1. Excretion and secretion are two processes that take place in the body of a mammal.

Complete the table below to compare the processes of excretion and secretion.

	excretion	secretion
one difference		
one example of a product		
one similarity		

[Total 3 marks]

2. Aerobic respiration may be summarised by the following equation:

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$$

Although carbon dioxide and water are products of aerobic respiration, the equation is an over-simplification of the process.

State **and** explain **one** way in which this equation is an over-simplification.

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.....

[Total 2 marks]

3. Over 2.3 million people in the UK are known to have diabetes. It is also estimated that a further 0.5 million people have the condition but are unaware of it.

(i) Explain how **Type 1** diabetes is caused.

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[2]

(ii) Describe **three** factors that increase a person's risk of developing **Type 2** diabetes.

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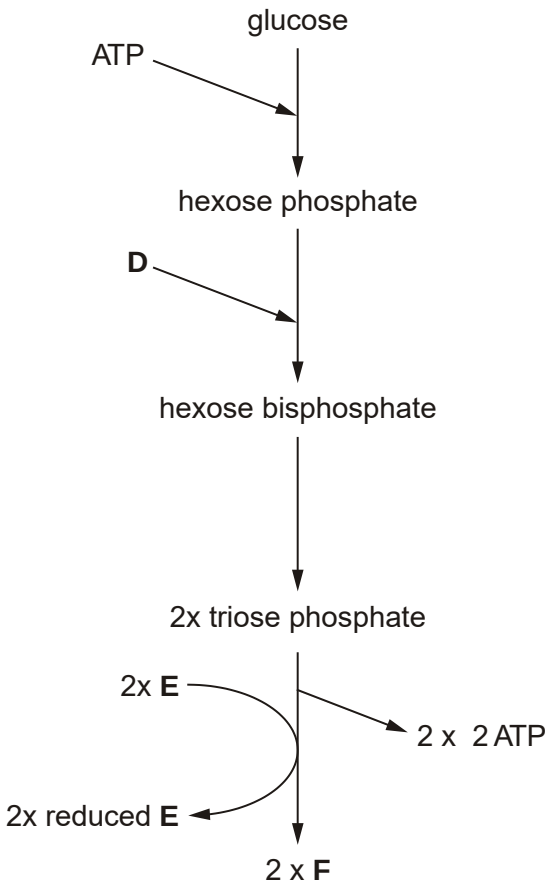
[3]

[Total 5 marks]

4. The figure below represents the first stage of respiration.



(i) Name the stage represented by the figure above.

.....

[1]

(ii) State precisely where in the cell this stage takes place.

.....

[1]

(iii) Identify the compounds **D**, **E** and **F**.

D .....

E .....

F .....

[3]

[Total 5 marks]

5. In **anaerobic** conditions, compound **F** does not proceed to the link reaction.

Describe the fate of compound **F** during anaerobic respiration in an animal cell **and** explain the importance of this reaction.

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[Total 5 marks]

6. Fig. 1 is a drawing of a common seal, *Phoca vitulina*, an aquatic mammal.

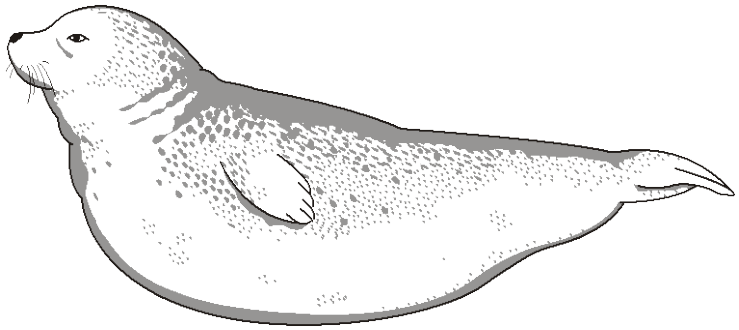

Fig. 1

The seal comes to the surface of the water to obtain air and it can then stay underwater for over 20 minutes.

Fig. 2 shows a seal at the surface of the water and Fig. 3 shows the same animal then submerging again.

