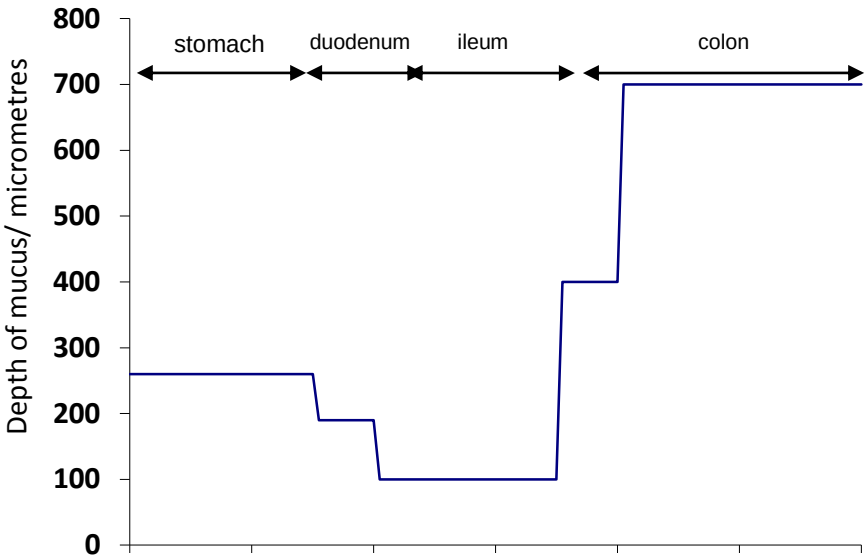
(b) Mucus is secreted in all regions of the gut. The diagram below represents the depth of the mucus in different regions of the gut.



Describe and explain the variation in the depth of the mucus shown in the different regions of the gut. [4]

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(c) An investigation was carried out into the digestive process in a wild dog (carnivore) and a sheep (herbivore). The percentage volume of the contents of different regions of their guts was determined. The results are shown in the table below.

	% volume of gut contents	
	sheep	**wild dog**
stomach	65	67
small intestine	20	20
large intestine	12	10

The results in the table could lead to the conclusion that the digestive process in the stomach was similar in herbivores and carnivores. Evaluate the validity of this conclusion. [3]

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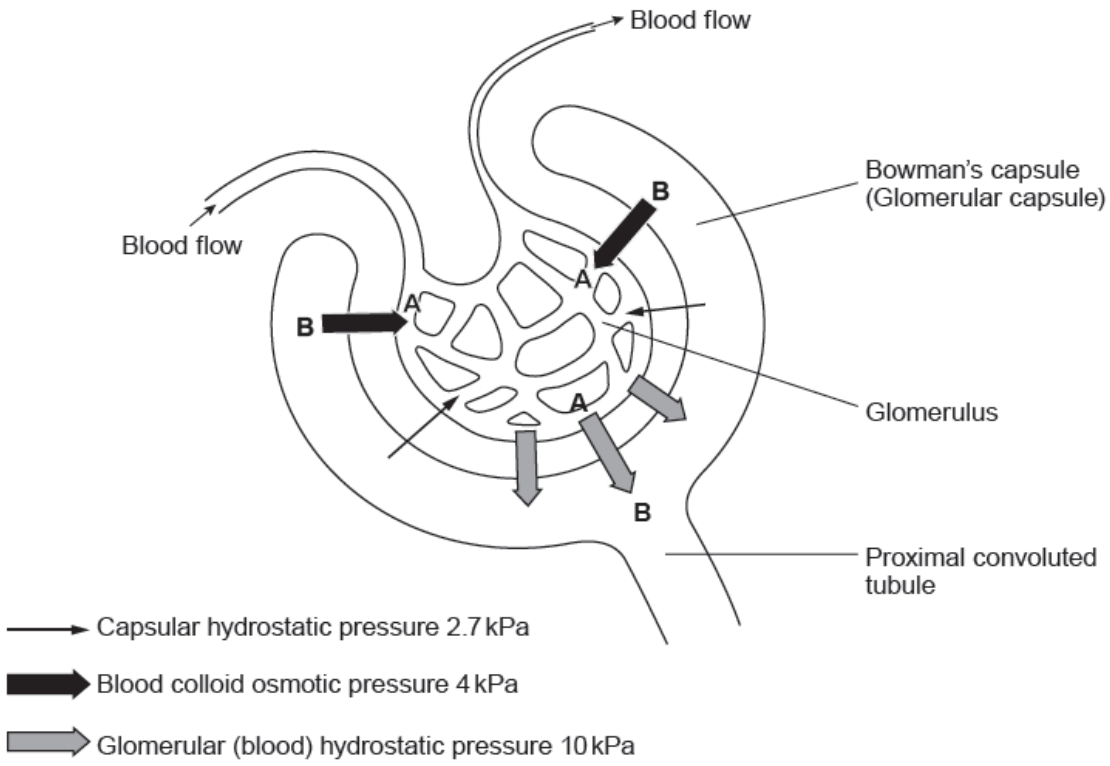
4. The diagram below represents part of a kidney nephron showing a glomerulus and Bowman's capsule.



