GCE A LEVEL

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Part of WJEC

WJEC Eduqas GCE A LEVEL in

BIOLOGY

ACCREDITED BY OFQUAL

SPECIMEN ASSESSMENT MATERIALS

Teaching from 2015

wjec
cbac

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Contents

Candidate Name	Centre Number					Candidate Number				

A LEVEL BIOLOGY

COMPONENT 1

Energy for Life

SPECIMEN PAPER

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**13**	
2.	**10**	
3.	**10**	
4.	**11**	
5.	**16**	
6.	**16**	
7.	**7**	
8.	**8**	
9.	**9**	
Total	**100**	

ADDITIONAL MATERIALS

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

INSTRUCTIONS TO CANDIDATES

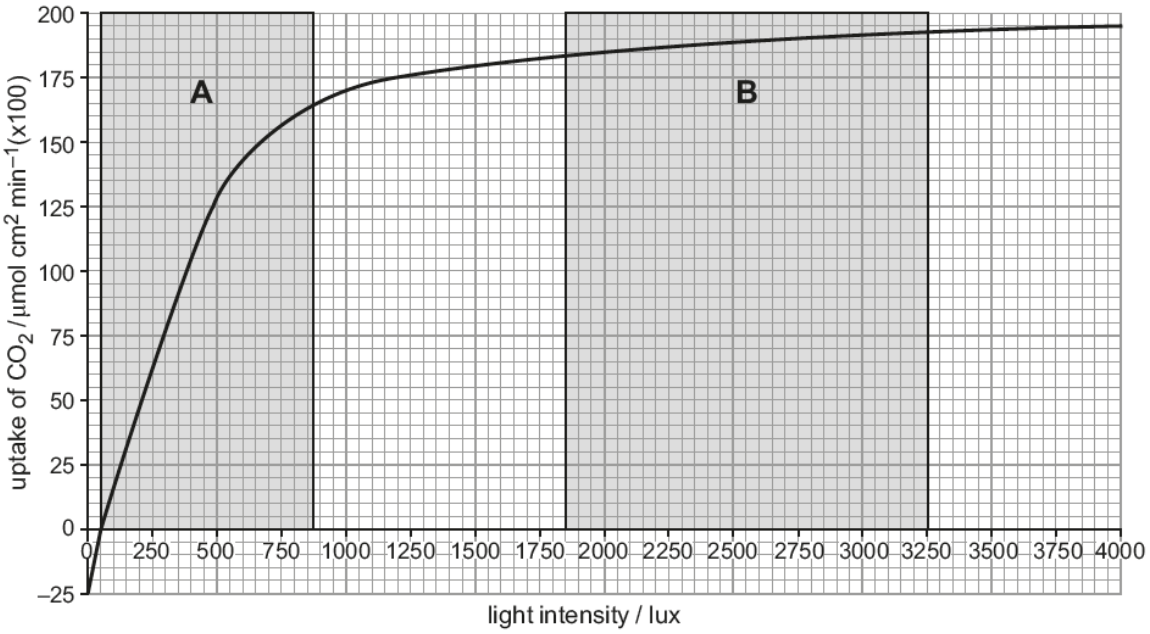
Use black ink or black ball-point pen. Do not use gel pen. Do not use correction fluid.
Write your name, centre number and candidate number in the spaces at the top of this page.
Answer **all** questions.
Write your answers in the spaces provided in this booklet.

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 9.

*Answer **all** questions.*

1. The diagram below shows the rate of uptake of carbon dioxide for a species of grass at different light intensities. Measurements were taken at a constant external carbon dioxide concentration and a temperature of 15 °C.



(a) Calculate the rate of uptake of carbon dioxide between 250 and 750 lux. Express your answer in standard form. [2]

Rate of uptake of carbon dioxide = ... µmol cm^{-2} min^{-1} lux^{-1}

(b) Explain the differences in the rate of uptake of carbon dioxide between parts A and B of the graph. [2]

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(c) Below a light intensity of 50 lux, photosynthesis takes place even though there is no uptake of carbon dioxide. What conclusions can be made regarding the rates of photosynthesis and respiration taking place at light intensities up to and including 50 lux? [2]

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(d) Diuron is a weed-killer which is a very specific and sensitive inhibitor of photosynthesis.
It blocks the electron carrier binding site on Photosystem II. This stops the electron flow from where it is generated in Photosystem II, to the electron carrier. This reduces the ability of the plant to convert light energy into chemical energy.
Diuron only blocks electron flow from Photosystem II. It has no effect on Photosystem I or other reactions in photosynthesis, such as light absorption or carbon fixation in the Calvin cycle.

Describe the effects of Diuron on non-cyclic photophosphorylation and explain why cyclic photophosphorylation is not affected. [4]

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(e) Explain why a plant would die when the weed-killer Diuron is sprayed onto it. [3]

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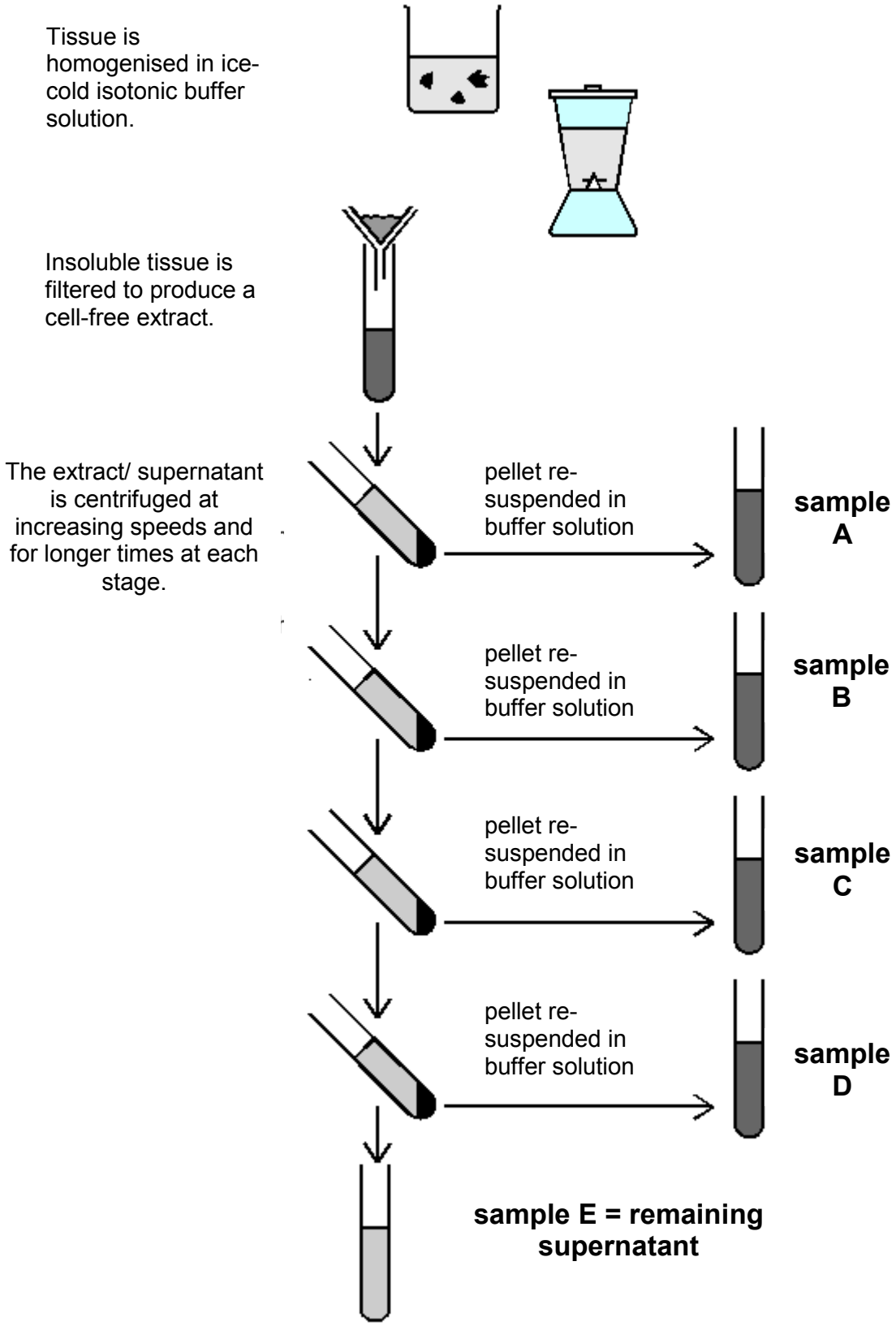
2. The process shown in the diagram below shows the preparation of animal cell fractions. Each fraction contains only one type of cell component.



Each sample was then incubated with glucose and pyruvate and the production of carbon dioxide and lactate was noted.

	Incubated with glucose		Incubated with pyruvate	
Sample	**Carbon dioxide produced**	**Lactate produced**	**Carbon dioxide produced**	**Lactate produced**
A	**NO**	**NO**	**NO**	**NO**
B	**NO**	**NO**	**YES**	**NO**
C	**NO**	**NO**	**NO**	**NO**
D	**NO**	**NO**	**NO**	**NO**
E	**NO**	**YES**	**NO**	**NO**

(a) Based on these results, identify the cell components which are present in samples **B** and **E**? Explain how you reached these conclusions. [5]

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(b) Cyanide inhibits the enzyme cytochrome oxidase and prevents the regeneration of NAD. Explain why cyanide could be used to confirm which sample contained resuspended mitochondria. [3]

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(c) Explain why the preparation of the cell fractions was carried out using an isotonic solution rather than pure water. [2]

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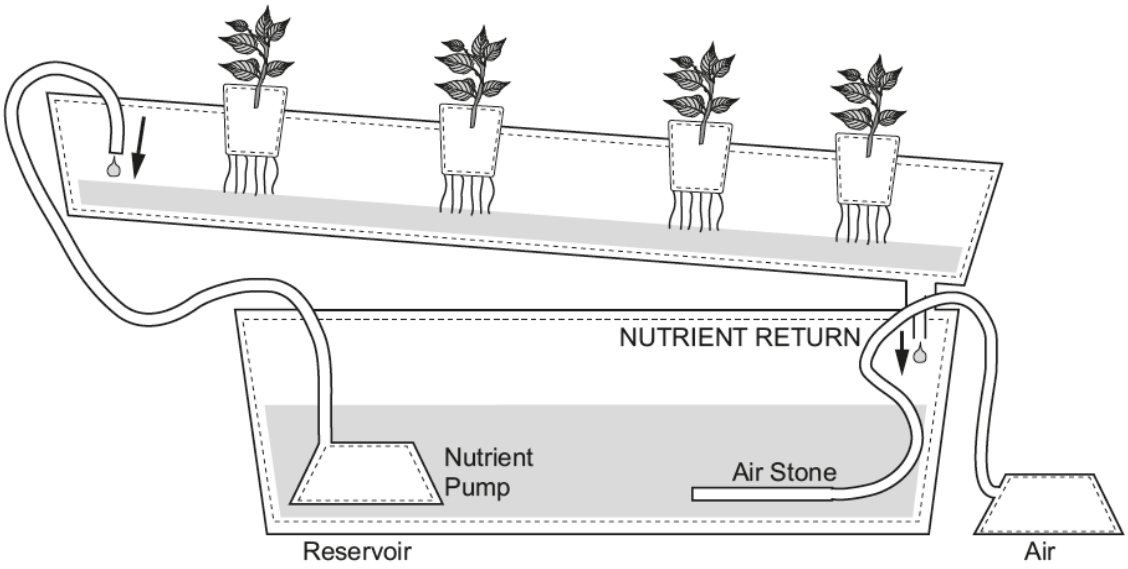
3. Hydroponics is a method used to grow crops without soil. It involves growing plants in an aerated solution of nutrients as shown in the diagram below.



(a) Tomatoes are often grown using hydroponic systems. A commercially available hydroponic nutrient solution contained the following concentrations of six of the elements essential for plant growth.

element	concentration (mg dm^{-3})
N	70
P	50
K	120
Ca	11
Mg	40
S	55

Explain why the concentration of nitrogen and magnesium would need to be increased during the growing period of the tomato plants. [2]

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(b) Explain how ions pass from the soil water into the xylem and why the solution must be aerated for this to take place. [4]

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(c) A tomato grower who used a hydroponic system was concerned over reports that nitrate levels in the nutrient medium either lower or higher than an optimum could have a negative impact on root growth and subsequently, a reduced yield. He adapted his hydroponic system to determine the optimum nitrate levels needed to achieve maximum yield.

Identify the independent, dependent and controlled variables he could have used in his investigation. (You are not expected to provide values for the variables.) [4]

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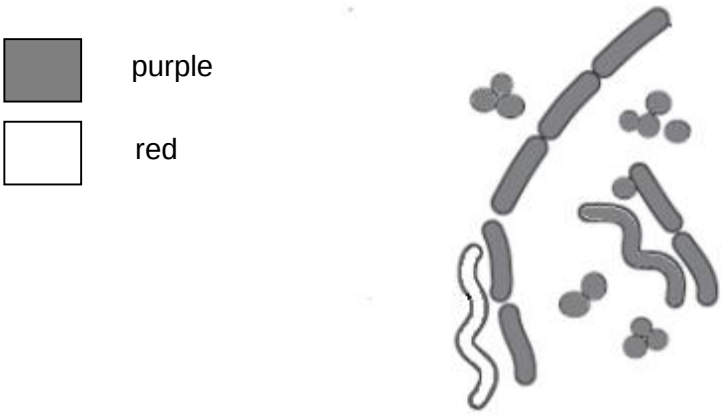
4. Following an outbreak of food poisoning in a school, samples were taken from infected patients. The Gram staining technique was used, in conjunction with the shape of bacterial cells, to identify potentially pathogenic bacteria in the samples.

The diagram below shows part of a bacterial smear stained using the Gram staining technique.



Tests showed that the bacterium responsible for the food poisoning was *Campylobacter jejuni*. This helical, Gram negative bacterium colonises the digestive tract of many birds and cases of food poisoning by this bacterium are usually associated with poor preparation of poultry.

(a) (i) On the diagram above label a bacterium that could be *C. jejuni*. Explain your choice of bacterium. [1]

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(ii) Explain why this bacterium might be resistant to treatment by antibiotics. [2]

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(iii) Birds have a higher body temperature than mammals. One diagnostic tool used to identify *C.jejuni* involves culturing samples from infected people at 42°C. Explain how this helps identify *C.jejuni* from a mixture of bacteria. [1]

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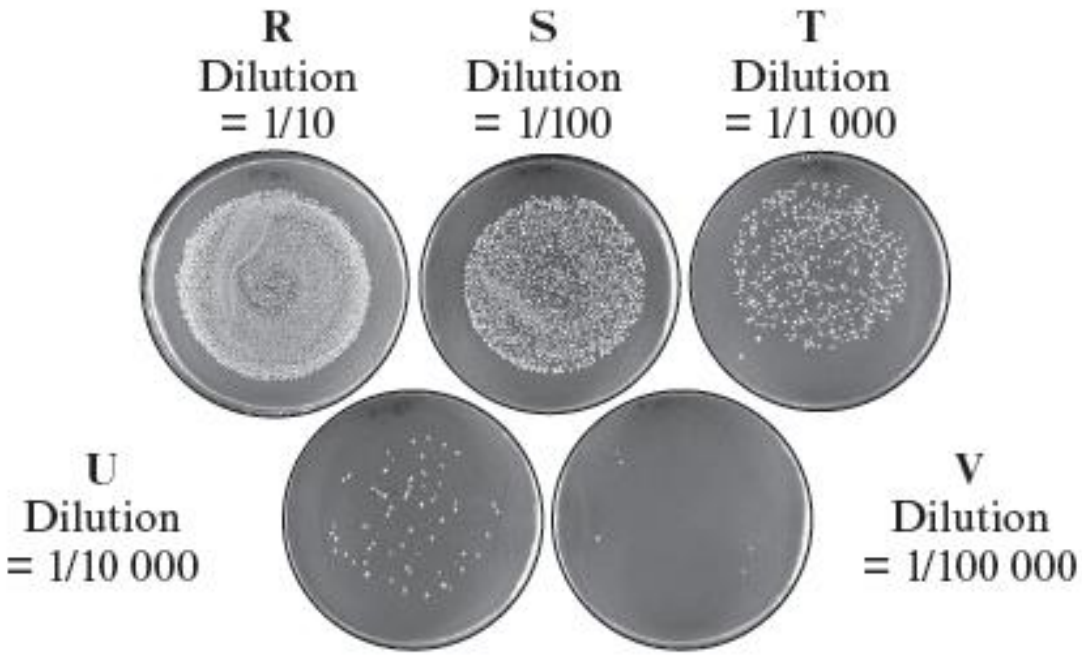
(b) The source of the infection was traced to a poultry dish that had been prepared in the school canteen. Using the viable count method Environmental Health Officers made an estimate of the number of bacteria in a sample of the food. Dilutions of 1/10, 1/100, 1/1 000, 1/10 000 and 1/100 000 were prepared and 0.5 cm^3 of each dilution were spread evenly over the surface of agar plates. The plates were incubated at 35°C for 24 hours. A photograph of the results is shown below.