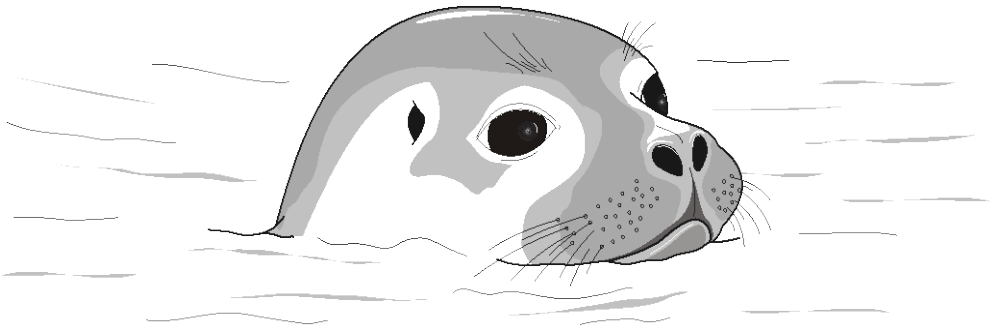

Fig. 2

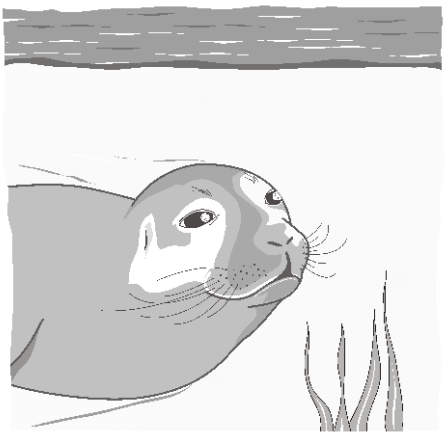

Fig. 3

Suggest how the seal is adapted to respire for such a long time underwater.

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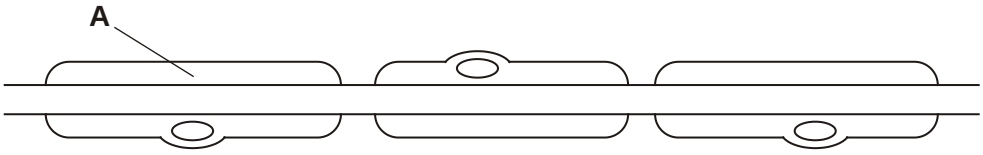
[Total 3 marks]

7. (a) The figure below represents part of the axon of a neurone.



Describe the **structure** of the feature labelled **A**.

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.....

[2]

The table below shows details of the diameter and speed of conduction of impulse along the neurones of different animal taxa.

type of neurone	axon diameter (μm)	speed of conduction ($m\ s^{-1}$)	animal taxon
myelinated	4	25	mammal
myelinated	10	30	amphibian
myelinated	14	35	amphibian
unmyelinated	15	3	mammal
unmyelinated	1000	30	mollusc

(b) Using **only the data in the table above**, describe the effect of each of the following on the speed of conduction:

(i) myelination,

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[2]

(ii) axon diameter.

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[2]

(c) The speed of conduction of a nerve impulse is also affected by temperature.

(i) Suggest why an increase in temperature results in an increase in the speed of conduction.

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[1]

(ii) As the temperature continues to increase, it reaches a point at which the conduction of the impulse ceases. Suggest why.

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[1]

[Total 8 marks]

8. Outline the events following the arrival of an action potential at the synaptic knob until the acetylcholine has been released into the synapse.

In your answer, you should use appropriate technical terms, spelt correctly.

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[Total 4 marks]

9. Blood enters the kidneys through the renal arteries and the human kidneys process 1200 cm^3 of blood every minute. This 1200 cm^3 of blood contains 700 cm^3 of plasma. As this blood passes through a glomerulus, 125 cm^3 of fluid passes into the renal tubule.

(i) Name the process by which the fluid passes from the glomerulus into the renal tubule.

.....

[1]

(ii) Calculate the percentage of plasma that passes into the renal tubule.

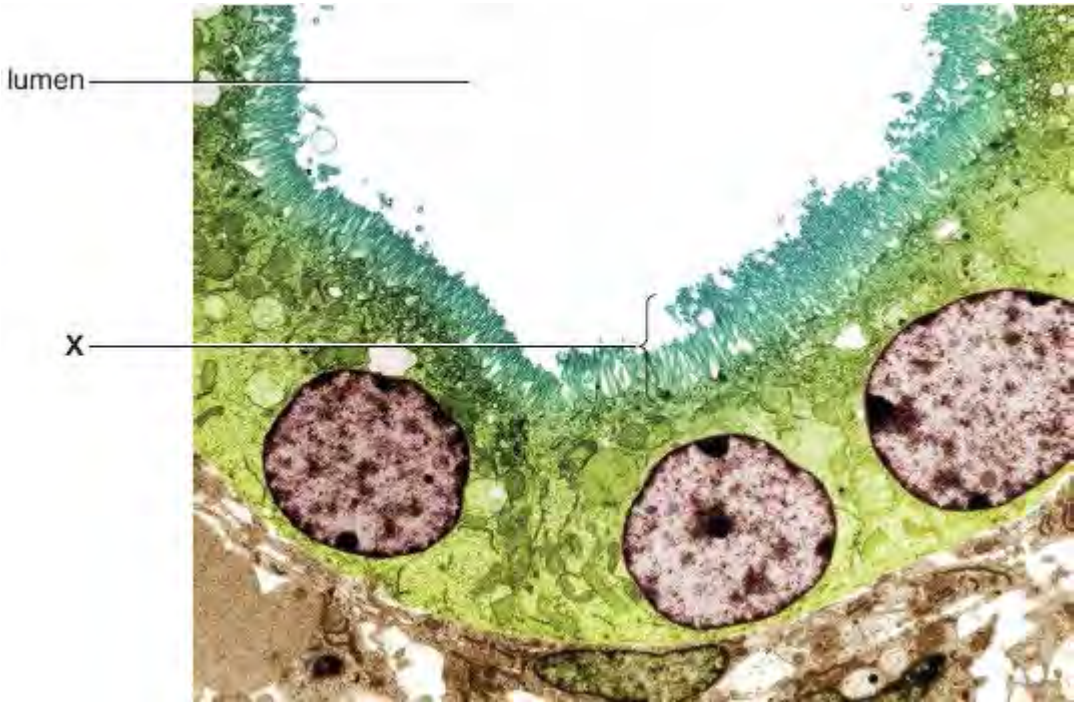
Show your working and **give your answer to one decimal place**.