(a) (i) Explain how the high hydrostatic pressure (10kPa) is achieved in the glomerulus. [1]

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(ii) Suggest which type of organic molecule in the blood is responsible for maintaining the blood osmotic pressure at 4kPa. [1]

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(iii) The net movement of water is from A to B. Explain the process by which some water molecules will move from B to A. [1]

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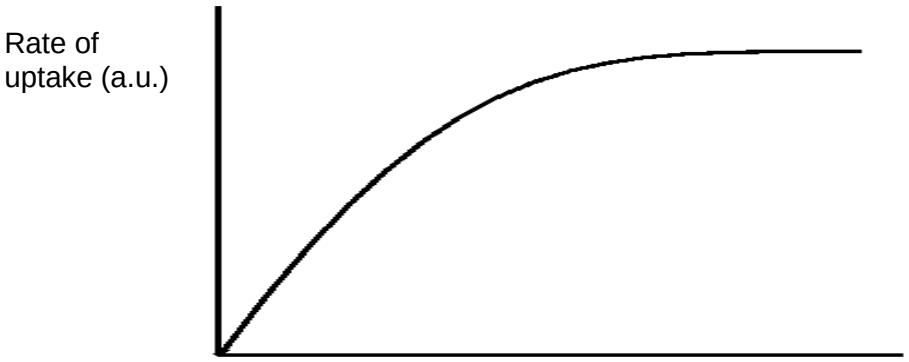
(iv) The net filtration pressure is the overall pressure responsible for ultrafiltration. From the data shown on the diagram calculate this value. Show your working and include units with your answer. [1]

Answer ……

(b) Selective reabsorption takes place from the proximal convoluted tubule into the blood.

The rate of uptake of an ion from the proximal convoluted tubule into the blood was measured and showed the following trend.



(i) Suggest what mechanisms were involved in the uptake and explain your answer. [3]

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(ii) Suggest why glucose uptake in the proximal convoluted tubule would reduce in the presence of cyanide. [3]

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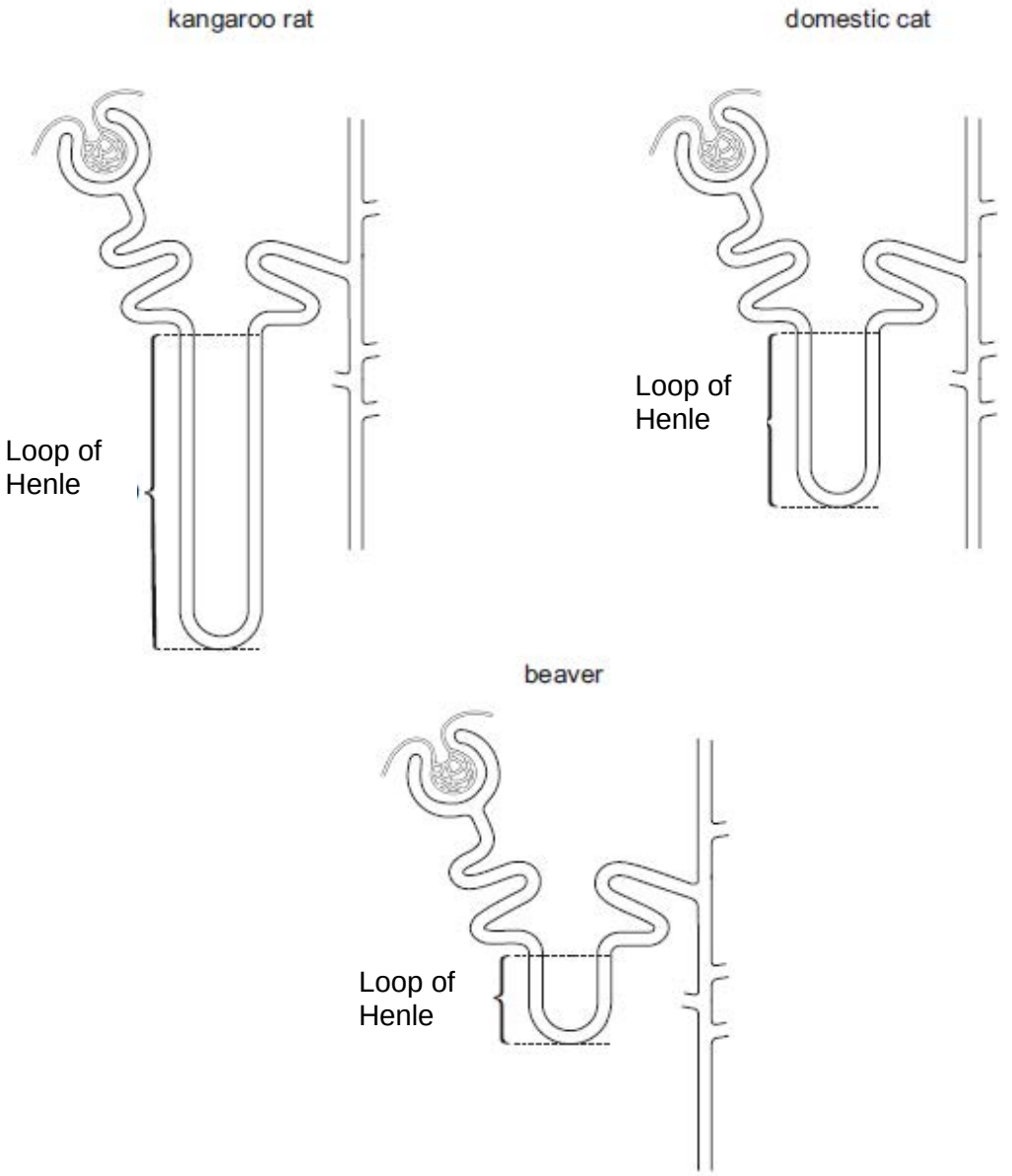
(c) The diagrams below show the relative sizes of nephrons from three mammals that live in different habitats.