(i) Explain why it was decided to use Plate U to estimate the number of bacteria in the food rather than the other plates. [3]

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(ii) It was found that 69 bacterial colonies were growing on Plate U. Use the information provided to estimate the number of *C.jejuni* bacteria present per cm^3 in the actual food. Show how you reached your answer. [2]

Estimated number of bacteria = ... per cm^3

(iii) Explain why this is likely to be an underestimate of the actual number present in the food. [2]

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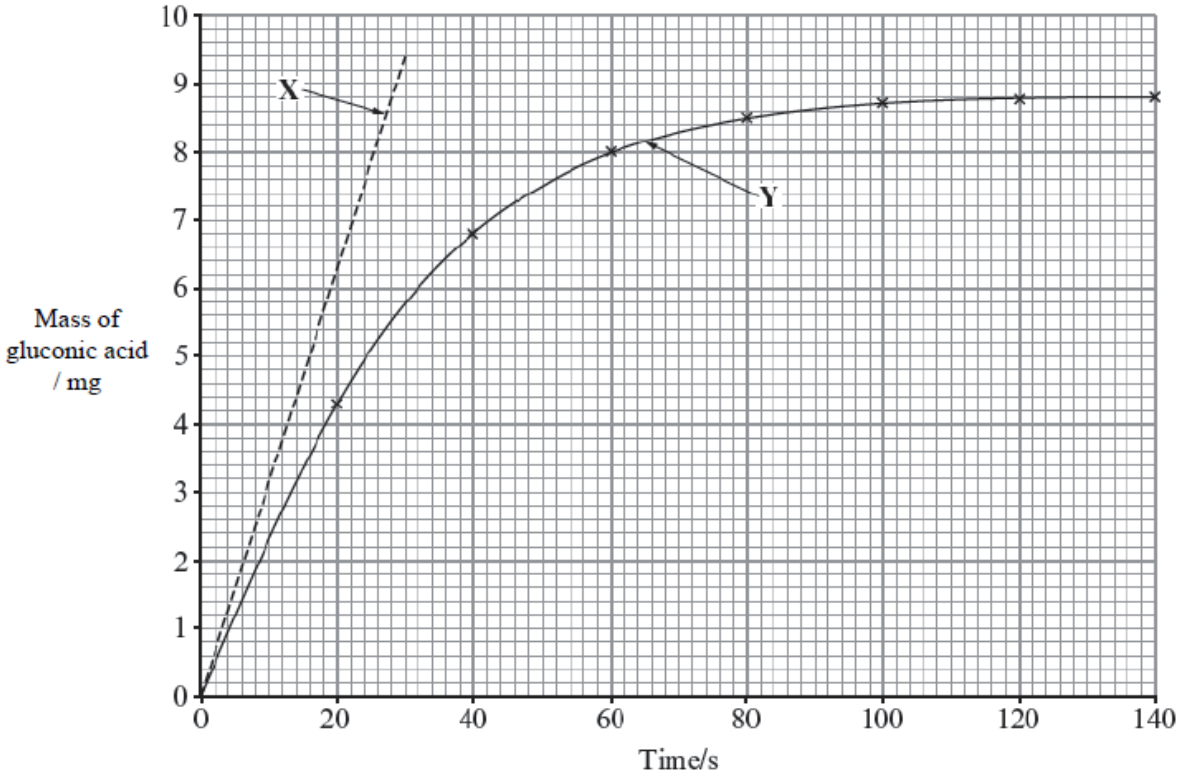
5. Glucose oxidase (GOx) is an enzyme that is used in biosensors to determine glucose levels in blood. It converts glucose to gluconic acid and hydrogen peroxide.

An investigation into the action of this enzyme produced the results shown in the graph below.



(a) (i) Use tangent **X** to calculate the **initial** rate of reaction for this enzyme. Express your answer in terms of rate of production of mass of gluconic acid per minute. Show your workings. [2]

Initial rate of reaction = ...

(ii) Explain why the rate calculated for the first 30 seconds would be lower than the initial rate. [2]

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(b) Part of the mechanism for the conversion of glucose to gluconic acid by GOx is shown by the equations below. In these reactions FAD is acting as a co-factor to the enzyme.

Step 1 glucose + GOx – FAD → gluconolactone + GOx-$FADH_2$

Step 2 GOx-$FADH_2$ + oxygen → GOx-FAD + hydrogen peroxide

(i) Suggest the function of FAD in this series of reactions. [1]

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(ii) One type of glucose biosensor involves the detection of oxygen concentrations in a sample of body fluid. Name **two** body fluids that could be analysed. [1]

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(iii) With reference to the information above, explain how an oxygen electrode could be used to give a quantitative measurement of the glucose concentration in a sample of a body fluid. [2]

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(iv) When using a glucose biosensor explain why it is important to maintain a constant temperature and use a buffer. [3]

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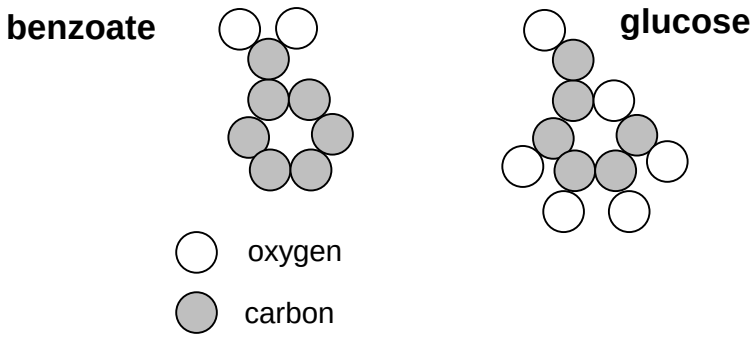
(c) Experiments have shown that sodium benzoate, a commonly used preservative, can inhibit GOx and affect the accuracy of a glucose biosensor.

The diagrams below show the arrangement of carbon and oxygen atoms in a molecule of glucose and a benzoate ion (hydrogen atoms are not shown).



Using the information provided in part (b) and the diagram above explain why contamination of a sample with sodium benzoate would affect the accuracy of the biosensor. [5]

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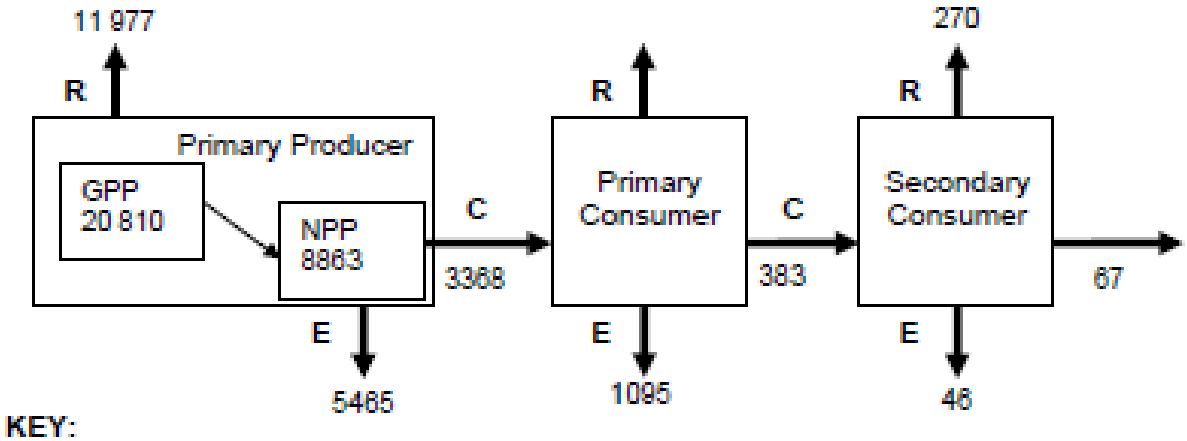
6. The diagram shows the transfer of energy through an ecosystem.

All values given are in kJ m^{-2} yr^{-1}.



KEY:
R = respiratory loss
C = consumed
E = expelled

(a) (i) State what is meant by the abbreviations **GPP** and **NPP** shown in the diagram and explain the difference between them. [3]

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(ii) What term is used to describe the transfer of energy between consumers? [1]

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(iii) Calculate the percentage energy lost through respiration by primary consumers. Give your answer to two significant figures. [2]

Answer …… %

(b) The values given are for marshland. Energy is expelled from the system at each trophic level.

(i) Identify **three** ways that energy could be expelled from the system. [2]

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(ii) The values given in kJ m^{-2} yr^{-1}. The area of the marshland is 17 000 m^2.

Calculate the total amount of energy 'expelled' by this ecosystem in one year. Express your answer in standard form. [2]

Answer ……..

(iii) Describe what happens to this expelled energy. [2]

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(c) The principles of energy transfer through food chains can be employed to compare the efficiency of different farming methods. With reference to the information provided, explain the increase in the use of factory farms for rearing herbivores such as cattle. [4]

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7. In 2009, a group of 28 internationally renowned scientists identified and quantified a set of nine planetary boundaries.
The table below shows the planetary boundaries for some of these global processes.

Global Process	Variable	Units of measurement	Boundary	Pre-industrial value	Recent data
Biodiversity loss	Extinction rate	species becoming extinct per million species per year	10	1	100 - 1 000
Climate change	Atmospheric carbon dioxide	ppm (parts per million)	350	280	390
Land use	Land used for crops	%	15	5	12
Fresh water	Use of fresh water	km^3 per year	4 000	415	2 600

(a) Explain what you understand by the term planetary boundary. [2]

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(b) Define the term biodiversity and describe **one** action that could delay biodiversity loss. [2]

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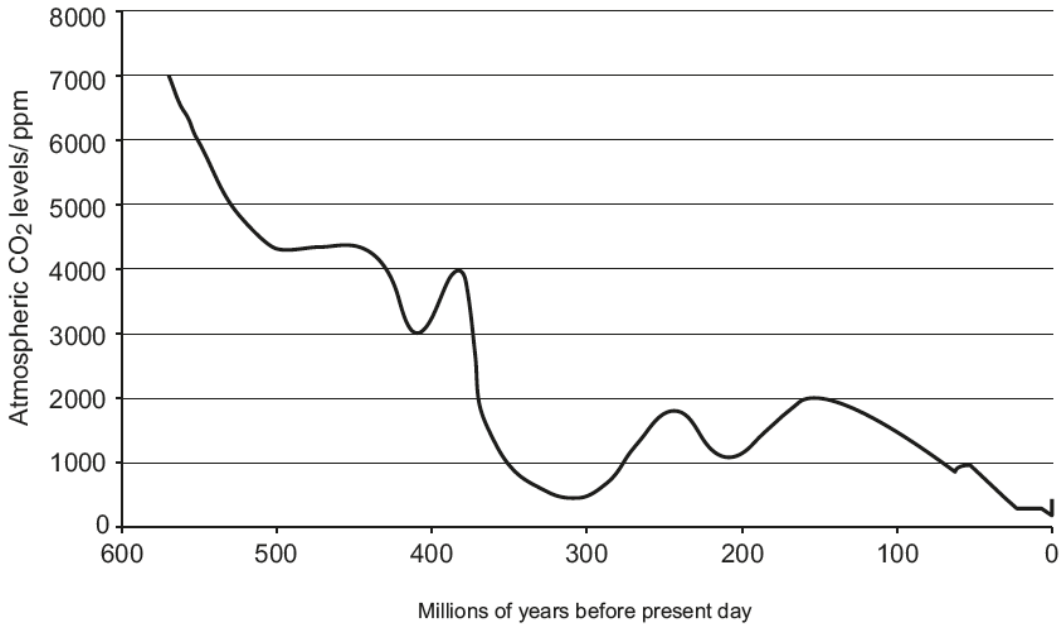
(c) It has been claimed that the increase in extinction rate observed in recent years is purely down to increasing atmospheric carbon dioxide levels. However, the graph below shows that carbon dioxide levels in the past have far exceeded current levels and in addition to this the extinction rate at those times was significantly lower.



Analyse the data given in the table and draw alternative conclusions as to the possible causes of the increasing extinction rate. Explain how you reached these conclusions. [3]

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8. Nucleic acids are formed from units called nucleotides. Each nucleotide contains an organic base and a phosphate group bonded to a pentose sugar.

Erwin Chargaff analysed the percentage composition of the different bases found in DNA. Some of his results are shown in the table below.

organism	Percentage composition of DNA				$\frac{A+T}{C+G}$	$\frac{C+T}{A+G}$
	A	G	T	C		
maize	26.8	22.8	27.2	23.2	1.17	1.02
human liver	29.3	20.6	30.0	20.1	1.45	1.01

(a) (i) Identify the types of bases represented by A, G, T and C and use this information to explain why the **C+T : A+G** ratio is approximately 1.0 in both maize and humans but the **A+T : C+G** ratio is different. [3]

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(ii) Suggest why the C+T:A+G ratio is not exactly 1.00. [1]

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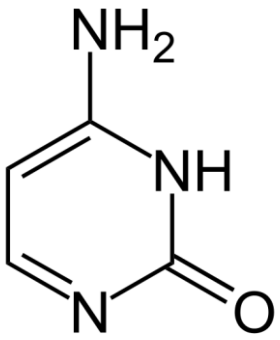
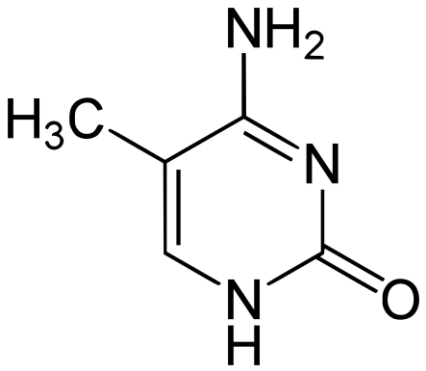
(b) The diagrams below show the structures of the base cytosine and a modified version called 5-methyl cytosine.

cytosine



5-methyl cytosine



Exposure to some chemicals can cause the modification of cytosine bases to 5-methyl cytosine. Genes with a high proportion of these modified bases may not be transcribed.

(i) Explain why this modification to the DNA would not result in a change to the structure of a protein. [2]

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(ii) Explain how this change could have an effect on the phenotype of a person. [2]

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9. Human activity and bacteria play a vital role in making nitrogen available to increase the yield of crops.
Explain the ways that human activity and bacterial action can influence nitrogen availability and the negative impacts that this may have on the environment.
(The quality of your extended response will be assessed in this question.) [9QER]

Candidate Name	Centre Number					Candidate Number				

A LEVEL BIOLOGY

COMPONENT 2

Continuity of Life

SPECIMEN PAPER

2 hours

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**10**	
2.	**12**	
3.	**12**	
4.	**18**	
5.	**13**	
6.	**12**	
7.	**14**	
8.	**9**	
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 8.

*Answer **all** questions.*

1. Species richness is one measure of biodiversity providing information on the number of species found in a particular area.

Simpson's Diversity Index is a different measure of biodiversity. It is calculated as shown below:

Simpson's Diversity Index = $1 - D$

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

N = the total number of organisms of all species
n = the total number of organisms of a particular species

(a) (i) Which measure provides better information regarding biodiversity? Explain your answer. [1]

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(ii) There are 288 known species of mammal on the island of Borneo. Explain how you could obtain the data required to calculate a Simpson's Diversity Index for the biodiversity of mammals on this island. [2]

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(iii) Suggest one problem associated with this method. Explain how it could affect the validity of any conclusions based on the calculated diversity index. [2]

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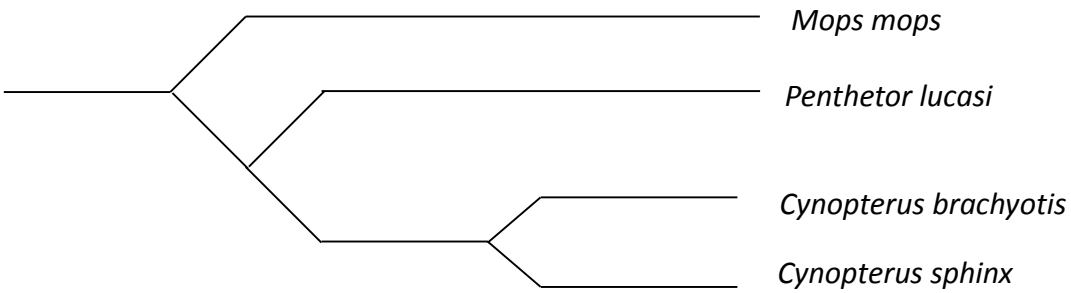
(b) Of the 288 species of mammals in Borneo, 102 are bats. The following diagram is a phylogenic tree showing the evolutionary relationship between some of the bats.



Amino acid sequences of cytochrome oxidase from blood samples from each species were prepared. The sequences for the other three bats were compared with the sequence for *Cynopterus brachyotis.* The number of positions at which there was a different amino acid is recorded in the table below.