Answer = ... %

[2]

[Total 3 marks]

10. The figure below is an electronmicrograph of a transverse section of part of a proximal convoluted tubule.



(i) Name the tissue that lines the proximal convoluted tubule.

.....

[1]

(ii) Name the structures indicated by **X**.

.....

[1]

(iii) The table below shows the approximate concentration of some of the substances in the blood plasma, the glomerular filtrate and the urine leaving the collecting duct.

substance	concentration in blood plasma ($g\ dm^{-3}$)	concentration in glomerular filtrate ($g\ dm^{-3}$)	concentration in urine leaving collecting duct ($g\ dm^{-3}$)
amino acids	0.50	0.50	0.00
glucose	1.00	1.00	0.00
inorganic ions	7.30	7.30	15.60
nitrogenous waste (not including urea)	0.03	0.03	0.28
protein	80.00	0.00	0.00
urea	0.30	0.30	21.00

Some of the changes observed between the glomerular filtrate and the urine are as a result of activity in the proximal convoluted tubule.

With reference to the table above, explain how these observed changes in concentration are brought about by the **proximal convoluted tubule**.

In your answer, you should use appropriate technical terms, spelt correctly.

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[4]

[Total 6 marks]

11. When the kidneys cease functioning or fail to work effectively, renal dialysis may be necessary.

Fig. 1 outlines the procedure of haemodialysis, a type of renal dialysis.

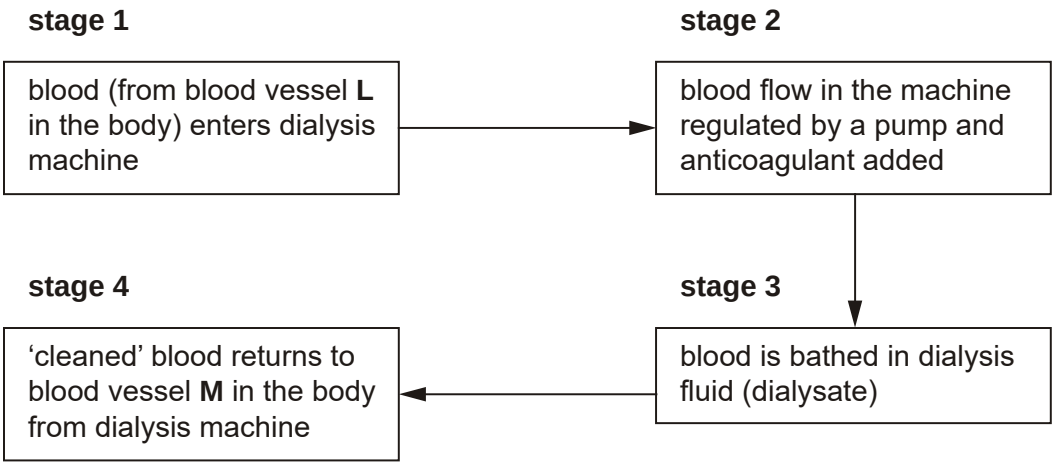

Fig. 1

Fig. 2 shows further detail of how **stage 3** is achieved.