The table shows urine concentrations from these three mammals.

name of mammal	**habitat**	**urine concentration (mosmol dm^{-3})**
kangaroo rat	xeric*	5 500
domestic cat	mesic	3 100
beaver	freshwater aquatic	520

* xeric habitats have limited availability of water

Using information in the diagram and the table, what conclusion can be made about the relationship between the length of the loop of Henle of the nephron and the adaptation of the mammals to their habitats? Explain your answer. [4]

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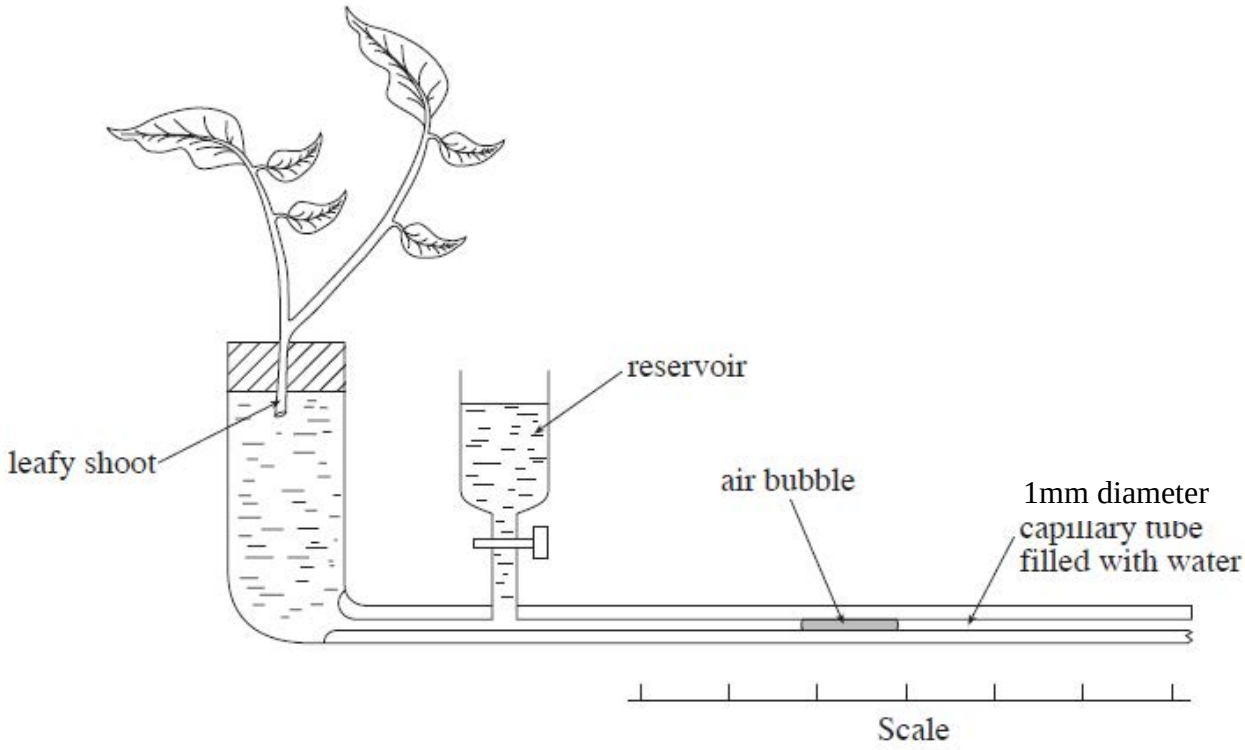
5. A student used the apparatus shown in the diagram to compare the rate of absorption of water by two different plant shoots of the same species.