Bat	**A**	**B**	**C**
Number of amino acids different to *Cynopterus brachyotis*	**19**	**7**	**13**

(i) Mark clearly on the phylogenic tree, with the letter **X**, the position of an ancestor common to *Penthetor lucas*i and *Cynopterus sphinx* but not common to *Mops mops*. [1]

(ii) Use the information in the table and the phylogenic tree to identify the bats. [1]

A .....

B .....

C .....

(c) *Mops mops* is a fruit-eating bat while *Cynopterus sphinx* feeds on insects. The table below shows the approximate nutritional composition of the food of these species.

	% composition	
	fruit	**insects**
carbohydrate	**23.4**	**2.5**
fat	**0.7**	**16.0**
protein	**2.2**	**18.0**

With reference to respiratory pathways, explain why *Cynopterus sphinx* eats a lower mass of food than *Mops mops* but is able to synthesise more ATP. [3]

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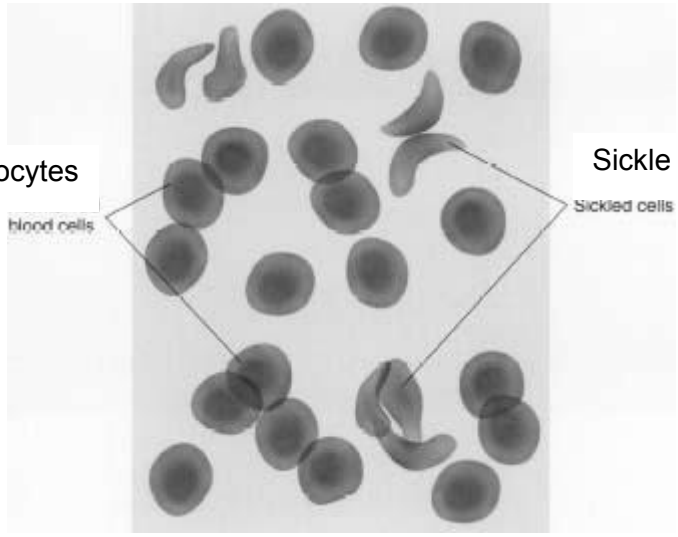
2. Sickle cell anaemia is an inherited disease. People who have the disease inherit two genes for sickle haemoglobin—one from each parent.

Sickle haemoglobin causes red blood cells to develop a sickle shape. These block blood flow in the blood vessels causing pain and organ damage. It leads to much reduced life expectancy. The photograph below shows the shape of normal and sickle cells.



People who inherit a sickle haemoglobin allele from one parent and a normal allele from the other parent have **sickle cell trait**. They usually have few symptoms and lead normal lives.

Plasmodium falciparum is one of the organisms that cause malaria in humans. When it infects erythrocytes it uses oxygen and causes the haemoglobin of people with sickle-cell trait to change its tertiary structure and the erythrocytes to take on the classic sickle cell shape.

(a) A survey was conducted into the relationship between sickle-cell trait and the incidence of malaria. Patients were tested for the presence of the malarial parasite *P.falciparum* and if they were positive for sickle-cell trait. The results of the survey of 150 people are shown below.

percentage of people in the sample			
sickle-cell trait		**normal haemoglobin**	
infected with *P.falciparum*	**not infected with *P.falciparum***	**infected with *P.falciparum***	**not infected with *P.falciparum***
4.7	**12.4**	**58.2**	**24.6**

(i) What conclusion can be drawn from these results? [1]

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(ii) Suggest how the survey could be modified to improve the validity of your conclusion. [2]

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(b) In the United States, the sickle cell disease occurs in 1 out of every 625 African-Americans.

The Hardy-Weinberg formula states that if alleles **A** and **a** are present in a population with the frequencies of *p* and *q*, the proportion of individuals homozygous for the dominant allele (**AA**) will be p^2, the proportion of heterozygotes (**Aa**) will be $2pq$, and the proportion or homozygous recessives (**aa**) will be q^2, where $p + q = 1$.

Use the Hardy Weinberg formula to estimate the number of African Americans from a population of 1000 people that would have **sickle cell trait**. [4]

Estimation of African Americans with sickle cell trait = ...

(c) The Hardy-Weinberg Principle states that allele frequencies remain the same from generation to generation in the absence of natural selection.

In the nineteenth century, many sub-Saharan Africans were taken as slaves to America. In 2007 fewer than 2000 cases of malaria were reported in the USA while over 150 million were affected in sub-Saharan Africa in the same year.

Predict how the proportion of people with sickle cell trait could have changed in the USA and sub-Saharan Africa since the nineteenth century. Explain the basis for your prediction. [5]

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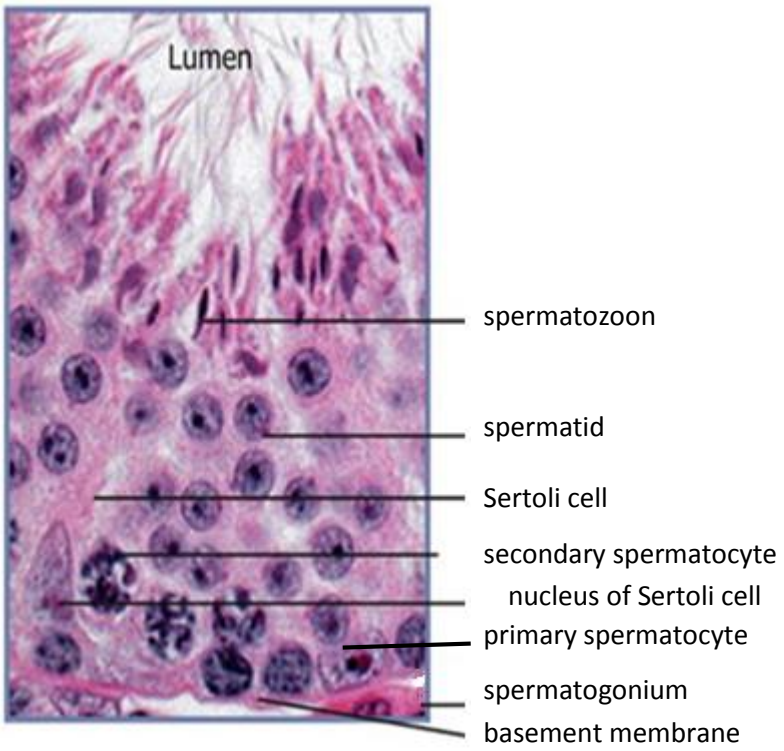
3. Spermatogenesis takes place in the seminiferous tubules of male mammals. The image below shows a transverse section of mouse seminiferous tubule.



(a) (i) Identify cells in the section that match the descriptions listed in the table below. The cells can match more than one description or none. [4]

Description	Name of cell(s)
undergoing meiosis	
will produce more cells by mitosis	
provides protection from the male immune system	
will undergo differentiation to produce a fully functional cell	

(ii) Explain why there will be more spermatids than spermatogonia. [1]

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(iii) The Sertoli cell contains a prominent nucleolus and large numbers of ribosomes. It is known that these cells are involved in providing nourishment to developing sperm cells.
Suggest what nutrients the Sertoli cells provide to the developing cells? Give reasons for your answer. [2]

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(iv) Another function of Sertoli cells is to remove debris from the lumen of the seminiferous tubule. Name the process by which Sertoli cells carry out this function. [1]

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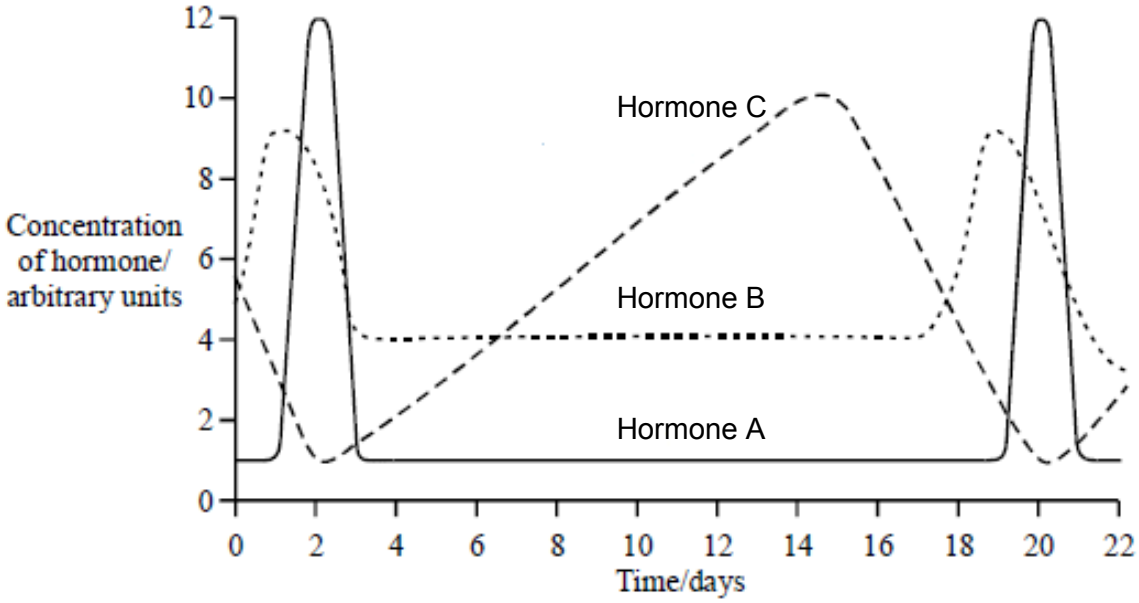
(b) The menstrual cycle in cows is controlled by the same hormones as women. The diagram below shows the changes in the levels of some hormones of a cow over a 22 day period.



(i) Identify hormones **A**, **B** and **C** shown in the graph above. [3]

A .....

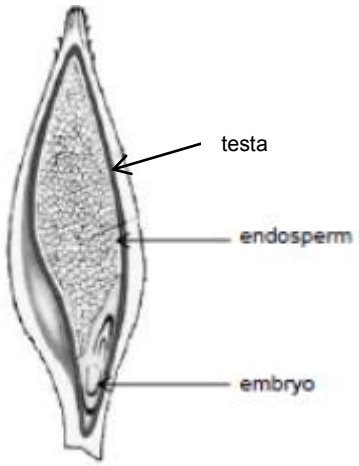
B .....

C .....

(ii) Estimate the length of the menstrual cycle shown. [1]

..... days

4. Barley (*Hordeum vulgare),* is an important cereal grown in the UK. It is used widely for animal fodder and as a source of maltose when brewing beer. The diagram below is a cross-section through a grain of barley, *Hordeum vulgare*.



(a) Explain why a barley grain is technically a fruit and not a seed. [2]

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(b) The endosperm cells contain 21 chromosomes. Calculate how many chromosomes there are in the cells of the embryo. Explain how you arrived at your answer. [4]

Number of chromosomes in embryo cells = ……

Explanation: .....

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(c) The table below shows the results obtained from a study of the germination and early growth of barley grains.

Time after sowing (days)	Dry mass of endosperm (mg)	Dry mass of embryo (mg)
0	42	2
2	41	2
4	32	8
6	20	16
8	9	24
10	6	34

What can be concluded from these results? [2]

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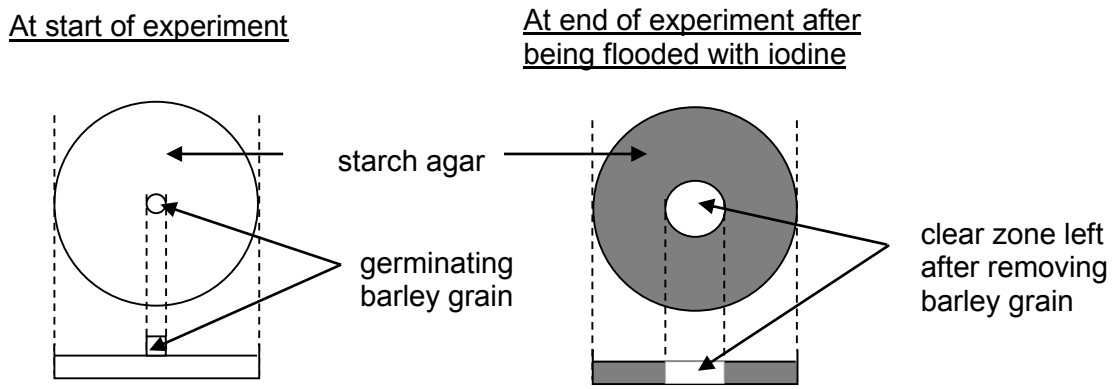
(d) The diagram below shows a view from above and from the side of an experiment demonstrating the presence of amylase in a germinating barley grain.



(i) The agar contained 1g starch per 100cm^3 of agar. The agar in each plate was 5mm deep and the clear zone left after removing the barley grain was 25mm in diameter. The volume of agar in the clear zone can be calculated as follows:

Volume = $\pi r^2 h$ (π = 3.142)

Calculate the mass of starch digested by the germinating barley grain. Show your working and give your answer in standard form. [3]

Mass of starch digested = ... g

(ii) During germination the amylase is synthesised from amino acids from protein stored in the barley grain. Name the tissue where the protein is stored and name the hormone responsible for mobilising the amino acids. [2]

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(iii) It is important that brewers know how the age of their barley affects the concentration of amylase produced so that they can obtain the best yield of malt.
Using the apparatus shown, design a method to investigate the effect of age of seed on the concentration of amylase produced. [5]

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5. Bacteria and Archaea produce restriction enzymes that cleave DNA that is foreign to their own DNA. These enzymes recognize and cut DNA molecules at or near specific sequences of nucleotides called restriction sites. One theory is that these enzymes have evolved as a defence mechanism against viruses called bacteriophages that can infect bacteria.
More than 3000 different restriction enzymes have been discovered to date and over 600 are available commercially for use in genetic engineering.

(a) Explain why these enzymes could be effective as defence mechanisms against these viruses. [1]

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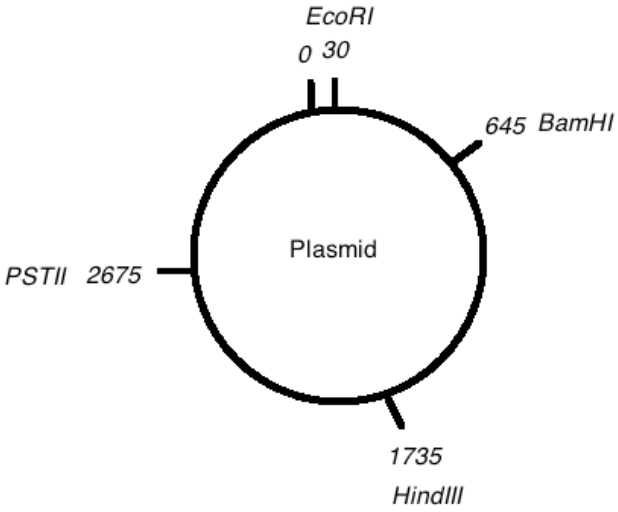
(b) The diagram below is of a bacterial plasmid 3 450 base pairs in length with the restriction sites of four different enzymes, EcoRI, BamHI, HindIII and PSTII shown.



Total length = 3450 base pairs (bp)
NOT drawn to scale

(i) If the plasmid was cut using EcoRI and PSTII **only**, what would be the size of the smallest fragment? Show your working. [2]

Answer ……..

(ii) A gene was present between 550 and 1 699 base pairs. Which two enzymes would be needed to cut out the gene leaving the smallest number of additional bases? [1]

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(c) "D7S280" is a short tandem repeat (STR) sequence of "GATA" found on human chromosome 7. This STR was sequenced and found to lie between 126 and 177 base pairs within the 341 base pair sequence shown below (**GATA shown in bold**).

Starting base number						
1	AATTTTTGTA	TTTTTTTTAG	AGACGGGGTT	TCACCATGTT	GGTCAGGCTG	ACTATGGAGT
61	TATTTTAAGG	TTAATATATA	TAAAGGGTAT	GATAGAACAC	TTGTCATAGT	TTAGAACGAA
121	CTAAC**GATAG**	**ATAGATAGAT**	**AGATAGATAG**	**ATAGATAGAT**	**AGATAGATAG**	**ATAGATA**GAT
181	TGATAGTTTT	TTTTTATCTC	ACTAAATAGT	CTATAGTAAA	CATTTAATTA	CCAATATTTG
241	GTGCAATTCT	GTCAATGAGG	ATAAATGTGG	AATCGTTATA	ATTCTTAAGA	ATATATATTC
301	CCTCTGAGTT	TTTGATACCT	CAGATTTTAA	GGCC		

The STR was then extracted and amplified using PCR.

(i) Explain why each stage of the PCR is conducted at the following temperatures: [3]

I 95°C .....

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II 50 – 60°C .....

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III 70°C .....