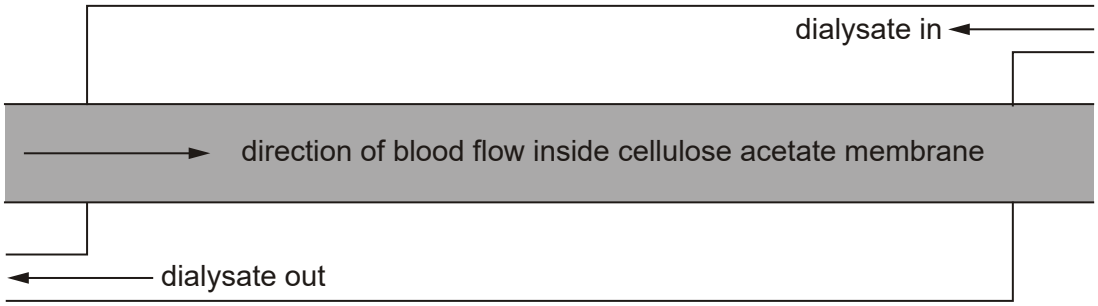

Fig. 2

(i) State the **types** of blood vessel represented by **L** and **M** in Fig. 1.

L .....

M .....

[1]

(ii) Suggest why it is necessary to add an anticoagulant to the blood in **stage 2**.

.....

.....

[1]

(iii) Suggest why **no** anticoagulant is added to the blood towards the end of a dialysis session.

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[1]

(iv) State the process by which molecules and ions, **other than water**, will move from the blood into the dialysate.

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[1]

(v) Suggest why the direction of flow of the blood and the dialysate is as shown in Fig. 2.

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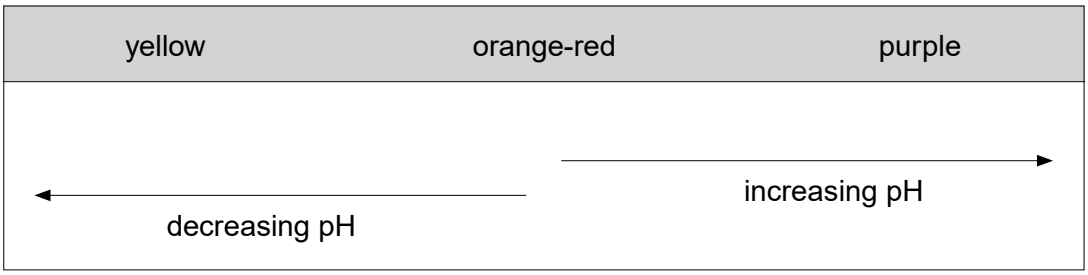
[1]

[Total 5 marks]

12. An experiment was carried out into the effect of different wavelengths of light on the rate of photosynthesis.

Four sealed test-tubes were set up, each containing three leaf discs from the same plant suspended above hydrogencarbonate indicator solution. This solution changes colour at different pH values, as shown below.



At the start of the experiment, the contents of all four tubes were orange-red.

Each tube was illuminated by a lamp with a coloured filter in front of it. The tubes were illuminated for the same length of time. The colour changes were noted and the results are shown in the table below.

colour of filter	final colour of hydrogencarbonate indicator
colourless	purple
blue	purple
green	orange-yellow
red	red

A fifth tube was set up in the same way as the other tubes. This tube was then covered in black paper before being illuminated for the same length of time. The final colour of the hydrogencarbonate indicator in this tube was yellow.

(i) State the purpose of the tube covered with black paper.

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[1]

(ii) State **two** precautions that need to be taken when designing and carrying out this experiment in order to obtain results from which valid conclusions can be drawn. Explain the need for each precaution.

precaution 1 .....

explanation .....

.....

precaution 2 .....

explanation .....

.....

[2]

(iii) Name the pigment at the reaction centre of photosystems I and II.

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[1]

(iv) Explain the change observed in the tube exposed to green light.

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[3]

[Total 7 marks]

13. In order to maximise production, market gardeners often grow plants in glasshouses. Light conditions can be controlled along with a number of other factors.

How can factors **other than light conditions** be controlled to increase the rate of photosynthesis and maximise production?

In your answer you should explain why the rate of photosynthesis is affected by the controlled factors you have discussed.