(a) Using the first shoot, it was observed that the air bubble moved 50mm along the capillary tube in ten minutes. Using the formula below calculate the rate of water absorption by the plant in $mm^3\ min^{-1}$. Give your answer to two significant figures. [3]

Volume of water = **distance travelled by bubble** x **π** x [**radius**]^2 ($\pi = 3.14$)

Answer = ……..$mm^3\ min^{-1}$

(b) When the student carried out the same experiment on the other plant shoot she found that water was absorbed at a rate of 1.3 mm^3 min^{-1}.

(i) Identify **four** environmental conditions that the student should have kept constant in her experiments. [2]

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(ii) Suggest what further measurement and calculation the student should carry out before reaching a valid conclusion about the difference in the rate of water absorption by the two plant shoots. [2]

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(c) In her conclusion to this experiment, the student included the following statements:

- not all the water lost through the leaves was absorbed by the shoot
- not all the water absorbed by the shoot was lost through the leaves

Use your knowledge of plant metabolism to give a scientific explanation forthese statements. [3]

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6. Haemoglobin is a protein found in red blood cells. It has a quaternary structure. There are three different types of haemoglobin found in adult humans, HbA, HbA_2 and HbF as shown in the table.

haemoglobin type	**% found in adult blood**	**types of polypeptide chain found in the haemoglobin molecule**
HbA	97	2 alpha chains 2 beta chains
HbA_2	2	2 alpha chains 2 delta chains
HbF	1	2 alpha chains 2 gamma chains

(a) From this data suggest how many genes are involved in the production of the haemoglobins found in the adult human. [1]

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(b) Beta thalassaemia is a condition in humans caused by a change in the nucleotide sequence which codes for primary structure of the beta polypeptide chain. Scientists have now discovered a drug which can switch on the gene for the production of HbF (this is the type of haemoglobin found in the foetus). Explain, using your knowledge of protein synthesis, how this drug results in the production of HbF. [4]

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(c) State the advantages and disadvantages to an adult human of producing mainly foetal haemoglobin. [3]

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7. It has been found that the level of ADH in the blood of a human increases markedly following ingestion of the drug MDMA (ecstasy). The normal range of ADH in the blood is between 1 and 2.5 pmol dm^{-3} but following ingestion of the drug MDMA it can rise to 4.5 pmol dm^{-3}. An increase in blood pressure also occurs following ingestion of the drug.

Suggest the effect the ingestion of MDMA would have on the homeostatic control of the water potential of the blood and suggest the implications this may have.
(The quality of your extended response will be assessed in this question.) [9QER]

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SECTION B: OPTIONAL TOPICS

Option A:	**Immunology and Disease**	
Option B:	**Human Musculoskeletal Anatomy**	
Option C:	**Neurobiology and Behaviour**	

Answer the question on **one topic only.**

Place a tick (✓) in one of the boxes above, to show which topic you are answering.

You are advised to spend about 20 minutes on this section.

OPTION A: IMMUNOLOGY AND DISEASE

8. Sore throats and chest infections can be caused by a number of pathogenic bacteria and viruses. To treat the disease by using antibiotics, medical practitioners need answers to the following questions.

- Is the disease caused by a virus or bacterium?
- If it is a bacterial infection, what organism is responsible for the disease?
- What antibiotics are effective against the disease?
- Is the infection caused by an antibiotic resistant strain of bacteria?

(a) Why is it important to know if the disease is caused by a bacterium or virus? [1]

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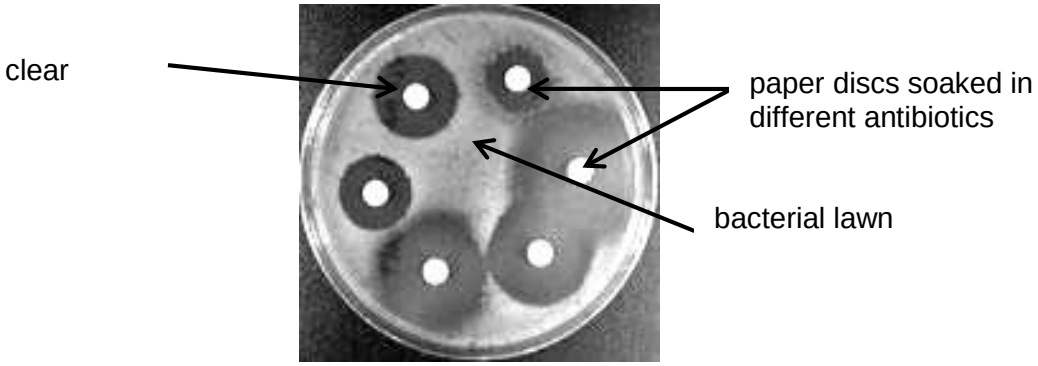
(b) One method of identifying if an antibiotic is effective against a bacterium is shown below.