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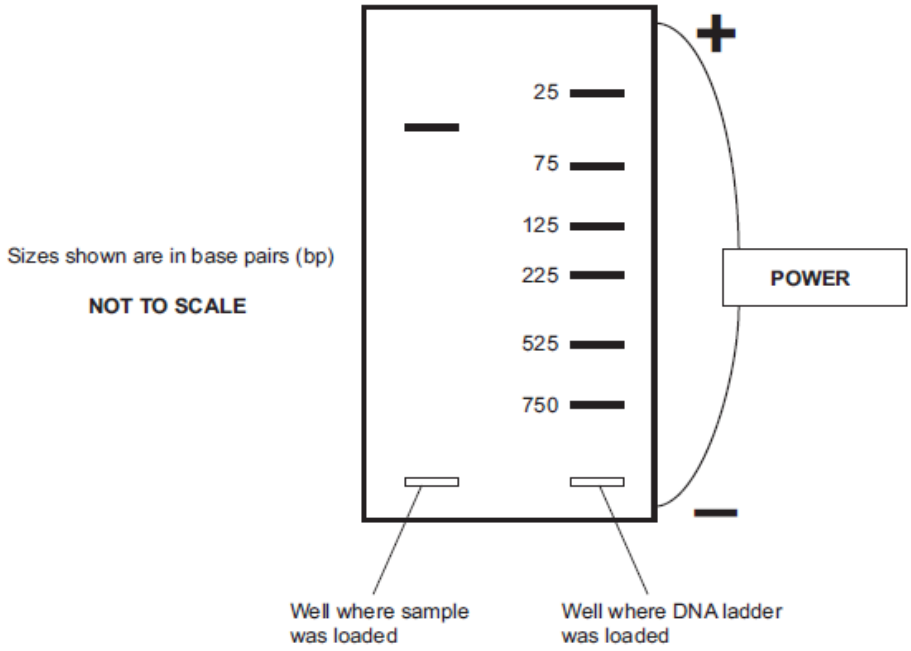
(ii) The amplified STR was run on an agarose gel using gel electrophoresis. The result is shown below.



Describe and explain how electrophoresis produced the results seen in the gel result. [3]

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(iii) Evaluate how well the results of the electrophoresis match the sequencing results. [2]

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(iv) How could the gel result be made more accurate? [1]

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6. In peas, the allele for wrinkled seeds (R) is dominant to that for smooth (r) and the allele for yellow seed colour (Y) is dominant to green (y).

A plant breeder has developed a new variety of wrinkled, yellow peas but thinks that his new variety is a hybrid. In order to confirm this, he crossed his new variety with a plant that produced smooth, green peas.

When the F_1 generation grew, he recorded the phenotype of the seeds they produced. His results are shown below.

Number of plants	Phenotype of seeds produced
31	yellow, wrinkled coat
22	green, wrinkled coat
29	yellow, smooth coat
26	green, smooth coat

(a) Complete the genetic diagram below to show how F_1 inherited the phenotypes shown in the table. [5]

Parental genotype ..... x .....

Gametes ..... x .....

F_1 genotypes .....

F_1 phenotypes .....

Phenotype ratio .....

(b) Based on the results of this cross he concluded that the new variety was pure-breeding.

(i) Calculate χ^2 for the results of this cross. A table is provided below for you to use. [3]

Phenotype of seeds produced	**Observed O**	**Expected E**			
yellow, wrinkled coat	31				
green, wrinkled coat	22				
yellow, smooth coat	29				
green, smooth coat	26				

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

= .....

(ii) Use your calculated value of χ^2 and the probability table to justify whether the plant grower's conclusion was valid. [4]

Degrees of freedom	**Probability**		
	P = 0.10	**P = 0.05**	**P = 0.02**
1	2.71	3.84	5.41
2	4.61	5.99	7.82
3	6.25	7.82	9.84
4	7.78	9.49	11.67
5	9.24	11.07	13.39

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7. In 2011, over 330,000 cases of cancer were diagnosed in the UK of which, cancer of the kidney was the eighth most common..

(a) With reference to the structures involved in the production of urine, explain how a kidney tumour could result in the presence of blood in the urine. [2]

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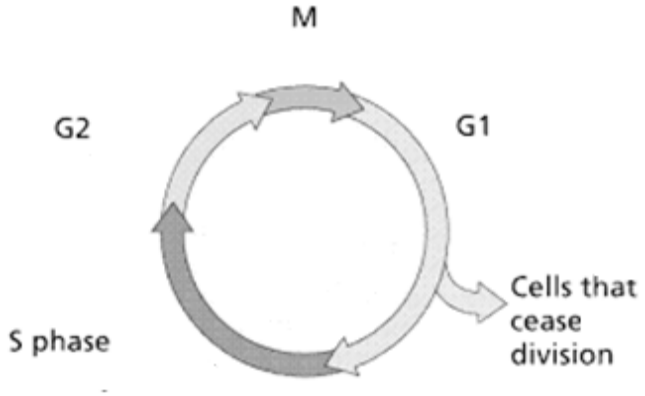
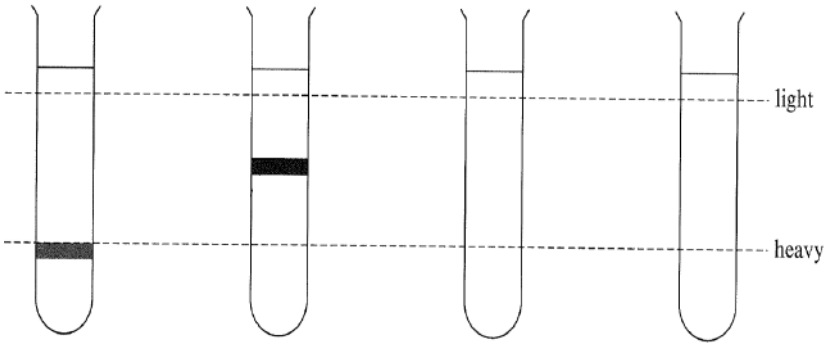
Cancer has been described as the uncontrolled, abnormal proliferation of cells and involves disruptions to the control of the normal cell cycle, as shown in the diagram below.



(b) During the S phase, cells that are undergoing cell division carry out DNA synthesis. In 1958, Meselson and Stahl carried out experiments to test which of three different theories did indeed describe the mechanism of DNA replication. Here is a brief description of their experimental method.

> The bacterium *Escherichia coli* (E. coli) was cultured in a nutrient broth, containing the heavy isotope as a source of nitrogen, ^{15}N, instead of the normal ^{14}N. After several generations all of the DNA in all of the bacteria contained the heavy isotope ^{15}N. They were then washed and transferred to a ^{14}N medium and allowed to replicate. After each generation, bacteria were removed and spun in a centrifuge. The position of the DNA in the medium was then determined.

(i) The diagram shows how the position of the DNA changed after successive cell divisions.



Initial position after growing in ^{15}N culture medium	After 1 division in ^{14}N culture medium	After 2 divisions in ^{14}N culture medium	After 3 divisions in ^{14}N culture medium

Complete the diagrams to show the pattern and relative proportions of DNA you would expect after 2 and 3 divisions in ^{14}N culture medium. [2]

(ii) Name the theory of DNA replication supported by the results of this experiment. [1]

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(iii) Explain how their results before and after the first division in ^{14}N culture medium support this theory and not the other theories proposed. [2]

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(c) p27 is a protein that is involved in the control of the cell cycle. High levels of this protein block the initiation of the S phase. This results in cells remaining in the G_1 phase for longer. In cells taken from breast cancers, it has been found that the levels of p27 are abnormally low.

(i) Suggest why it would be an advantage for normal cells to have: [2]

I high levels of p27 .....

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II low levels of p27. .....

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(ii) Suggest why abnormally low levels of p27 could result in the development of a tumour. [2]

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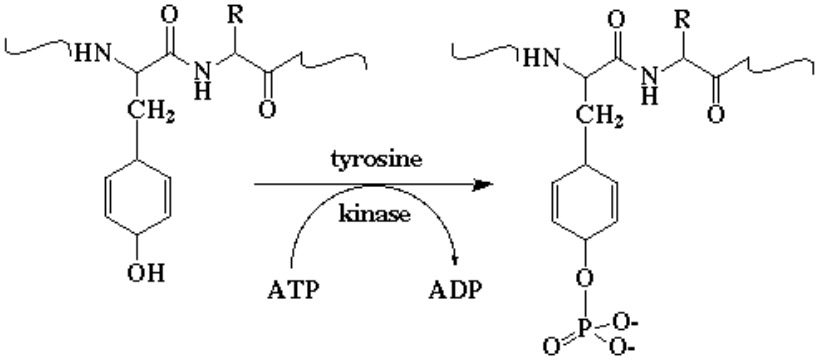
(d) The structure of the p27 protein is shown in the diagram below.

Research has shown that p27 acts as a competitive inhibitor of one of the enzymes responsible for the initiation of DNA replication.
The enzyme tyrosine kinase can phosphorylate a tyrosine molecule at position 88 in the p27 polypeptide chain as shown in the diagram below.



Explain how this could reduce p27s ability to inhibit its target enzyme. [3]

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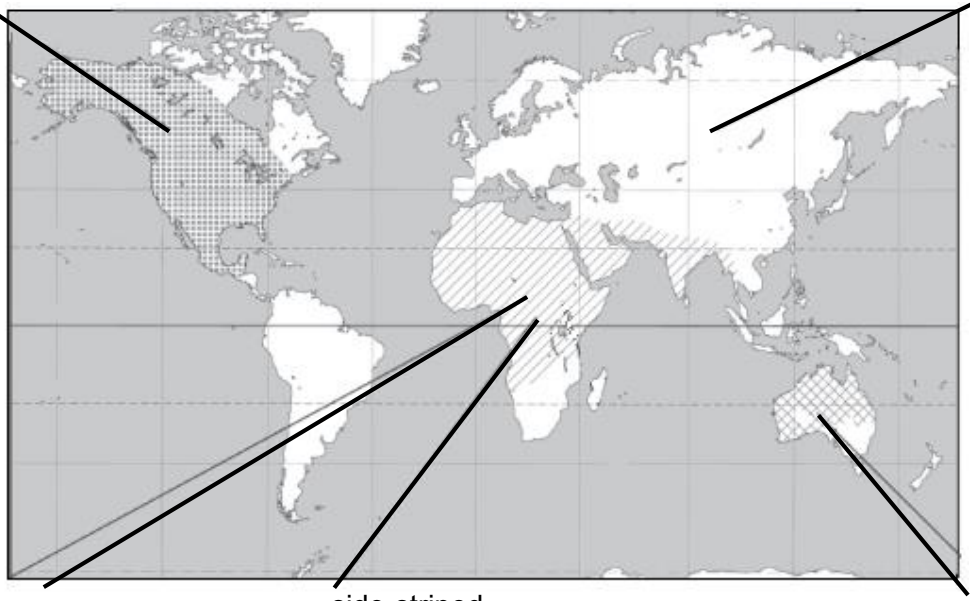
8. It is believed that the canine (dog) family evolved from a common ancestor about seven million years ago. The map below shows the world distribution of some members of the canine family.

coyote

wolf



black-backed jackal

side-striped jackal

dingo

In order to determine whether all the examples shown on the map were the same species, mating experiments were carried out. The results are shown in the table below.

	Coyote	Wolf	Dingo	Black backed Jackal	Side striped jackal
Coyote	✓	✓	✓	×	×
Wolf	✓	✓	✓	×	×
Dingo	✓	✓	✓	×	×
Black backed jackal	×	×	×	✓	×
Side striped jackal	×	×	×	×	✓

Using the information given, determine how many different species are shown on the map. Explain how you arrived at your conclusion and suggest how the different species could have arisen.
(The quality of your extended response will be assessed in this question.) [9QER]

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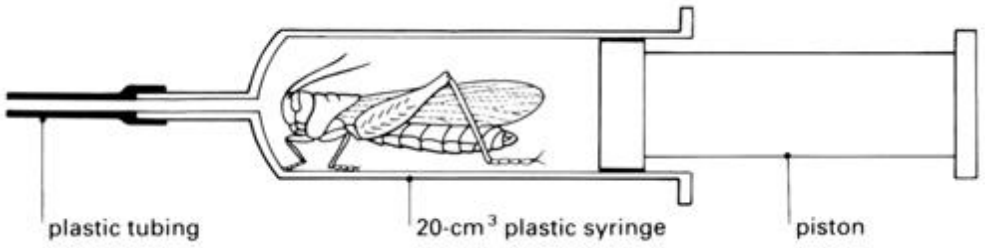
(b) Ventilation of the tracheal system involves contractions of the abdomen. These are called breathing movements. In an experiment to investigate ventilation in insects, a locust was placed in a syringe as shown in the diagram below.



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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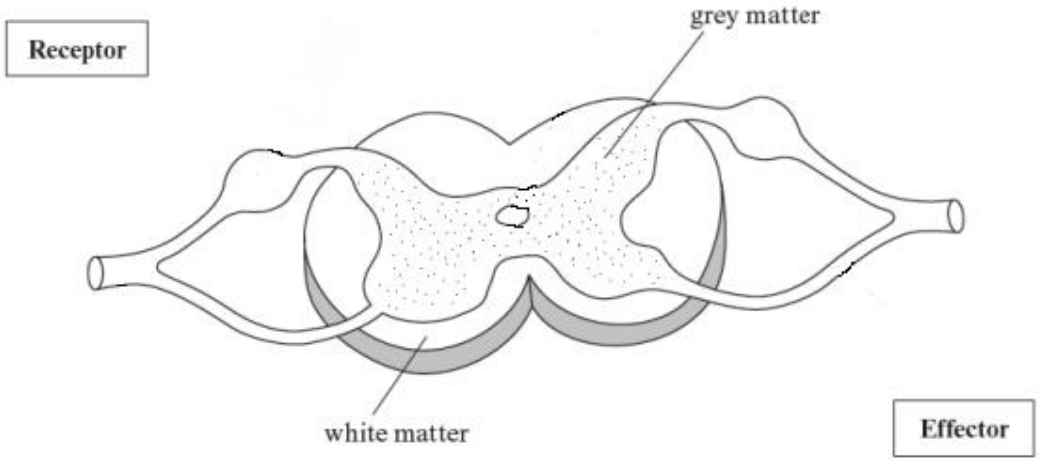
2. There are many reflex actions involving a sensory input to one side of the spinal cord which result in the contraction of an effector on the opposite side of the body. This is referred to as a crossed extensor reflex. An example of this is when one foot steps on a nail, the crossed extensor reflex 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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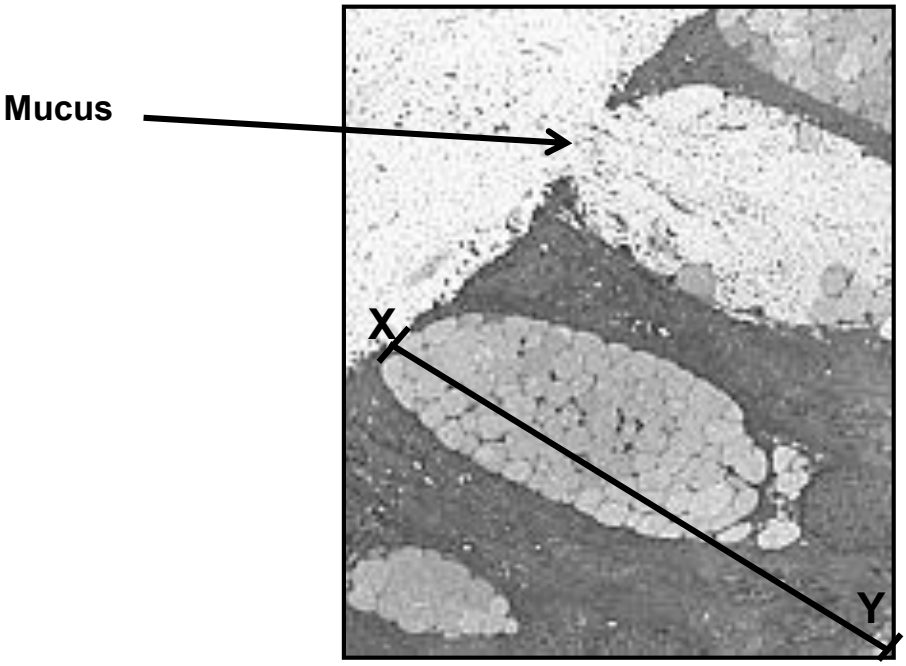
3. (a) Passage of food through the gut is aided by the production of mucus. The electron micrograph below shows some goblet cells that produce and secrete mucus in the small intestine.