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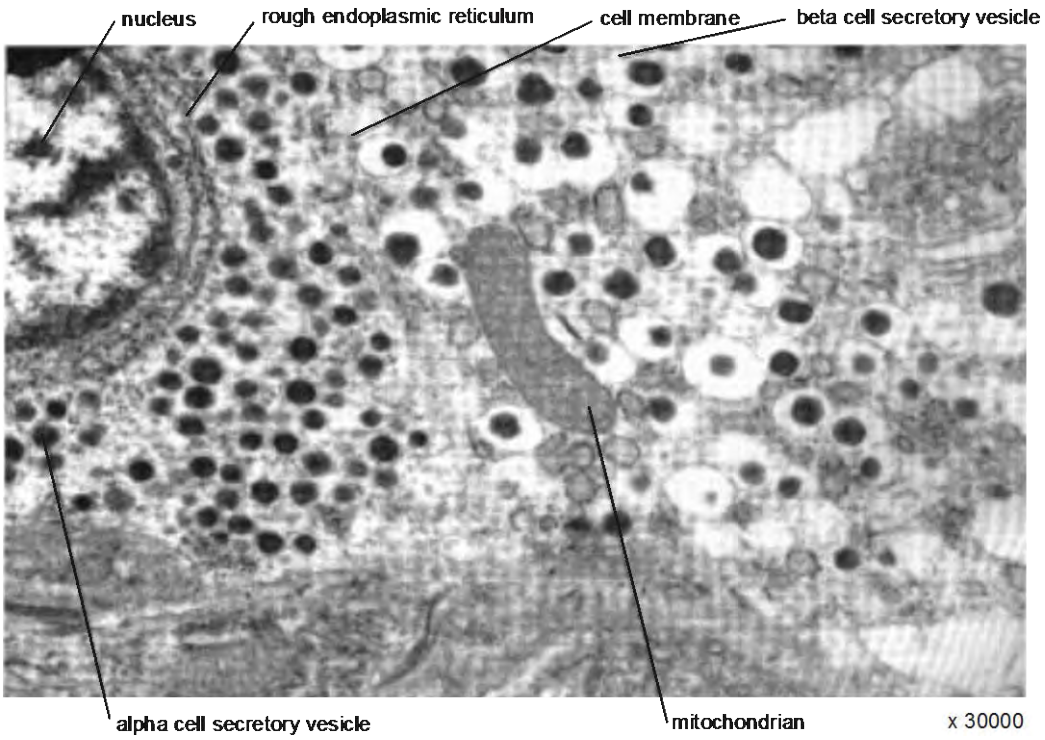
[Total 4 marks]

14. The pancreas contains endocrine tissue. The figure below shows an electronmicrograph of a section of pancreatic endocrine tissue.



(a) Name the endocrine tissue shown in the figure.

.....

[1]

(b) Name the hormone present in the secretory vesicles of alpha cells.

.....

[1]

(c) During vigorous exercise, the blood glucose concentration falls.

Describe the changes that take place to make sure that the blood glucose concentration does not fall to a dangerous level.

In your answer, you should use appropriate technical terms, spelled correctly.

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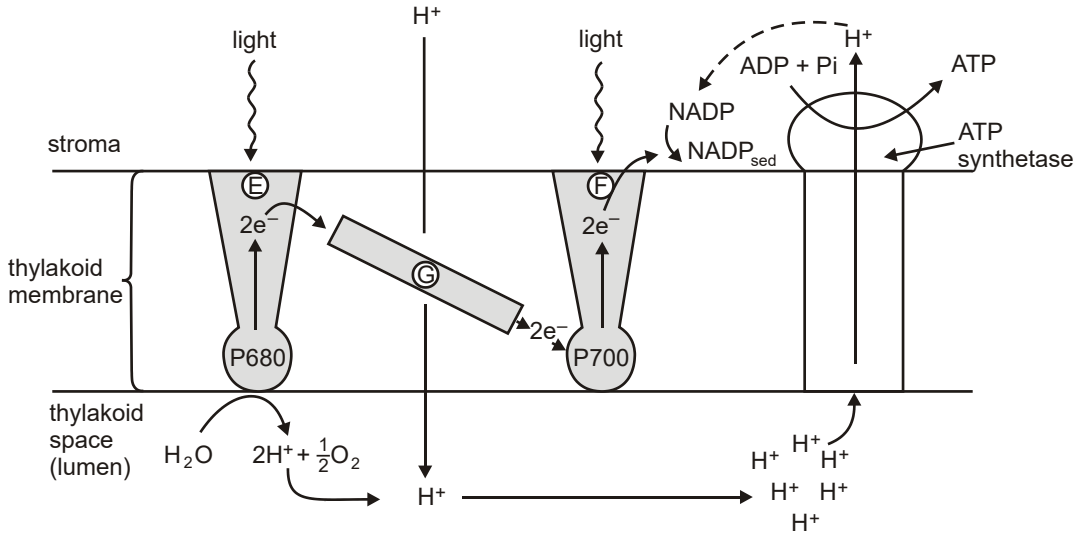
[6]

[Total 8 marks]

15. The light-dependent stage of photosynthesis takes place on thylakoid membranes in chloroplasts. These membranes surround the thylakoid space (lumen) and are arranged into stacks known as grana. Below is a diagram showing the arrangement of photosystems in the thylakoid membrane, and summarising the processes that take place there.



(a) (i) Name the pigment represented by P680 and P700.

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[1]

(ii) Name the **type** of molecule represented by **G**.