(i) Explain what has caused the appearance of the **clear zones** around each paper disc and describe how the plate would look if the bacteria were resistant to one of the antibiotics tested. [2]

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(ii) Describe how this method could be adapted to determine what concentration of an antibiotic is needed to treat a bacterial infection. [2]

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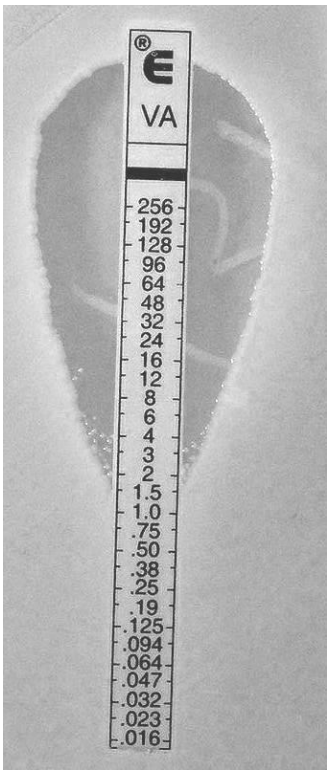
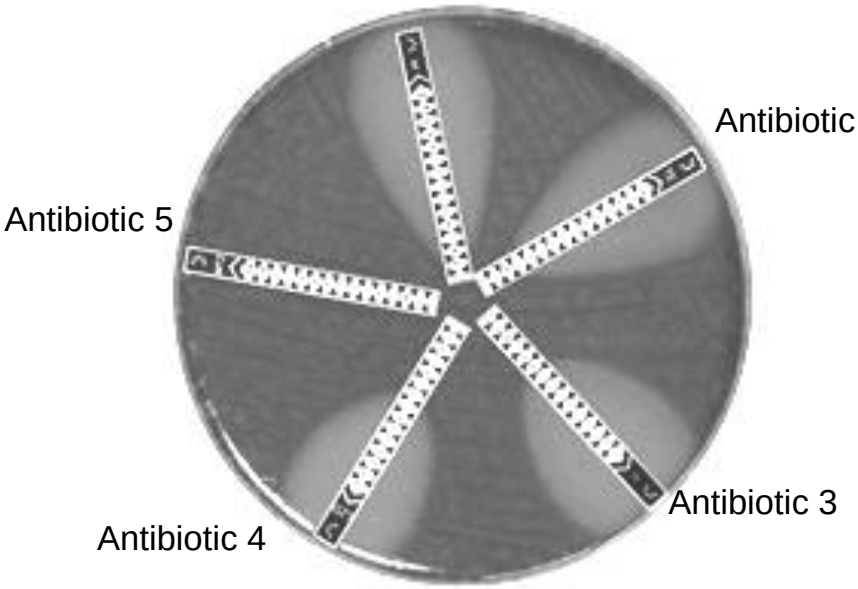
(c) If it is found that a species or strain of a bacterium is resistant to a particular antibiotic it is also important to know the **minimum inhibitory concentration**. This is the lowest concentration of the antibiotic that is effective against the bacterium.

In the technique shown in diagram **A** below, each strip contains an accurately prepared gradient of antibiotic concentrations measured in μg cm^{-3}

A



B



(i) The antibiotic is said to be bacteriostatic when it is at its minimum inhibitory concentration.
Explain what is meant by the term bacteriostatic and determine the minimum inhibitory concentration shown by the antibiotic in diagram **A**. [2]

…… μg cm^{-3}

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(ii) Suggest why this method provides better quality data than the simple disc assay method. [1]

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(iii) Which of the antibiotics tested in figure **B** has the greatest potential for future development? Justify your answer. [2]

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(d) Tetracycline is a **broad spectrum** bacteriostatic antibiotic. It is effective against many species of bacteria but it does not affect human cells. Once inside the bacterial cell, tetracycline prevents protein synthesis by blocking a tRNA binding site in bacterial ribosomes. Scientists have recently discovered a worrying feature about tetracycline. It increases the transfer of antibiotic resistant genes from one species of bacterium to another.

(i) What is the meaning of the term **broad spectrum**? [1]

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(ii) Explain what is meant by the term **antibiotic resistance**. [1]

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(e) Penicillin is a **narrow spectrum** antibiotic that is **bactericidal**. It prevents the formation of bonds in the peptidoglycan cell wall of bacteria.

Explain why tetracycline can be administered without knowing the exact identity of the bacterium causing an infection whilst penicillin could only be used if the infection is known to be caused by a Gram-positive bacterium. [3]