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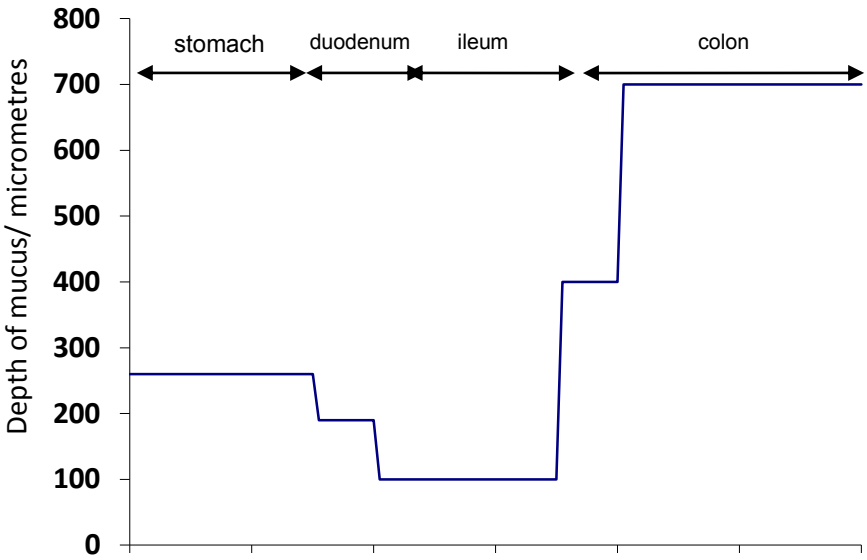
(b) Mucus is secreted in all regions of the gut. The diagram below represents the depth of the mucus in different regions of the gut.



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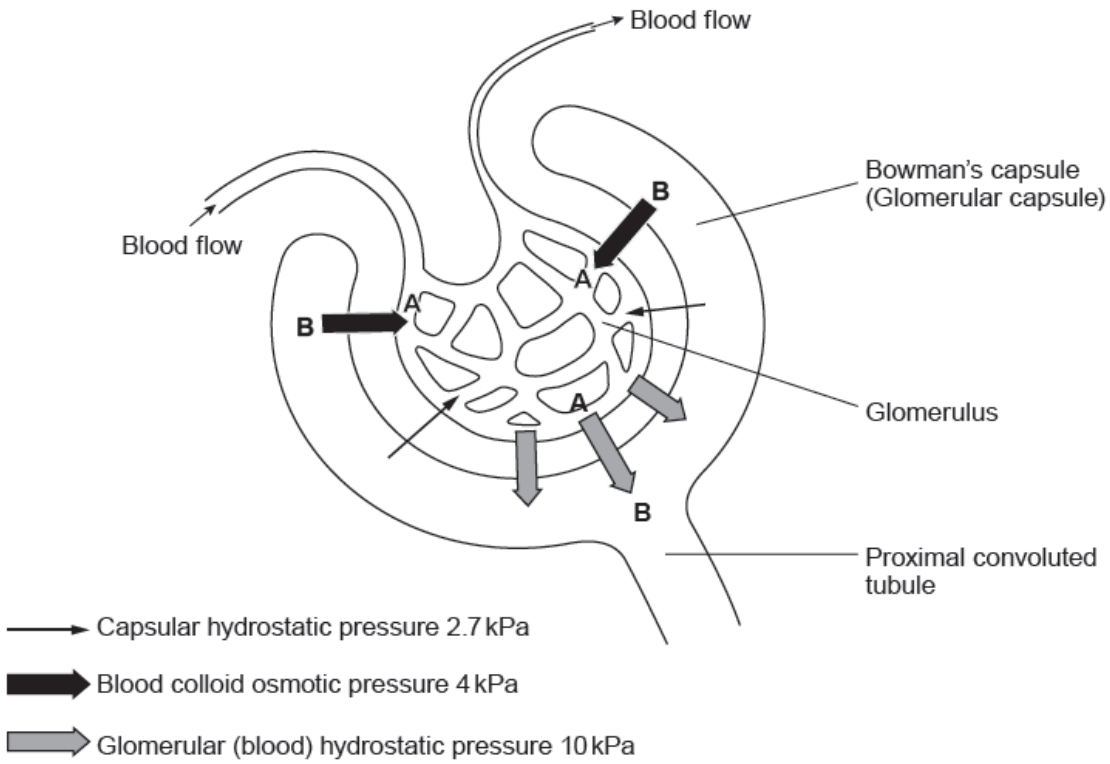
4. The diagram below represents part of a kidney nephron showing a glomerulus and Bowman's capsule.



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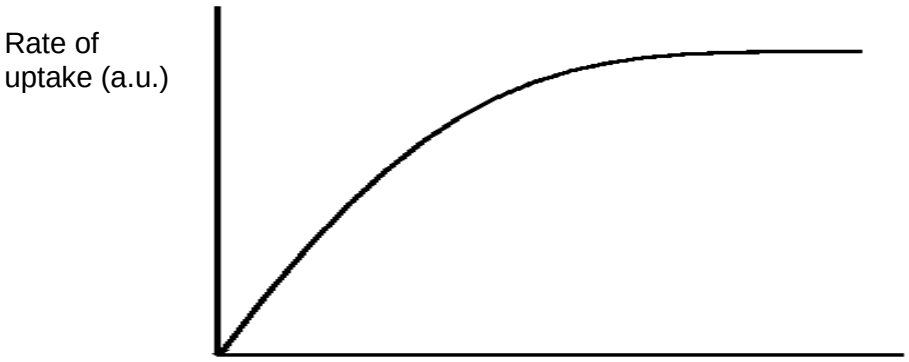
(iv) The net filtration pressure is the overall pressure responsible for ultrafiltration. From the data shown on the diagram calculate this value. Show your working and include units with your answer. [1]

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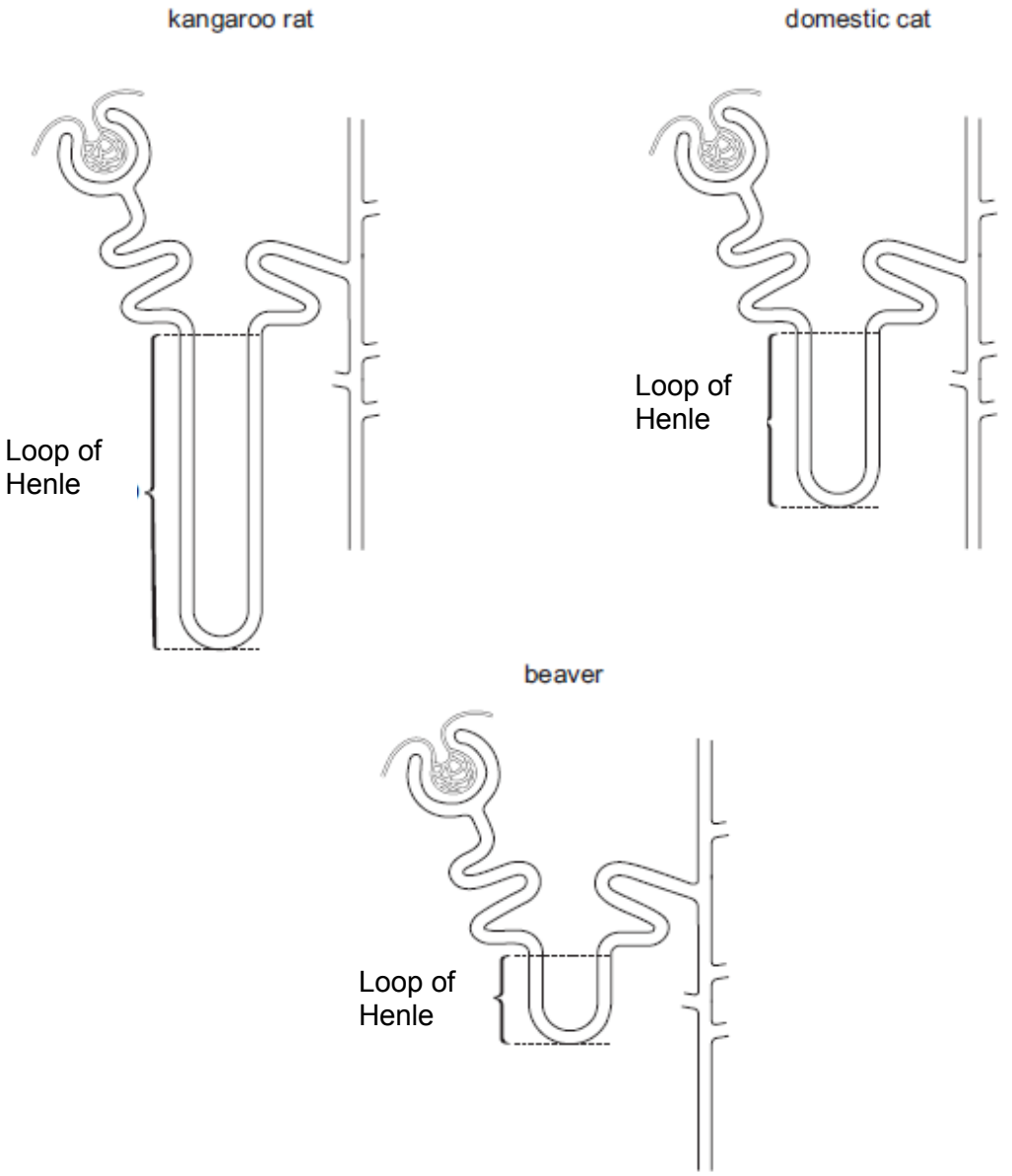
(c) The diagrams below show the relative sizes of nephrons from three mammals that live in different habitats.



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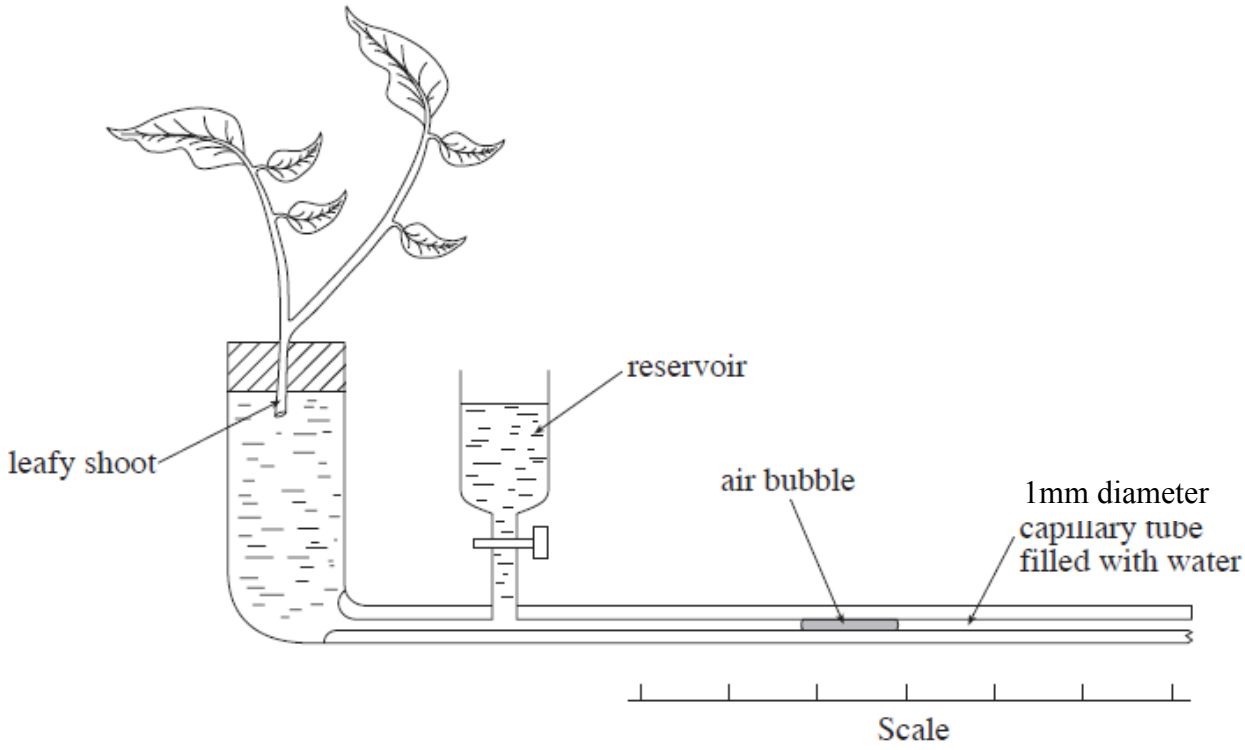
5. A student used the apparatus shown in the diagram to compare the rate of absorption of water by two different plant shoots of the same species.



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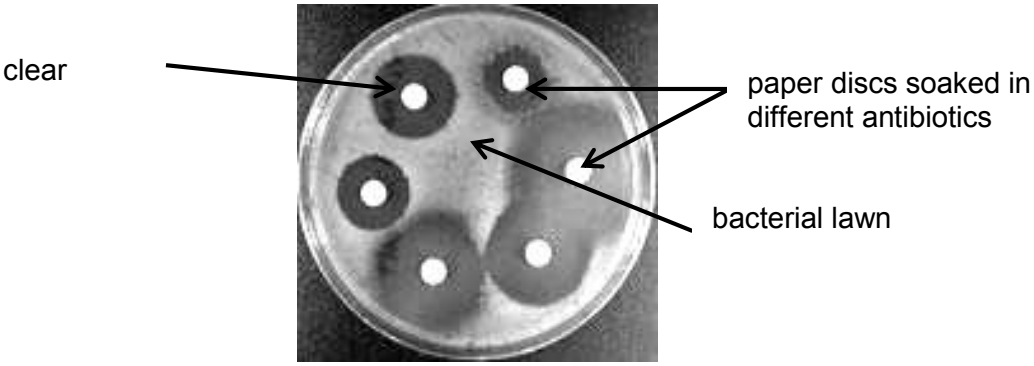
(b) One method of identifying if an antibiotic is effective against a bacterium is shown below.



(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]

.....

.....

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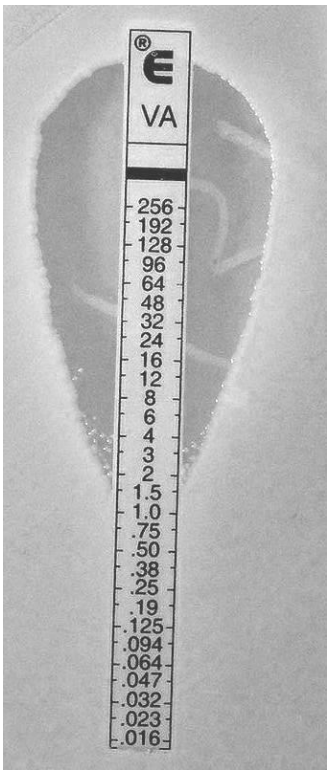
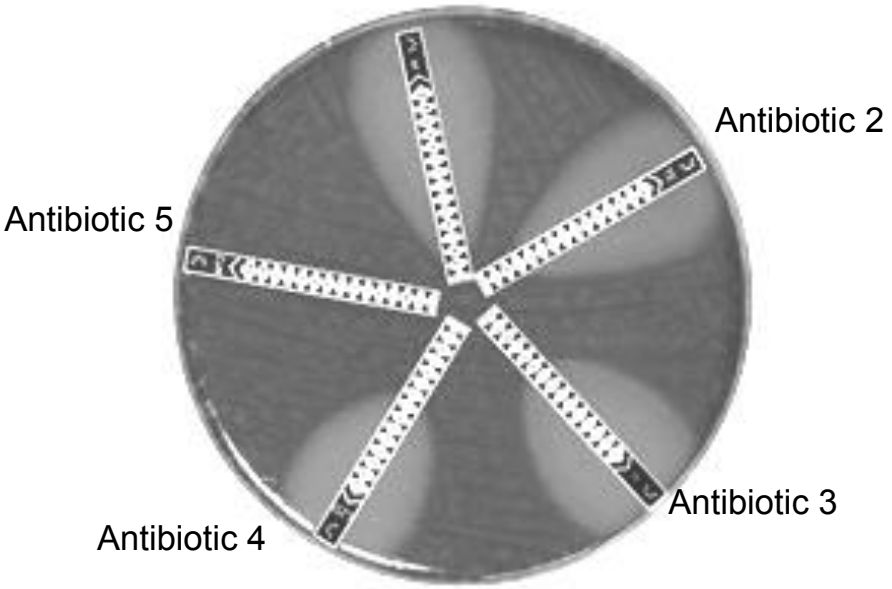
(c) If it is found that a species or strain of a bacterium is resistant to a particular antibiotic it is also important to know the **minimum inhibitory concentration**. This is the lowest concentration of the antibiotic that is effective against the bacterium.

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}

.....

.....

(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]

.....

.....