.....

[1]

(b) Explain, **using the information in the diagram**, why the pH of the thylakoid space (lumen) is lower than that of the stroma **and** what significance this has for ATP production.

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[4]

[Total 6 marks]

16. Herbicides (weedkillers) interfere with electron transport by accepting electrons.

Suggest how this causes plants to die.

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[Total 3 marks]

17. Define the term *excretion*.

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[Total 2 marks]

18. The table below shows the mass of different substances excreted by a volunteer during two 24 hour periods. During the first 24 hour period, the volunteer was fed a protein-deficient diet; during the second 24 hour period, the volunteer was fed a protein-rich diet. All other variables were kept constant.

	mass of substance excreted / g	
substance excreted	protein-deficient diet	protein-rich diet
urea	2.20	14.70
uric acid	0.09	0.18
ammonium ions	0.04	0.49
creatinine	0.60	0.58

(i) Calculate the percentage increase in urea excreted when the volunteer switched from a protein-deficient to a protein-rich diet. Show your working.

Answer = ...%

[2]

(ii) Describe how excess protein is converted into urea.

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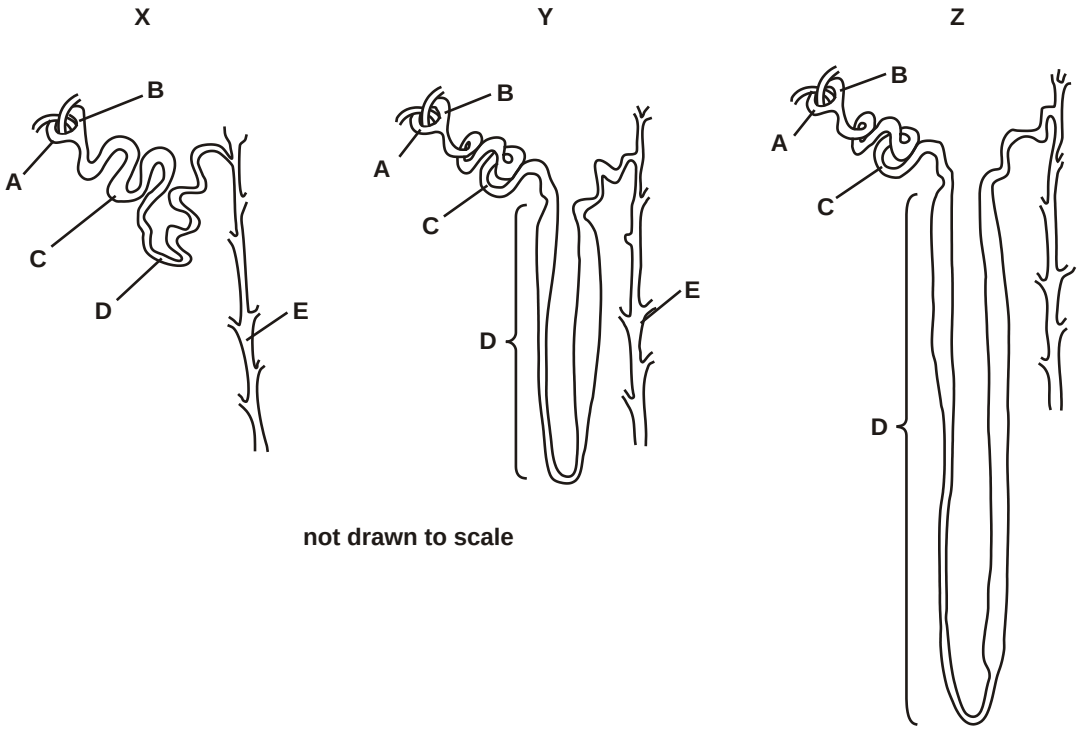
[3]

[Total 5 marks]

19. The figure below shows diagrams of nephrons from the kidneys of three different mammals, **X**, **Y** and **Z**.



not drawn to scale

	X	Y	Z
name of mammal	beaver	house mouse	desert living gerbil
water potential of urine	high	low	very low

Explain the relationship between the length of the section D in the nephrons and the water potential of the urine each mammal produces.

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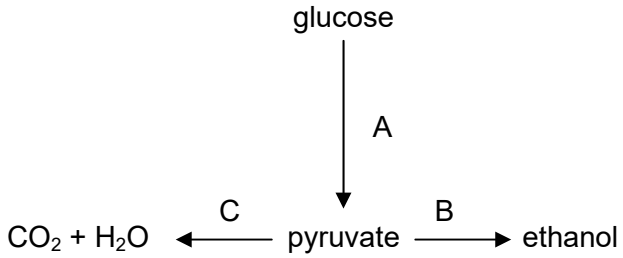
[Total 3 marks]

20. The figure below shows the relationship between various metabolic processes in yeast



(i) Identify the three metabolic processes.