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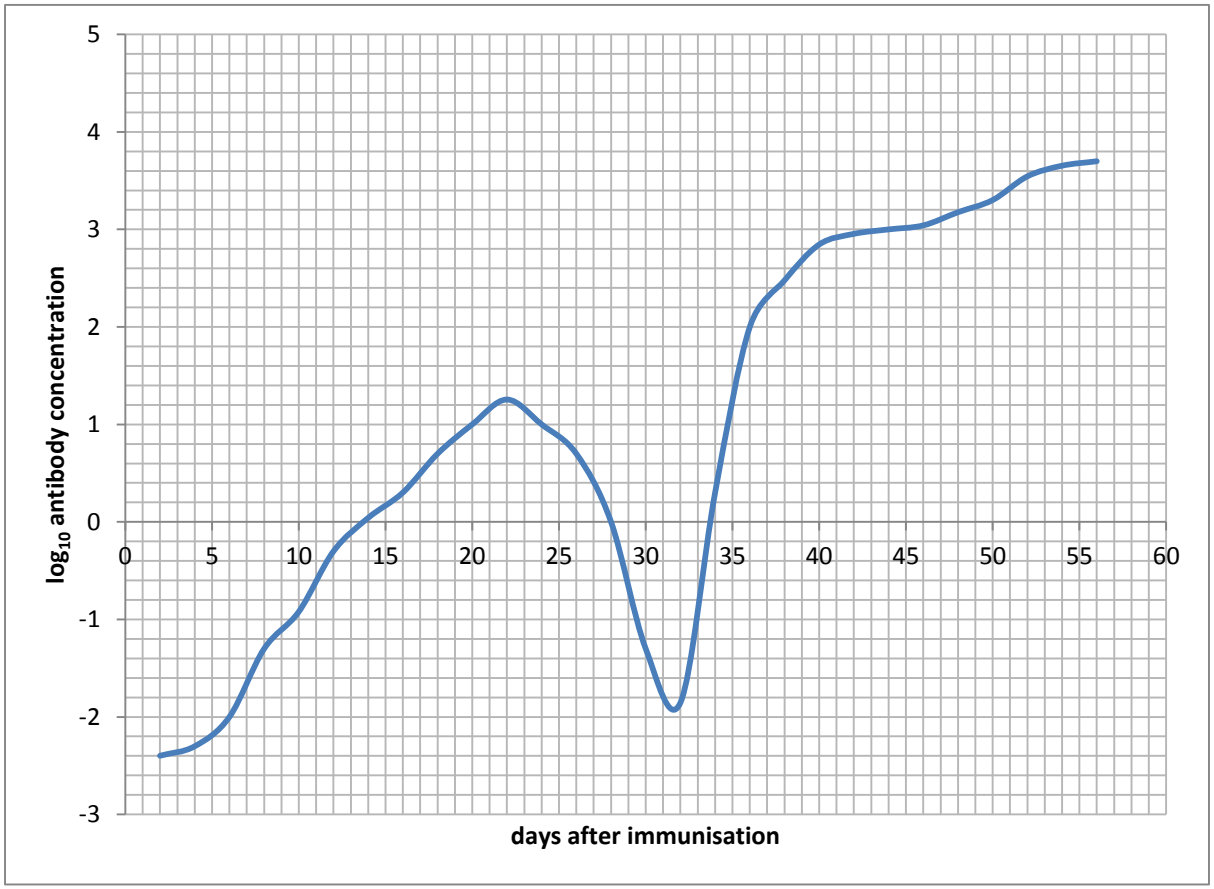
(f) For a number of viral diseases immunisation is a way of avoiding infection. The graph shows the change in antibody concentration in the plasma following a course of immunisation against a viral pathogen.



(i) The $\log_{10}$ antibody concentrations at 22 and 40 days were 1.26 and 2.85 respectively. Calculate the increase in antibody concentration between these days in µg cm^{-3}. [3]

Increase in antibody concentration = ... µg cm^{-3}

(ii) Explain why a booster injection at 32 days would be needed to obtain the difference in the antibody concentrations between 22 and 40 days.. [2]

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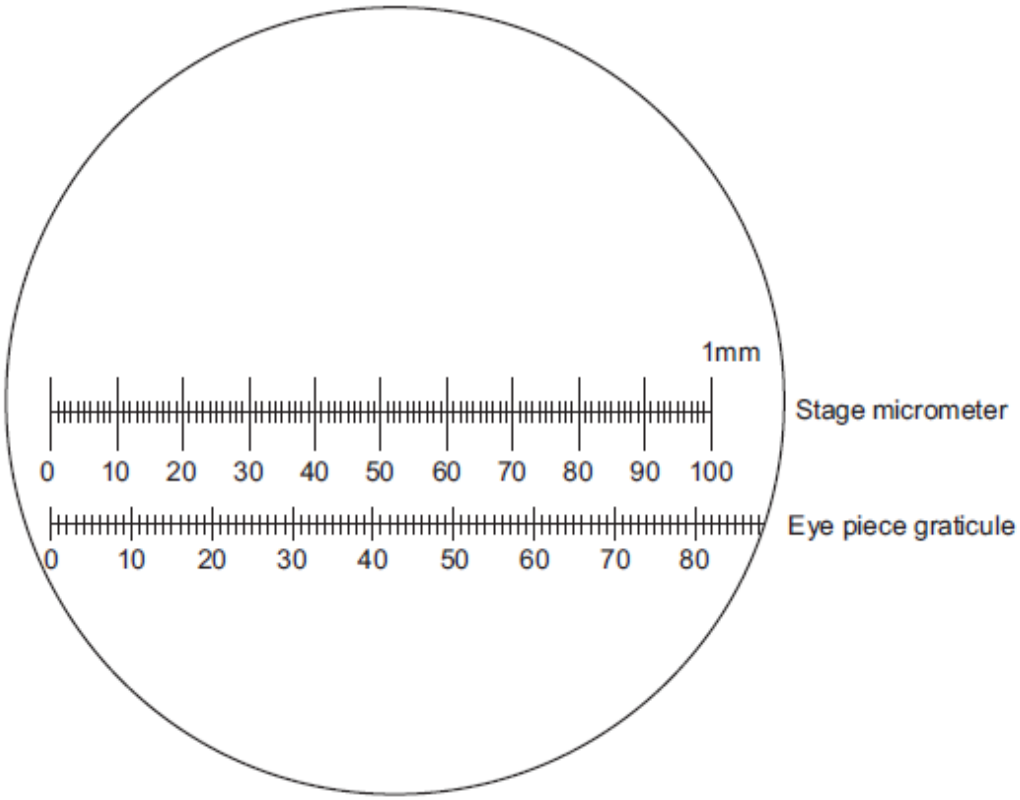
OPTION B: HUMAN MUSCULOSKELETAL ANATOMY