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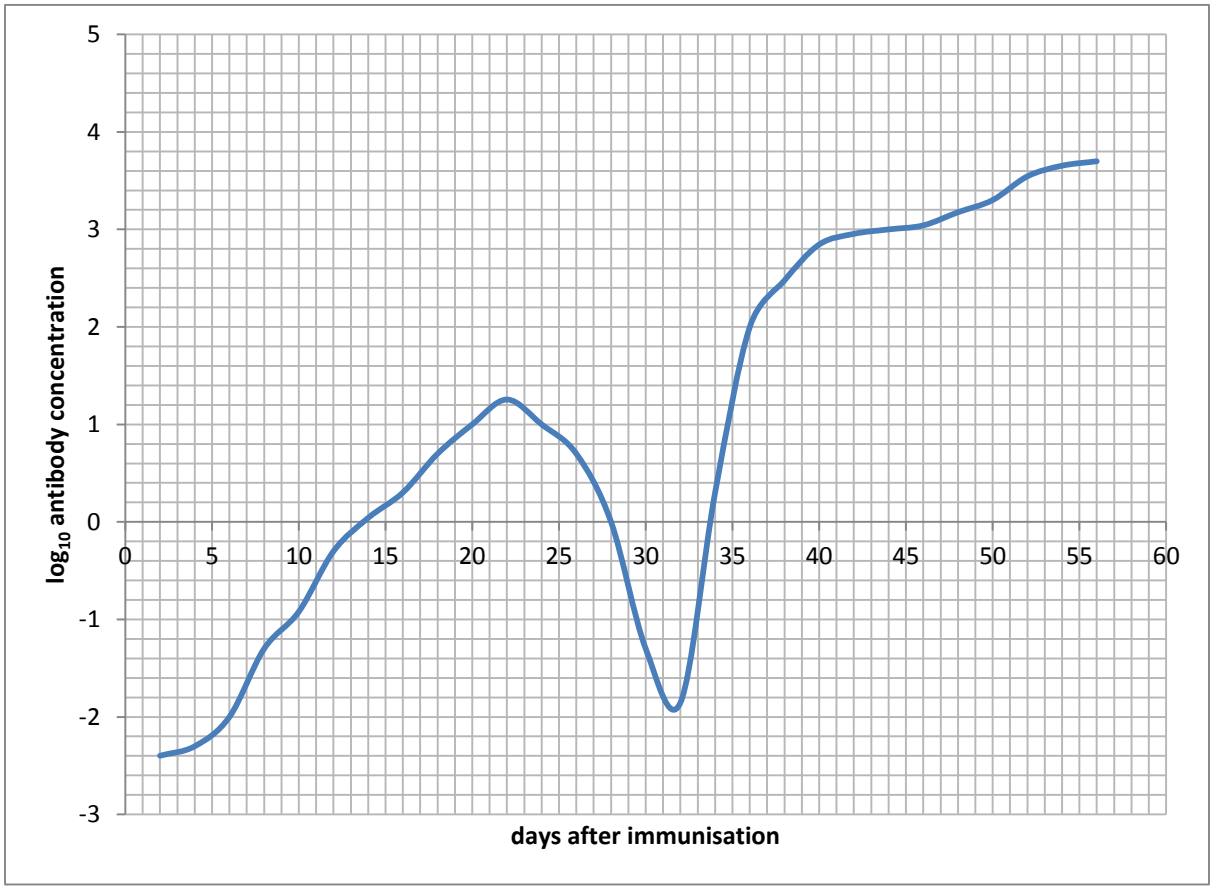
(f) For a number of viral diseases immunisation is a way of avoiding infection. The graph shows the change in antibody concentration in the plasma following a course of immunisation against a viral pathogen.



(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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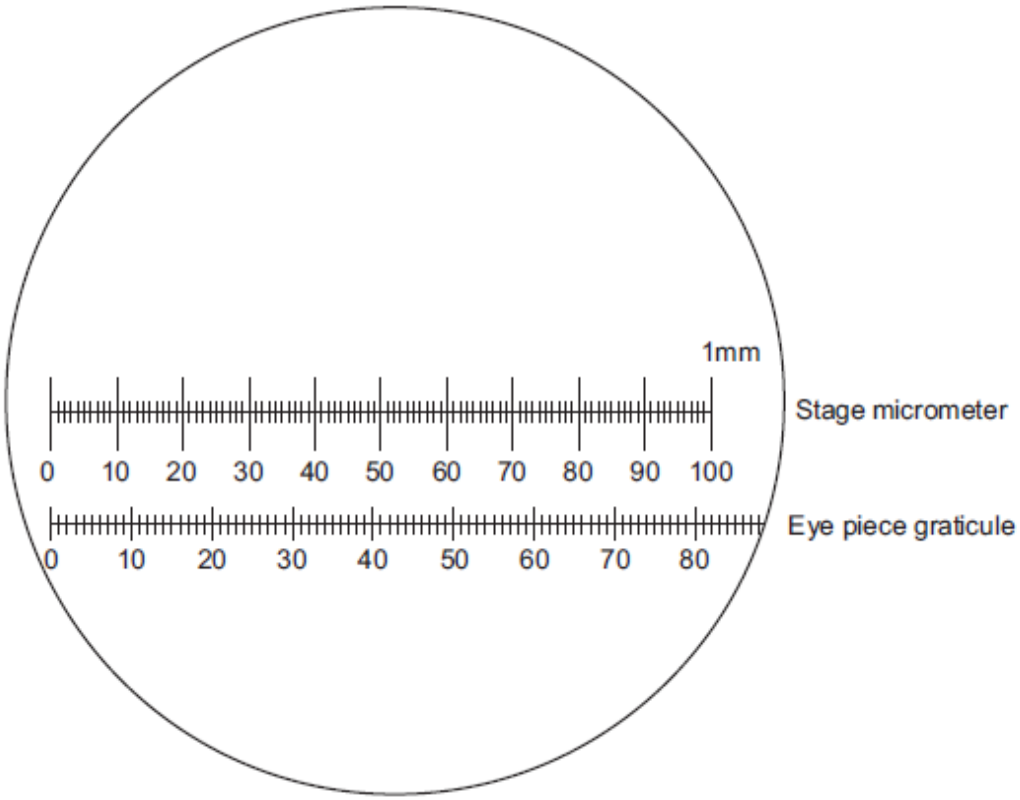
OPTION B: HUMAN MUSCULOSKELETAL ANATOMY

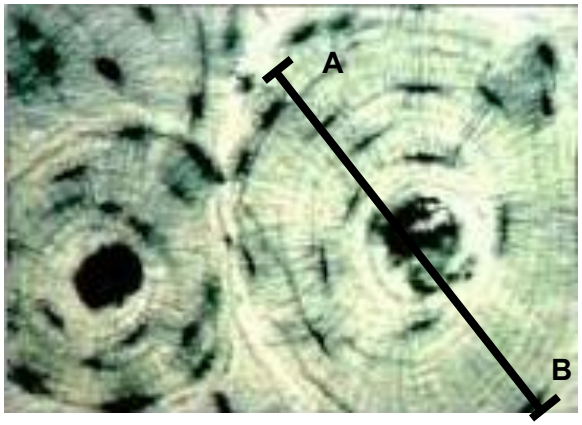
9. (a) The diagram represents a stage micrometer and an eye piece graticule.



(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]

.....

.....

(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]

.....

(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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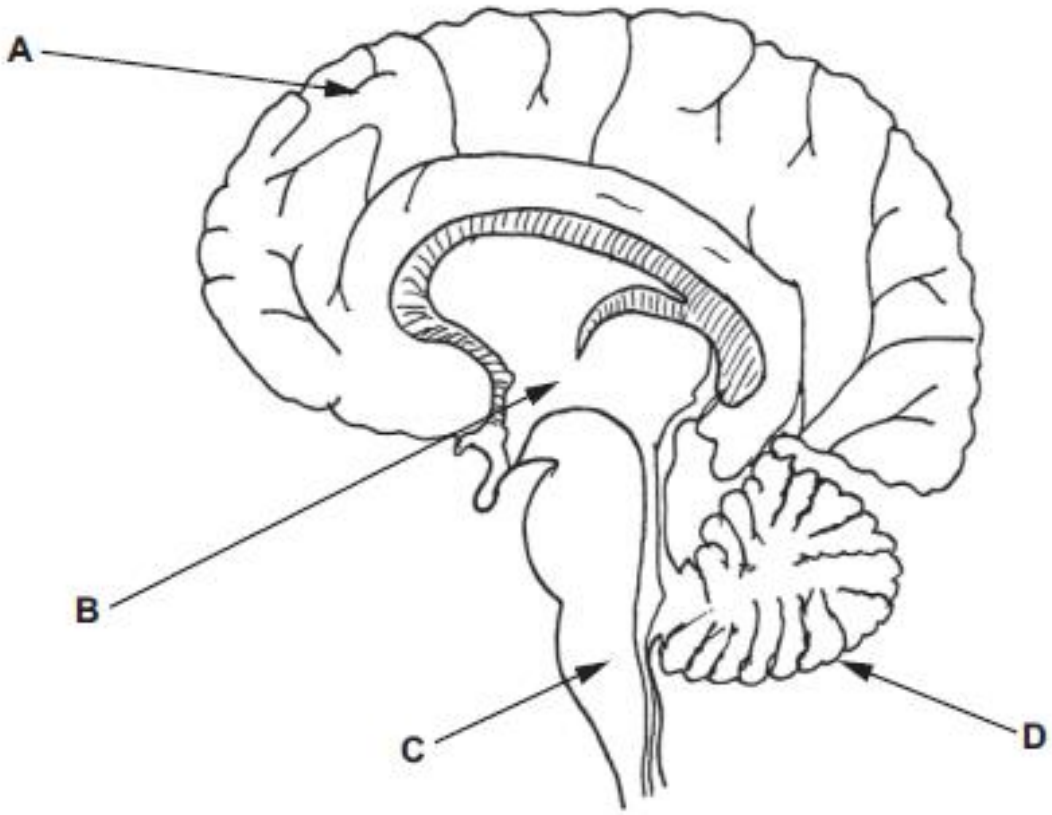
The diagram below is a section through the brain.



(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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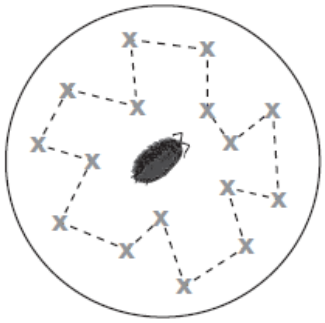
(d) A student set up an experiment to investigate the hypothesis that woodlice turn more in dry conditions than moist conditions.
Woodlice are crustaceans that have gills on their underside that they use for gas exchange. The student set up two Petri dishes. One had moist filter paper in the bottom the 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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COMPONENT 1 – ENERGY FOR LIFE

MARK SCHEME

GENERAL INSTRUCTIONS

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Marking abbreviations

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cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*			155-65 = 90 /500 = 0.18 /100 = 0.0018 (1) 2×10^{-3} (1) Max 1 if not expressed in standard form		2		2	2	
	(b)			Part A: CO_2 is in excess so as light intensity increases so does rate of uptake (1) Part B: concentration of CO_2 becomes a limiting factor for photosynthesis(1)	2			2		2
	(c)			(below 50 lux) rate of respiration must be higher than rate of photosynthesis as {CO_2 is being produced / -ve uptake of CO_2} (1) (at 50 lux) CO_2 produced in respiration equals that used in photosynthesis / O_2 produced in photosynthesis equals that used in respiration/ description of compensation point(1)			2	2		
	(d)			It stops electrons from PS II being moved to PS I (1) So blocking the reduction of $NADP^+$ to NADPH (1) No photolysis of water (1) Cyclic Photophosphorylation is not stopped as the electrons pass from PSI and return to PSI (1)		4		4		
	(e)			Plant cannot generate $NADPH_2$/ less ATP synthesised (1) Calvin cycle stops (1) So growing parts of the plant/sinks will not have glucose for respiration (1)		3		3		
				Question 1 total	**2**	**9**	**2**	**13**	**2**	**2**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*			Sample B must contain mitochondria (1) Because only mitochondria can use pyruvate as a substrate (1) And CO_2 is only produced in Link reaction and Krebs Cycle which only take place in mitochondria/ matrix (1) Sample E must contain only cytoplasm as it does not contain organelles(1) so only glycolysis can take place (1)		1	1 1 1 1	5		
	(b)			Cyanide would only affect mitochondria as cytochrome oxidase is part of the electron transport chain (1) No NAD is available to act as the hydrogen acceptor and Krebs cycle would therefore stop(1) No carbon dioxide would be produced(1)		1 1	1	3		
	(c)			So that water potential / solute concentration inside and outside organelles is the same (1) Organelles would burst / lyse in pure water (1)		2		2		2
				Question 2 total	**0**	**5**	**5**	**10**	**0**	**2**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*			(as plants get older / larger) more N for protein / nucleic acid synthesis (1) more Mg for chlorophyll synthesis (1)	2			2		
	(b)			oxygen needed for ATP synthesis and ATP needed for active transport of ions (1) into root hairs to follow the symplast route (1) (then) move ions from apoplast into symplast route at the endodermis (1) (and) for pericycle to control movement of ions into the xylem (1)		4		4		
	(c)			Independent: concentration of nitrate (1) Dependent: change in mass of roots (1) Controlled: time exposed to each concentration (1) same temperature / light intensity / volume of growth medium (1)			4	4		4
				Question 3 total	**2**	**4**	**4**	**10**	**0**	**4**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*	(i)		Correct bacterium labelled + *C.jejuni* is a helical bacterium so has a spiral shape + is Gram negative so would stain red (1)	1			1		1
		(ii)		(because it is Gram –ve) lipoprotein / lipopolysaccharide layer outside cell wall (1) Penicillin / antibiotics cannot penetrate and reach cell / cell wall (1)	2			2		
		(iii)		most human pathogens would have an optimum temperature of 37/38^{o}C so only *C.jejuni* would grow well at 42^{o}C (1)		1		1		1
	(b)	(i)		Plate U – there are enough colonies for reliable results and the colonies are easily countable (1) Plate R/S/T - cannot distinguish individual colonies and too many colonies to count accurately (1) Plate V has too few colonies to provide a reliable estimate (1)			3	3		3
		(ii)		69 colonies x 10 000 (dilution factor) x 2 (or 1/0.5) (1) 1 380 000/ 1.38 x 10^6 colonies per cm^3 (1)		2		2	2	2
		(iii)		does not include {dead / non-viable bacteria}(1) cannot be sure that {each colony has grown from a single bacterium/ colonies are not clumped}/ ORA; (1)	2			2		
				Question 4 total	**5**	**3**	**3**	**11**	**2**	**7**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*	(i)		9.4/30 x 60 or use suitable values from the tangent (1) 18.8 mg min^{-1} (1)		2		2	2	
		(ii)		Maximum concentration of glucose at start/ less glucose available as reaction progresses (1) All active sites occupied at start/ some active sites vacant as reaction progresses (1)	2			2		
	(b)	(i)		FAD acts as a hydrogen acceptor/ electron acceptor(1)		1		1		
		(ii)		Blood + urine (1)	1			1		
		(iii)		(oxygen electrode) could detect {use / depletion} of oxygen (1) The number of molecules of oxygen used in <u>Step 2</u> is proportional to the number of molecule of glucose broken down(1)			2	2		
		(iv)		Change in temperature would affect kinetic energy and result in readings being higher or lower than expected (1) Production of gluconic acid would lower pH (1) lowering pH would change shape of active sites resulting in readings being lower than expected (1)		3		3		3
	(c)			Change in oxygen levels would not be proportional to glucose concentration in sample (1) (because) Benzoate ion has a similar shape to glucose so would act as a competitive inhibitor of glucose oxidase (1) Benzoate would occupy active site and prevent formation of enzyme-substrate complexes (1) Therefore less $FADH_2$ would be reduced in <u>Step 1</u>(1) and so {less oxygen would be used in <u>Step 2</u> (1)		1	1 1 1 1	5		
				Question 5 total	**3**	**7**	**6**	**16**	**2**	**3**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*	(i)		GPP = gross primary <u>productivity</u> + NPP = net primary <u>productivity</u> (1) GPP is the rate at which producers convert light energy into chemical energy in glucose (1) NPP is the rate at which energy is converted into {biomass / chemical energy} that can be passed on to consumers / the rate of photosynthesis, minus respiration of the producers (1)	3			3		
		(ii)		Secondary productivity	1			1		
		(iii)		Respiratory loss = 3368 – 1095 – 383 = 1890 (1) % energy lost through respiration = 1890 / 3368 x 100 = 56.1163 = 56% (to 2 sig figs) (1) Max 1 if not expressed as 2 sig figs		2		2	2	
	(b)	(i)		Excretion and egestion Death Emigration /movement of animals from the area / removal of organisms by humans 3 correct = 2 marks, 2 correct = 1 mark 1/0 correct = 0 marks	2			2		
		(ii)		6 606 x 17 000 =112 302 000 (kJ m^{-2} yr^{-1}) (1) 1.12302 x 10^8 (1)		2		2	2	
		(iii)		Passes to {decomposers / detritivores} (1) {Respired / released} by decomposers/ lost as heat (1)	2			2		
	(c)			Factory farms more efficient as less energy is lost (1) reduces energy losses via respiration by controlling the temperature as less energy needed to maintain body temperature (1) animals are stocked at high densities which restricts movement so reduces energy loss (via respiration) for muscle contraction (1) herbivores are lower down the food chain than carnivores so less energy is lost via respiration or being expelled (1)		4		4		
				Question 6 total	**8**	**8**	**0**	**16**	**4**	**0**