A .....

B .....

C .....

[3]

(ii) State the letter of the pathway in which acetyl coenzyme A is required.

.....

[1]

(iii) State the letter of the pathway in which ATP is utilised.

.....

[1]

[Total 5 marks]

21. In an investigation yeast cells were homogenised (broken up) and the resulting homogenate centrifuged. Portions containing only nuclei, ribosomes, mitochondria and cytosol (residual cytoplasm) were each isolated. Samples of each portion, and of the complete homogenate, were incubated in four ways:

1 With glucose.

2 With pyruvate.

3 With glucose and cyanide.

4 With pyruvate and cyanide.

Cyanide inhibits carriers in the electron transport chain, such as cytochromes.

After incubation, the presence or absence of carbon dioxide and lactate in each sample was determined.

The results are summarised in the table below.

✗ = absent ✓ = present ✓ = a little

	samples of homogenate									
	complete		nuclei only		ribosomes only		mitochondria only		cytosol	
	carbon dioxide	ethanol	carbon dioxide	ethanol	carbon dioxide	ethanol	carbon dioxide	ethanol	carbon dioxide	ethanol
1 glucose	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓
2 pyruvate	✓	✓	✗	✗	✗	✗	✓	✗	✓	✓
3 glucose and cyanide	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓
4 pyruvate and cyanide	✓	✓	✗	✗	✗	✗	✗	✗	✓	✓

(i) Explain why more carbon dioxide is produced when the complete homogenate is incubated with just glucose or pyruvate than when cyanide is present.

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[3]

(ii) Explain why carbon dioxide is produced when mitochondria are incubated with pyruvate but **not** when incubated with glucose.

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[3]

(iii) Explain why, in the presence of cyanide, ethanol production can still occur.

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[3]

[Total 9 marks]

22. (a) Fig. 1 is a diagram of a neurone.

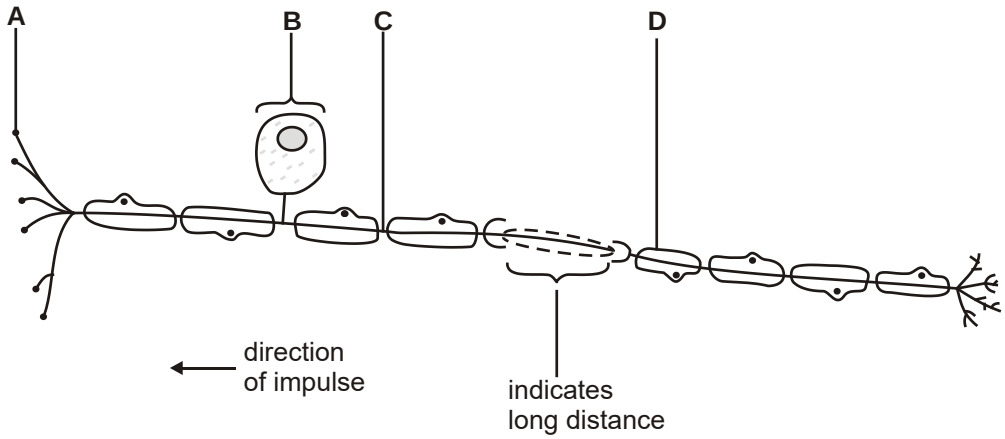

Fig. 1

Name the structures **A** and **B**.

A .....

B .....

[2]

Fig. 2 shows a recording of the potential difference across the membrane of an axon as an action potential is transmitted.