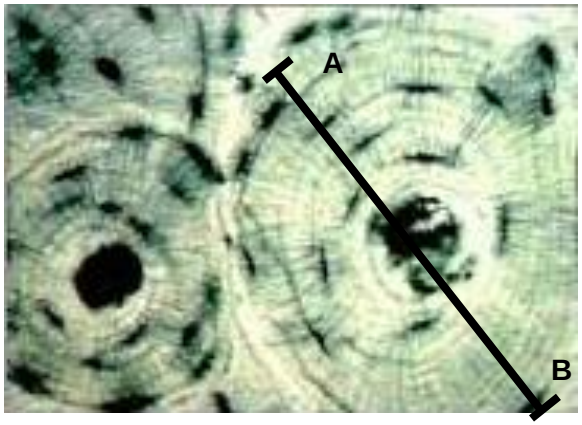
9. (a) The diagram represents a stage micrometer and an eye piece graticule.



(i) Use the diagram to calibrate the eye piece graticule for the objective lens used. Show all your working. Include units with your answer. [3]

1 eye piece unit = ……..

(ii) Using the calibrated eye piece graticule, a section of bone was viewed. The diameter of the Haversian system shown below was measured between A and B and calculated to be 450 μm.



Why would it be necessary to recalibrate the eye piece graticule if a higher power objective lens was then used? [1]

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(iii) In the space below draw the structure shown above, as it would appear in LS (longitudinal section) between points **A** and **B**. [1]

(b) (i) Many of the cells found in the lacunae have well developed rough endoplasmic reticulum and Golgi bodies, they are also rich in RNA. What does this suggest about the function of these cells? [2]

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(ii) Describe the transport system by which oxygen and nutrients are supplied to these cells. [3]

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(c) Since the 17th century there has been a decline in the incidence of rickets in the UK. However, some health trusts in the UK have found that more than 20% of children tested in recent years show signs of rickets.
It has been concluded that there is a possible link between the increase in the incidence of rickets with the decrease in milk consumption and hours spent in outdoor play. Suggest how these factors may be linked to the incidence of rickets in this conclusion. [3]

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(d) (i) Describe the role of calcium ions in the contraction of skeletal muscle. [3]

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(ii) Explain why immediately after death, muscles remain in a contracted state, a condition termed 'rigor mortis'. [2]

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(e) Muscle samples were taken from the thigh of three humans and the % of fast and slow twitch fibres determined. The results are shown in the table.

	% slow twitch muscle fibres	% fast twitch muscle fibres
Person A	50	50
Person B	95	5
Person C	20	80

Identify which person is likely to be a world class sprinter and which an extreme endurance athlete. Explain your answers. [2]

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OPTION C: NEUROBIOLOGY AND BEHAVIOUR

10. (a) If a head injury has occurred, bleeding in the brain is possible. Head scans can be performed to assess the amount of damage to the brain. Two types of scan can be performed, magnetic resonance imaging (MRI) and computerised axial tomography (CT).