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*		A threshold value for a global process that is affected by human activity(1) Crossing these boundaries could generate abrupt or irreversible environmental changes. (1)	2			2		
	(b)		The number of species and the number of organisms of each species in a particular area (1) Any **1** from: (1) Seed / sperm banks Captive breeding programmes Fishing quota Trade restrictions Management of wild populations Restrict habitat destruction / pollution / deforestation / other means of habitat destruction	2			2		
	(c)		{Increasing demand for fresh water/ land for crops} are possible causes of an increase in extinction rate (1) {Because demand for fresh water increased by 627% / land use for crops 24%} greater than the preindustrial value (1) {Increased land use for crops/ for dams to provide fresh water} leads to destruction of habitats (1)			3	3		
			Question 7 total	**4**	**0**	**3**	**7**	**0**	**0**

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
8	*(a)*	(i)	C and T are pyrimidines and A and G are purines (1) DNA is double stranded and a purine in one strand bonds to a pyrimidine in the complementary strand so same % purine as % pyrimidine (1) Maize and humans have different DNA sequences so A+T : C+G ratio will be different (1)	1	2		3		
		(ii)	(ratio not exactly 1.00) due to experimental error / loss of material during experimental processes(1)		1		1		1
	(b)	(i)	change (from cytosine to 5 methyl cytosine) does not alter the DNA base sequence (1) so no effect on {primary structure / amino acid sequence} of protein (1)	1	1		2		
		(ii)	(epigenetic) because the change to the DNA changes the ability of the gene to be transcribed (1) protein would not be produced and so change {appearance / ability to digest / process} (1) Accept suitable example where a protein plays a structural or functional role			2	2		
			Question 8 total	**2**	**4**	**2**	**8**	**0**	**1**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
9				**Indicative content** Farmers can improve soil fertility through the addition of manure / dead animal and plant material which is decomposed by bacteria. This provides a slow release of nitrogen in a suitable form. Organic forms of nitrogen have to be broken down into ammonium compounds and then converted into nitrates. *Nitrosomonas* converting ammonium ions into nitrites. *Nitrobacter* converting nitrites into nitrates. Farmers can also apply nitrate fertilisers which are soluble and are in a form that can be taken up by plants. This is a faster way of improving soil fertility. Farmers could also plant leguminous plants to increase nitrate levels; Leguminous plants have the bacteria *Rhizobium* in root nodules. *Rhizobium* combines glucose from plant with nitrogen from the air to form amino acids. Ploughing and drainage encourages aerobic conditions which favours nitrification and discourages denitrification. The growing of leguminous crops increases soil fertility if ploughed in and not removed. Improving soil fertility by the addition of organic and inorganic nitrogen has a negative environmental impact if it is leached into water courses- eutrophication. The energy/ electrical input needed to produce inorganic fertilisers is very large and would lead to increased carbon dioxide production and consequently increasing global warming.	4	5		9		

				7-9 marks The candidate gives a full and detailed account of how the application of fertilizers, planting leguminous crops and farming practices increase soil fertility. This must include a detailed explanation of the role of named bacteria in each of these processes. In addition a detailed explanation of the negative impacts of eutrophication and impact of fertilizer production on global warming. *The candidate constructs an articulate, integrated account, correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses scientific conventions and vocabulary appropriately and accurately.* **4-6 marks** The candidate gives an account of how the application of fertilizers, planting leguminous crops and farming practices increase soil fertility. This must include the role of some named bacteria in these processes. In addition some explanation of the negative impacts of eutrophication and/or the impact of fertilizer production on global warming. *The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate usually uses scientific conventions and vocabulary appropriately and accurately.*						

				1-3 marks The candidate gives a limited account of how farming practices increase soil fertility. This must include a reference to named bacteria. In addition, identifies at least one negative impact of these farming practices. *The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate has limited use of scientific conventions and vocabulary.* **0 marks** *The candidate does not make any attempt or give a relevant answer worthy of credit.*						
				Question 9 total	**4**	**5**	**0**	**9**	**0**	**0**

COMPONENT 1: ENERGY FOR LIFE

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Q	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	2	9	2	13	2	2
2	0	5	5	10	0	2
3	2	4	4	10	0	4
4	5	3	3	11	2	7
5	3	7	6	16	2	3
6	8	8	0	16	4	0
7	4	0	3	7	0	0
8	2	4	2	8	0	1
9	4	5	0	9	0	0
TOTAL	30	45	25	100	10	19

COMPONENT 2 - CONTINUITY OF LIFE

MARK SCHEME

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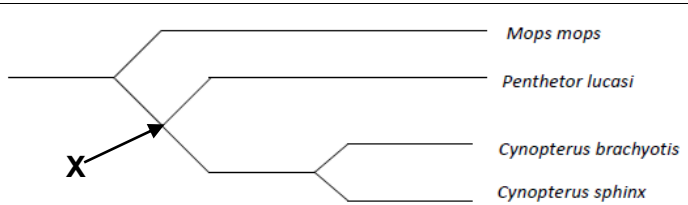
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*	(i)		Simpsons's Index is a better measure of biodiversity As it provides information on the number of species and also the number of individuals of each species while species richness only tells you the number of species present (1)	1			1		
		(ii)		Use the capture/recapture technique / Lincoln Index (1) {Trap/catch} samples of different species of mammal, mark and release, {trap/catch} second sample, calculate proportion of marked animals. (1)	2			2		2
		(iii)		Trapping animals could cause harm / marking them could make them more visible to {prey / predators} (1) Numbers of animals re-caught in second sample could be lower (1)	2			2		2
	(b)	(i)				1		1		
		(ii)		A = *Mops mops* B = *Cynopterus sphinx* C = *Penthetor lucasi*			1	1		
	(c)			insects have a higher fat content than fruit and fat produces nearly twice the energy per g through respiration than carbohydrate so less needs to be eaten(1) fats /fatty acids and glycerol contain more hydrogen atoms than glucose (1) therefore, {more H donors / reduced NAD or FAD} produced to pass H atoms to electron transport chain (1)	1	2		3		
				Question 1 total	**6**	**3**	**1**	**10**	**0**	**4**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*	(i)		Sickle cell trait must provide protection against malaria (1)			1	1		
		(ii)		Increase the sample size (1) Account for age / sex (1)			2	2		2
	(b)			q^2 = 1/625 =0.0016, q = 0.04 (1) $p + q = 1$, p = 1.0 – 0.04 = 0.96 (1) (1 for each of working out each of q and p if answer not correct) $2pq = 2pq$ = 2 x 0.04 x 0.96 = 0.0768 (1) Number = 0.0768 x 1000 = 76.8/77 (1)		2	2	4	4	
	(c)			In Africa the proportion of people with sickle cell trait would increase but in the USA the number of people with sickle cell trait would decrease(1) People with sickle-trait have a selective advantage so are less likely to be killed by malaria (1) More will survive to pass on the sickle allele to the next generation (1) In the USA few cases of malaria so no selective advantage (1) Sickle cell trait is a disadvantage and selected against (1)		 1 1	 1 1 1	5		
				Question 2 total	**0**	**4**	**8**	**12**	**4**	**2**

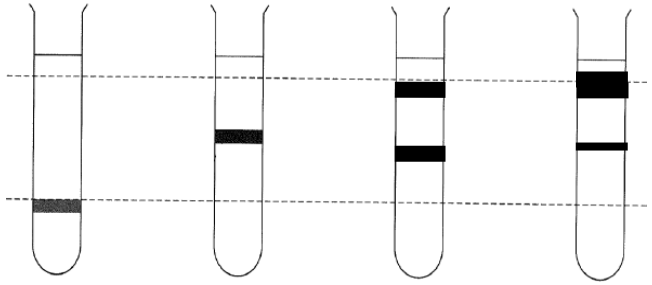
<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>3</td><td>(a)</td><td>(i)</td><td></td><td>
<table>
<tr><th>Description</th><th>Name of cell</th><th></th></tr>
<tr><td>... meiosis</td><td>Primary and secondary spermatocytes</td><td>(1)</td></tr>
<tr><td>... mitosis</td><td>spermatogonium</td><td>(1)</td></tr>
<tr><td>... protection ...</td><td>Sertoli cell</td><td>(1)</td></tr>
<tr><td>... differentiation...</td><td>spermatid</td><td>(1)</td></tr>
</table>
</td><td>4</td><td></td><td></td><td>4</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>Spermatogonia divide to produce primary spermatocytes and each primary spermatocyte produces 4 spermatids (1)</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iii)</td><td></td><td>Protein (1)
Nucleolus involved in producing rRNA / ribosomes and ribosomes carry out protein synthesis (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(iv)</td><td></td><td>Endocytosis / phagocytosis (1)</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td></td><td>A = LH
B = oestrogen
C = progesterone
3 ✓ = (2) ; 2 ✓ = (1) ; 1or 0 ✓ = 0</td><td>3</td><td></td><td></td><td>3</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>18 days</td><td></td><td>1</td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 3 total</td><td>9</td><td>3</td><td>0</td><td>12</td><td>0</td><td>0</td></tr>
</table>

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*			A seed is surrounded by the testa only / a fruit originates from the pericarp (1) a barley grain is a fruit because it is surrounded by the testa and the pericarp (1)	2			2		
	(b)			Number of chromosomes in embryo cells = 14 (1) Because of double fertilisation (1) Endosperm cells are triploid / formed from fusion of 1 male gamete and 2 polar nuclei each of which has 7 chromosomes(1) Embryo cells are diploid – fusion of 1 male gamete and 1 female gamete(1)		1 1 1	1 1	4		
	(c)			The mass lost from the endosperm must be used to increase the mass of the embryo (1) As mass of embryo is increasing but plant cannot produce biomass through photosynthesis (1)			2	2		
	(d)	(i)		Volume of agar = 3.142 x 1.25^2 x 0.5 (1) [conversion of mm to cm] Mass of agar = 2.4546... / 100 (1) Mass of agar = 2.46 x 10^{-2} g (1)		3		3	3	
		(ii)		aleurone layer (1) gibberellin (1)	2			2		
		(iii)		range of seeds of different ages (1) Measure diameter/area of clear zone (1) Two controlled variables - Same mass of seeds +Same/ fixed time (1) Repeats (1) Reference to suitable control (1)			5	5		5
				Question 4 total	**4**	**5**	**9**	**`18**	**3**	**5**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*			Enzymes would digest the viral DNA and destroy genes / make it impossible for viral proteins to be made (1)		1		1		
	(b)	(i)		3450-2675 = 775 (1) +30 = 805 bp (1) 2 marks for correct answer with units		2		2	2	
		(ii)		EcoRI **and** HindIII (1)		1		1		
	(c)	(i)	I II III	breaks hydrogen bonds/ causing DNA strands to separate (1) allows {primers/short pieces of DNA} to {anneal/bind/join} (1) Enzyme adds complementary nucleotides / extension/ forms the phosphodiester bonds in the sugar-phosphate backbone (1)	3			3		
		(ii)		DNA is attracted to the positive electrode due to its negative charge on the phosphate group (1) Smaller fragments find it easier to migrate through the pores in the gel and so travel further than larger fragments in the same time (1) Fragment size can be estimated by running a DNA ladder (which contains fragments of known size) alongside (1)	3			3		3
		(iii)		From sequencing the expected fragment size = 52bp **and** From gel result band produced is approximately 50bp/half way between 75 bp and 25 bp ladder band OWTTE (1) Therefore good agreement between the results of the two tests (1)			2	2		
		(iv)		Use more DNA fragments of values between 25 and 75/ smaller size than 75/ OWTTE (1)			1	1		1
				Question 5 total	**6**	**4**	**3**	**13**	**2**	**4**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td>6</td><td>(a)</td><td></td><td></td><td>Parental genotypes RrYy rryy (1)
Gametes RY, Ry, rY and ry ry (1)
F1 genotypes RrYy Rryy rrYy rryy (1)
Genotype linked to phenotype wrinkled yellow wrinkled green smooth yellow smooth green (1)
ratio 1 : 1: 1: 1 (1)</td><td></td><td>5</td><td></td><td>5</td><td>1</td><td></td></tr>
<tr><td colspan="10"></td></tr>
<tr><td></td><td>(b)</td><td>(i)</td><td></td><td>
<table>
<tr><th>Observed
O</th><th>Expected
E</th><th>(O-E)</th><th>$(O-E)^2$</th><th>$\frac{(O-E)^2}{E}$</th></tr>
<tr><td>31</td><td>27</td><td>4</td><td>16</td><td>0.592593</td></tr>
<tr><td>22</td><td>27</td><td>-5</td><td>25</td><td>0.925926</td></tr>
<tr><td>29</td><td>27</td><td>2</td><td>4</td><td>0.148148</td></tr>
<tr><td>26</td><td>27</td><td>-1</td><td>1</td><td>0.037037</td></tr>
<tr><td>108</td><td>108</td><td></td><td></td><td></td></tr>
</table>
χ^2 = 1.07 (1.070374) (3) for correct value of χ^2

If incorrect award up to 2 marks:
correct value of expected results(1)
correct values of $(O-E)^2$ (1)</td><td></td><td>3</td><td></td><td>3</td><td>3</td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>Critical value from table = 7.82(1)
Therefore conclusion is valid(1)
Because χ^2 value < critical value at 0.05 (1)
Deviation is due to chance(1)</td><td></td><td>2</td><td>2</td><td>4</td><td>2</td><td></td></tr>
<tr><td colspan="10"></td></tr>
<tr><td></td><td></td><td></td><td></td><td>Question 6 total</td><td>0</td><td>10</td><td>2</td><td>12</td><td>6</td><td>0</td></tr>
</table>

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7	*(a)*			(tumour) damages basement membranes in glomerulus(1) so red blood cells can pass through (1) OR (tumour) could increase blood pressure in kidneys(1) which causes damage to capillaries / podocytes in glomerulus (1)		2		2		
	(b)	*(i)*		 After 2 divisions: intermediate and light equal amounts (1) After 3 divisions: intermediate and light more light than intermediate e.g. shown as thicker or wider line (1)	2			2		
		(ii)		Semi-conservative (1)	1			1		
		(iii)		After 1 division DNA mixture of heavy and light DNA (1) DNA after 1 division must be made from one strand of heavy and one light / each molecule must contain 1 original and 1 new strand of DNA(1)	2			2		
	(c)	*(i)*	I	High level: stays in period of normal cell activity longer / continues to perform particular function (1)		1		1		
			II	Low level: decreases time for cell division/ Increases rate of growth / repair (1)		1		1		
		(ii)		(abnormally low levels of p27) results in cells entering S phase too quickly (1) Speeds up rate of growth to above normal rate / no control on rate of growth (1)		2		2		
	(d)			the phosphate group has a strong negative charge (1) this could change the tertiary structure of p27 (1) so p27 would not bind to the active site of the target enzyme (1)		3		3		
				Question 7 total	**5**	**9**	**0**	**14**	**0**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8				Indicative content Because only members of the same species can interbreed to produce fertile offspring there are only three species present. ● Coyote, wolf and dingo can all interbreed to produce fertile offspring and are therefore one species. ● Black-backed and side-striped jackals cannot interbreed successfully with any other shown, therefore they are both separate species. Following evolution from a common ancestor the canines have migrated to different parts of the world where there would be different selective pressures in different habitats such as differences in climate, predators and food availability. There is a variation in the different populations of canines caused by mutation, so individuals in the populations would have variations giving them a selective advantage to survive under these different selection pressures. Natural selection would result in there being morphological differences between the canines. It would appear that the wolf, dingo, and coyote diverged relatively recently as even though they are geographically separated they could still interbreed. The side-striped jackal and black-backed jackal appear to have diverged less recently allowing more time for speciation to occur. Allopatric speciation has occurred between those canines that can produce fertile offspring and the black-backed and side-striped jackals due to geographical isolation, such as the oceans and deserts.	0	7	2	9		

				Sympatric speciation has occurred to produce the black-backed and side-striped jackals as they occupy the same habitat but cannot produce fertile offspring. Isolation mechanisms such as different reproductive cycles; differences in reproductive or courtship behaviour; changes in chromosome numbers / ploidy; different activity times; mechanical isolation; could be the cause of this. **7-9 marks** The candidate gives a full and detailed explanation of why there are only three actual species shown on the map. The effect of natural selection resulting in morphological differences is also clearly explained in terms of survival of the fittest under different selection pressures. Speciation due to both sympatric and allopatric isolation mechanisms are explained in detail to account for the evolution of three species of canine. Some comment made on divergence of the jackals less recently than the other species. *The candidate constructs an articulate, integrated account, correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses scientific conventions* **4-6 marks** The candidate explains why the black-backed and side-striped jackals are different species to the other canines does not clearly explain why there are only 3 actual species shown. The effect of natural selection resulting in morphological differences is explained in terms of survival of the fittest under different selection pressures. Speciation due to both sympatric and allopatric causes are correctly described and an attempt is made to use these mechanisms to account for the different species of canine shown.						