(i) State one advantage of using a CT scan over an MRI scan for a patient with a head injury. [1]

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(ii) An MRI scan may detect excessive bleeding in the motor areas of the cerebral cortex in the right hemisphere of the brain. Suggest the effect this bleeding may have on the individual. [2]

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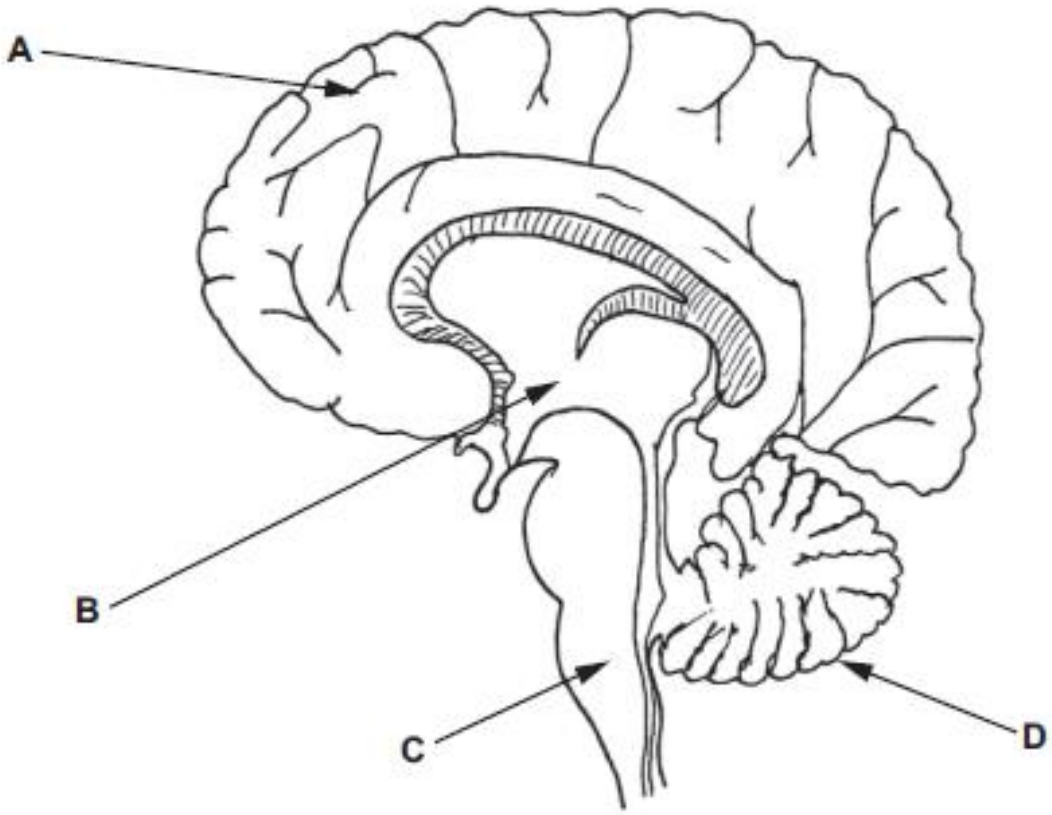
The diagram below is a section through the brain.



(b) Use the letters from the diagram to complete the table to indicate the part of the brain that is involved in the following activities and name the part. [4]

Activity	**Letter**	**Name of part**
regulating core body temperature		
recognising a face in a picture		
drinking from a glass		
regulating the CO_2 concentration of the blood		

(c) Heart rate increases during exercise to provide muscles with the oxygen required for ATP synthesis.

(i) Describe how chemoreceptors monitor the change in the rate of respiration. [2]

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(ii) Describe the role of the cardiovascular centre in increasing the heart rate. [3]

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(d) A student set up an experiment to investigate the hypothesis that woodlice turn more in dry conditions than moist conditions.
Woodlice are crustaceans that have gills on their underside that they use for gas exchange. The student set up two Petri dishes. One had moist filter paper in the bottom the other had had no filter paper. The student then observed the movements of the woodlice and counted the number of turns that occurred during a three-minute period.
The data obtained is shown below.

Environment	Number of turns in a three minute period					Mean	Standard deviation
Moist conditions	7	5	12	4	7	6.5	2.61
	6	9	8	12	4		
	5	11	9	8	14		
	9	7	8	9	6		
Dry conditions	22	23	17	21	18	15.8	2.05
	18	21	19	23	17		
	24	18	19	18	21		
	12	20	21	17	18		

(i) Calculate a t value for the data using the formula below. [2]

$$t = \frac{\left|\overline{x}^{1} - \overline{x}^{2}\right|}{\sqrt{\left(\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}\right)}}$$

where,

$\left|\overline{x}^{1} - \overline{x}^{2}\right|$ = the difference in mean values of sample 1 and sample 2

s_1^2 and s_2^2 are the squares if the standard deviation of the samples

n_1 and n_2 are the sample sizes.

Give your answer to two decimal places.

Answer ……..

(ii) The null hypothesis is that there is no significant difference between the mean number of turns in dry and moist conditions.
The critical values at 38 degrees of freedom are shown below.

Degrees of freedom	$p = 0.10$	$p = 0.05$	$p = 0.01$	$p = 0.001$
38	1.30	1.69	2.43	3.32

Using the table of critical values and your calculated value of t, explain whether you would accept or reject the null hypothesis [1]

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(iii) What type of behaviour is being exhibited by the woodlice?
Explain your answer [1]

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(iv) What conclusion can be drawn about woodlice behaviour from the data? [2]

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(v) Explain **two** ways in which this experiment could have been improved. [2]

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