				The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate usually uses scientific conventions and vocabulary appropriately and accurately. **1-3 marks** The candidate attempts to explain why there are fewer than five actual species shown on the map. Natural selection is used to explain the morphological differences but may not include a clear understanding of the effects of different selection pressures. Mechanisms of speciation due to sympatric and / or allopatric causes are suggested but with insufficient detail to account for the different species of canine shown. *The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate has limited use of scientific conventions and vocabulary.* **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.						
				Question 8 total	**0**	**7**	**2**	**9**	**0**	**0**

COMPONENT 2: CONTINUITY OF LIFE

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Q	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	6	3	1	10	0	4
2	0	4	8	12	4	2
3	9	3	0	12	0	0
4	4	5	9	18	3	5
5	6	4	3	13	2	4
6	0	10	2	12	6	0
7	5	9	0	14	0	0
8	0	7	2	9	0	0
TOTAL	**30**	**45**	**25**	**100**	**15**	**15**

COMPONENT 3 - REQUIREMENTS FOR LIFE

MARK SCHEME

GENERAL INSTRUCTIONS

Recording of marks

Examiners must mark in red ink.

One tick must equate to one mark (apart from the questions where a level of response mark scheme is applied).

Question totals should be written in the box at the end of the question.

Question totals should be entered onto the grid on the front cover and these should be added to give the script total for each candidate.

Marking rules

All work should be seen to have been marked.

Marking schemes will indicate when explicit working is deemed to be a necessary part of a correct answer.

Crossed out responses not replaced should be marked.

Credit will be given for correct relevant alternative responses which are not recorded in the mark scheme.

Extended response question

A level of response mark scheme is used. Before applying the mark scheme please read through the whole answer from start to finish. Firstly, decide which level descriptor matches best with the candidate's response: remember that you should be considering the overall quality of the response. Then decide which mark to award within the level. Award the higher mark in the level if there is a good match with both the content statements and the communication statement. Award the middle mark in the level if most of the content statements are given and the communication statement is partially met. Award the lower mark if only the content statements are matched.

Marking abbreviations

The following may be used in marking schemes or in the marking of scripts to indicate reasons for the marks awarded.

cao = correct answer only
ecf = error carried forward
bod = benefit of doubt

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
1	*(a)*			animalia (1) **and** Any 3 of the following = 2 marks, Any 2 = 1 mark, 1 or 0 = 0 marks multicellular eukaryotes no cell wall nervous co-ordination heterotrophic	3			3		
	(b)	(i)		To become acclimatised/ adjusted to the surroundings (1)			1	1		1
		(ii)		Replace the air with normal air to restore normal breathing patterns (1)			1	1		1
		(iii)		Movement / contraction of body needed to force air in and out of tracheae (1)		1		1		
		(iv)		Air through spiracles (1) diffuses to tissue through the tracheal system (1)	2			2		
	(c)	(i)		Carbon dioxide (1) Increase of O_2 from 83-97% decrease of 7 breathing movements per minute (1) but increase of CO_2 from 0 – 3% increase of 35 (1)			3	3		1
		(ii)		Accept a number between 43 and 45 (1) Little difference between the results seen at 3 + 6%(1)			2	2	0	1
				Question 1 total	**5**	**1**	**7**	**13**	**0**	**4**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*			sensory , relay, motor neurones labelled correctly (1) synapses shown in grey matter (1) cell body of sensory neurone in dorsal root ganglion, other cell bodies in grey matter (1) sensory neurone in dorsal root and motor neurone in ventral root on opposite side (1)	1 1 1	 1		4		
	(b)			Chloride ions move in and potassium ions move out (1) Resting potential is lowered/ potential difference in post synaptic neurone becomes more negative (1) Threshold requires more depolarisation (1)		3		3		
	(c)			2.5 / 5.7 (1) 0.438….. (1) 0.44 (to 3 sig figures) (1)		3		3	3	
	(d)	(i)		Na^+ ion (voltage gated) channels open and Na^+ {flood / diffuse rapidly} into cytoplasm by facilitated diffusion (1) K^+ ion channels remain closed (1) More $^+$ions inside axon than outside (1) depolarisation of the axon membrane (1)	4			4		
		(ii)		Once the threshold potential is reached the same size action potential is generated (1) Correct ref to all or nothing (1)	2			2		
				Question 2 total	**9**	**7**	**0**	**16**	**3**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*	(i)		77 / 3 700 x 1000 (1) =20.8 μm (1)		2		2	2	2
		(ii)		exocytosis (1)	1			1		
	(b)			Stomach - thick layer to prevent damage by pepsin and hydrochloric acid(1) First part of duodenum - mucus layer thick prevent damage from acid from stomach(1) Ileum - mucus thin to allow more efficient absorption(1) Colon – thick mucus for lubrication as much water has been reabsorbed(1)		4		4		
	(c)			Conclusion is not valid although percentage is similar, the diet of the animals are different/ description of (1) Protein digested initially in stomach of wild dog (1) Cellulose digested by bacteria in {stomach / rumen} of sheep (1)			3	3		
				Question 3 total	**1**	**6**	**3**	**10**	**2**	**2**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*	(i)		Efferent arteriole narrower than afferent/ ORA/ ventricular systole (1)	1			1		
		(ii)		Protein(1)	1			1		
		(iii)		Down water potential gradient by osmosis(1)	1			1		
		(iv)		10 – 6.7(1) 3.3kPa(1)		1		1		
	(b)	(i)		Active transport + Facilitated diffusion (1) both use carrier proteins in the membrane(1) Graph levels off when all carrier proteins are occupied(1)	3			3		
		(ii)		Glucose taken up by active transport(1) Active transport requires ATP (1) Cyanide prevents oxidative phosphorylation so no ATP produced (1)		3		3		
	(c)			The longer the loop of Henle the better adapted the organism is to a dry environment/ORA(1) Because the urine is more concentrated as the longer the loop of Henle more water is reabsorbed/ ORA (1) Therefore less water is lost by organisms living in xeric conditions(1) beaver does not need to control water loss as lives in aquatic habitat therefore loop of Henle is short(1)			4	4		
				Question 4 total	**6**	**4**	**4**	**14**	**0**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*			50 x 3.14 x 0.5^2 (1) = 39.25/10 = 3.925 ($mm^3\ min^{-1}$)(1) 3.9 (1)		3		3	3	
	(b)	(i)		**4** for **2** marks/ OR any **2/3** for **1** mark from: Temperature Humidity Wind speed Light intensity			2	2		2
		(ii)		Measure surface area of leaves(1) Calculate result as water loss per mm^2 of leaf / express result in $mm^3\ min^{-1}mm^{-2}$ (1)			2	2		2
	(c)			water produced in respiration and used up in photosynthesis (1) Some water produced in respiration when oxygen accepts final electron and combines with protons (1) Some water used in photosynthesis during photolysis to provide protons for ATP synthesis(1)	1	2		3		
				Question 5 total	**1**	**5**	**4**	**10**	**3**	**4**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
6	*(a)*			4 (1)		1		1		
	(b)			Transcription of genes for alpha and gamma chains (1) Produces mRNA (1) Translation by ribosomes to produce alpha and gamma polypeptides(1) Combination of alpha and gamma chains to give quaternary structure(1)		4		4		
	(c)			Advantages: Increased oxygen affinity (1) More oxygen absorbed (1) Disadvantage: Less oxygen released at low partial pressures of oxygen (1)		3		3		
				Question 6 total	**0**	**8**	**0**	**8**	**0**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
7				Indicative content ADH is a hormone which controls water loss from the body by affecting the permeability of the collecting duct walls in the kidney. As more water is reabsorbed the water potential of the urine falls and the water potential of the blood will rise. The volume of blood in the body will rise because of the increased water levels. Ecstasy increases the concentration of ADH in the blood and therefore more water is reabsorbed into the blood . The normal homeostatic control of water levels in the body is affected. The body is unable to get rid of excess water in the urine and this results in the water potential of the blood rising. Cells will absorb water by osmosis and expand possibly bursting and the pressure of the brain against the cranium increases. Blood pressure increases because there is more water in the blood which increases the volume and causes a dilution of ions such as sodium in the blood. The cells in the body cannot tolerate changes in the cellular environment and fluctuations from the norm will result in the impairment of the normal physiology within cells. **7-9 marks** The candidate gives a full and detailed explanation of the role and function of ADH in the control of water concentration in the body, including reference to water potential. The effect of ecstasy with relation to ADH is also clearly explained. A clear account of the effects on the body is given including effect on cells, blood pressure, dilution of ions and the effect on physiology.	2	5	2	9		

				The candidate constructs an articulate, integrated account, correctly linking relevant points, such as those in the indicative content, which shows sequential reasoning. The answer fully addresses the question with no irrelevant inclusions or significant omissions. The candidate uses scientific conventions and vocabulary appropriately and accurately. **4-6 marks** The candidate gives an explanation of the role and function of ADH in the control of water concentration in the body, including some reference to water potential. The effect of ecstasy with relation to ADH is explained. A clear account of some of the effects on the body is given including two of cells lysis, blood pressure, dilution of ions and the effect on normal physiology. *The candidate constructs an account correctly linking some relevant points, such as those in the indicative content, showing some reasoning. The answer addresses the question with some omissions. The candidate usually uses scientific conventions and vocabulary appropriately and accurately.* **1-3 marks** The candidate gives a brief explanation of the role and function of ADH in the control of water concentration in the body. The link between ecstasy and water concentration is mentioned. Some attempt at the effects on the body is given. *The candidate makes some relevant points, such as those in the indicative content, showing limited reasoning. The answer addresses the question with significant omissions. The candidate has limited use of scientific conventions and vocabulary.* **0 marks** The candidate does not make any attempt or give a relevant answer worthy of credit.						
				Question 7 total	**2**	**5**	**2**	**9**	**0**	**0**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
Option A										
8	*(a)*			Bacteria can be treated with antibiotics + viruses not affected (1) Accept: <u>only</u> bacteria affected by antibiotics	1			1		
	(b)	(i)		Antibiotics have killed bacteria in region around discs (1) No clear zone observed (1)	2			2		
		(ii)		Use different concentrations of <u>same</u> antibiotic (1) measure {diameter / area} of bacteria killed (1)			2	2		2
	(c)	(i)		Prevent the division of bacteria (1) 1.5 μg cm^{-3} (1)		2		2		
		(ii)		Gives quantitative data/ Actual concentration at different points known (1)			1	1		1
		(iii)		Antibiotic 1 (1) Causes inhibition /death of bacteria at <u>lowest</u> concentration (1)			2	2		
	(d)	(i)		Affect metabolic processes common to most bacteria (1)	1			1		
		(ii)		A microorganism which should be affected by an antibiotic is no longer susceptible to it OWTTE (1)	1			1		

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
8	*(e)*			Tetracycline affects protein synthesis which is common to all bacteria (1) (AO2) Gram -ve bacteria have an {outer / protective} layer of {lipopolysaccharide / lipoprotein} (1) (AO1) Prevents penicillin reaching murein cell wall (1) (AO2)	1	2		3		
	(f)	(i)		at 22 days: concentration = $10^{1.26}$ = 18.20 µg cm^{-3} (1) at 40 days: concentration = $10^{2.85}$ = 707.95 µg cm^{-3} (1) increase = 707.95 – 18.2 = 689.75 µg cm^{-3} (1)		3		3	2	
		(ii)		Booster stimulates higher number of memory cells (1) Antibodies produced faster if exposed to the infection (1)		2		2		
				Option A Question total	**6**	**9**	**5**	**20**	**2**	**3**

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
Option B										
9	*(a)*	(i)		80 eye piece units = 98 stage micrometer units (1) 1 epu = $\frac{98 \times 10}{80}$ (1) = 12.25μm (1)		3		3	2	2
		(ii)		Eye piece unit has different values for each calibration (1)		1		1		1
		(iii)		Haversian canal in LS at centre, lacunae in parallel strips (1)		1		1		
	(b)	(i)		Protein synthesis (1) For release / secretion from cell (1)		2		2		
		(ii)		Arteries and veins in Haversian canals (1) Haversian canals connected by Volkmanns canals (1) Capillaries in canaliculi (1)	3			3		
	(c)			Lack of Vitamin D and calcium from milk (1) not enough time exposed to sun for vitamin D production(1) Vitamin D needed for absorption of calcium from gut (1)			3	3		

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
9	*(d)*	(i)		Any **3** (x1) from: Released from sarcoplasmic reticulum binds to troponin (1) Troponin changes shape (1) Moves tropomyosin away from binding sites on actin (1) Cross bridges can then form (1)	3			3		
		(ii)		Energy from ATP needed to break cross bridge (1) No respiration in muscle after death therefore ATP not synthesised (1)		2		2		
	(e)			Person B extreme endurance athlete + high numbers mitochondria / large amount myoglobin + aerobic, +fatigue slowly (1) Person C world class sprinter + anaerobic + quick contraction + strong force (1)			2	2		
				Option B Question total	**6**	**9**	**5**	**20**	**2**	**3**

<table>
<tr><th colspan="4" rowspan="2">Question</th><th rowspan="2">Marking details</th><th colspan="6">Marks Available</th></tr>
<tr><th>AO1</th><th>AO2</th><th>AO3</th><th>Total</th><th>Maths</th><th>Prac</th></tr>
<tr><td colspan="4">Option C</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>10</td><td>(a)</td><td>(i)</td><td></td><td>Produces an image/diagnosis faster (1)</td><td>1</td><td></td><td></td><td>1</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>May cause a stroke resulting in paralysis (1)
In the left side of the body (1)</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
<tr><td colspan="11"></td></tr>
<tr><td></td><td>(b)</td><td colspan="3"></td><td>
<table>
<tr><th>Activity</th><th>Letter</th><th>Part</th></tr>
<tr><td>Regulating
core body temperature.</td><td>B</td><td>Thalamus (1)</td></tr>
<tr><td>Recognising a face in a picture.</td><td>A</td><td>Cerebral
hemisphere (1)</td></tr>
<tr><td>Drinking from a glass.</td><td>D</td><td>Cerebellum (1)</td></tr>
<tr><td>Regulating the CO_2
concentration of the blood.</td><td>C</td><td>Medulla
oblongata (1)</td></tr>
</table>
</td><td></td><td>4</td><td></td><td>4</td><td></td><td></td></tr>
<tr><td colspan="11"></td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td></td><td>Increased (rate of) respiration - more carbon dioxide(1)
Chemoreceptors in the carotid/aortic sinus detect a decrease in blood pH (1)</td><td>2</td><td></td><td></td><td>2</td><td></td><td></td></tr>
<tr><td></td><td></td><td>(ii)</td><td></td><td>More nerve impulses are sent to the SAN (1)
Along the sympathetic neurone resulting in the release of more noradrenalin (1)
SAN discharges at a higher frequency (1)</td><td>3</td><td></td><td></td><td>3</td><td></td><td></td></tr>
<tr><td colspan="11"></td></tr>
<tr><td></td><td>(d)</td><td>(i)</td><td></td><td>t= 12.57(2)
1 mark for correct substitutions
$t = \frac{|15.8 - 16.5|}{\sqrt{\left(\frac{2.05^2}{20} + \frac{2.61^2}{20}\right)}}$</td><td></td><td>2</td><td></td><td>2</td><td></td><td></td></tr>
</table>

Question				Marking details	Marks Available					
					AO1	AO2	AO3	Total	Maths	Prac
10	*(d)*	(ii)		t value is greater than the critical value at 0.001/ there is a chance of below 0.001 that the differences in the mean turning rate are due to chance + Reject null hypothesis (1)			1	1		
		(iii)		Kinesis + movement of the woodlice away from the stimulus(1)		1		1		
		(iv)		In dry conditions the woodlice turns more frequently to try to leave the area of dry conditions and find moist conditions (1) Because in dry conditions the gills of the woodlice would dry out (1)			2	2		1
		(v)		Use dry filter paper in the bottom of the petri dish in dry conditions/ use a range of humidity (1) Longer time period (1)			2	2		2
				Option C Question total	**6**	**9**	**5**	**20**	**2**	**3**

COMPONENT 3: REQUIREMENTS FOR LIFE

SUMMARY OF MARKS ALLOCATED TO ASSESSMENT OBJECTIVES

Q	AO1	AO2	AO3	TOTAL MARK	MATHS	PRAC
1	**5**	**1**	**7**	**13**	**0**	**4**
2	**9**	**7**	**0**	**16**	**3**	**0**
3	**1**	**6**	**3**	**10**	**2**	**2**
4	**6**	**4**	**4**	**14**	**0**	**0**
5	**1**	**5**	**4**	**10**	**3**	**4**
6	**0**	**8**	**0**	**8**	**0**	**0**
7	**2**	**5**	**2**	**9**	**0**	**0**
SECTION A TOTAL	**24**	**36**	**20**	**80**	**8**	**10**
SECTION B TOTAL	**6**	**9**	**5**	**20**	**2**	**3**
OVERALL TOTAL	**30**	**45**	**25**	**100**	**10**	**13**