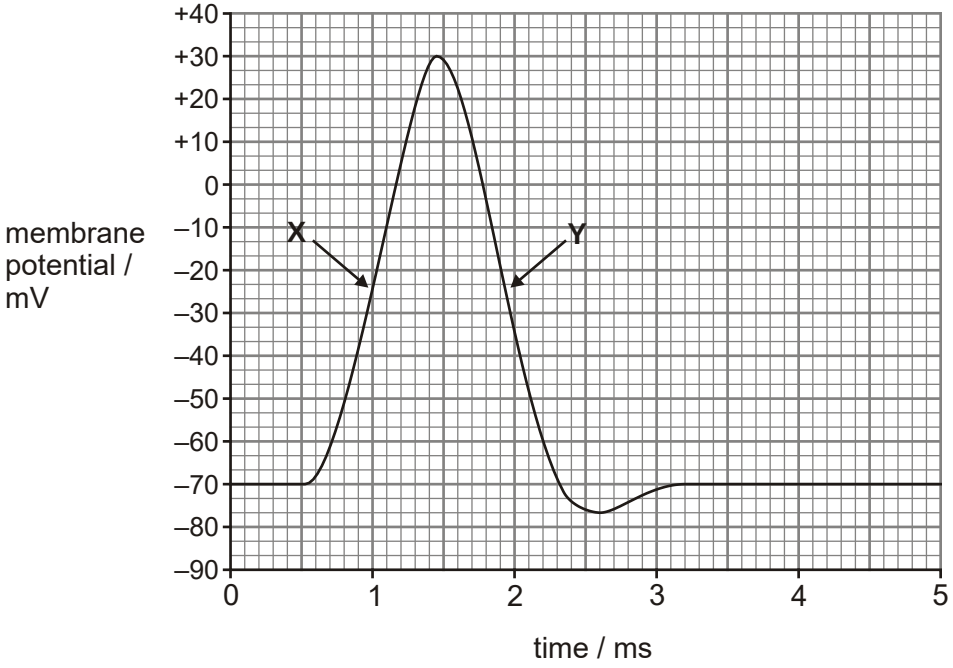

Fig. 2

(b) Describe the events taking place in the neurone during stages **X** and **Y**.

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[4]

The table below shows how the speed of conduction of an action potential varies with the diameter of myelinated and non-myelinated axons in different organisms.

organism	type of axon	axon diameter / μm	speed of conduction / ms^{-1}
crab	non-myelinated	30	5
squid	non-myelinated	500	25
cat	myelinated	20	100
frog	myelinated	16	32

(c) Describe the effect of myelination on the **rate** of conduction of an action potential **and** explain how this effect is achieved.

In your answer, you should use appropriate technical terms, spelled correctly.

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[5]

[Total 11 marks]

23. (i) State what is meant by the term respiratory substrate.

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[1]

The equation below shows aerobic respiration of compound **A**.

$$C_{55}H_{100}O_6 + 77O_2 \rightarrow 55CO_2 + 50H_2O$$

compound **A**

The respiratory quotient (RQ) is defined as:

$$RQ = \frac{\text{volume of } CO_2 \text{ released}}{\text{volume of } O_2 \text{ absorbed}}$$

(ii) Calculate the RQ for this reaction. Show your working.

Answer = ...

[2]

(iii) Compound **A** is a fat.

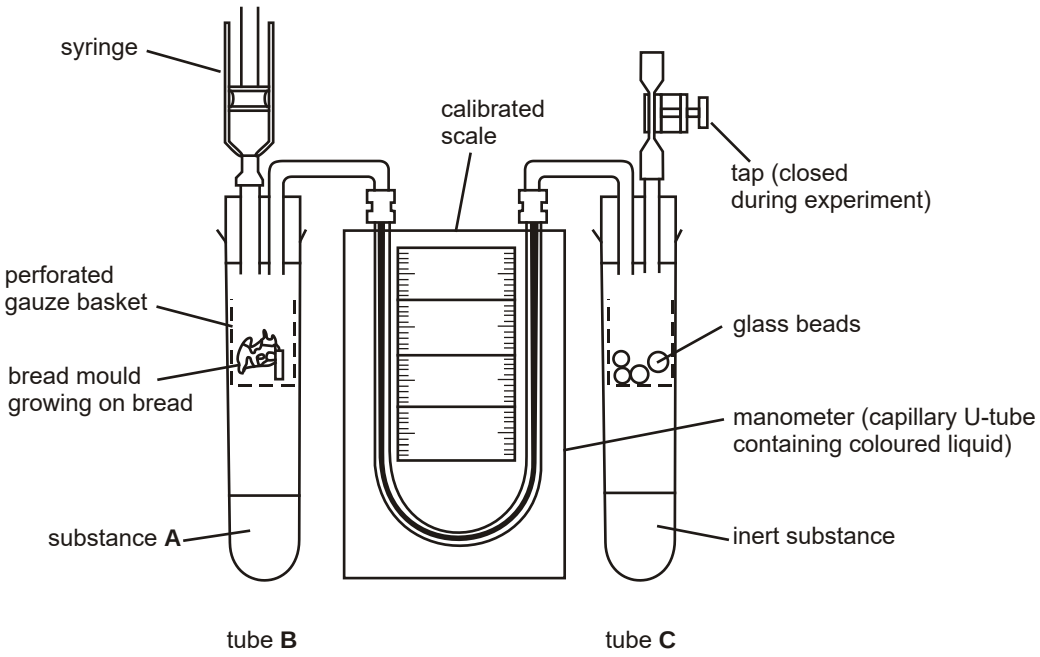
Suggest what the RQ of a carbohydrate, such as glucose, might be.

.....

[1]

[Total 4 marks]

24. Below is a diagram of a respirometer. A respirometer can be used to measure the oxygen uptake of living organisms.



Describe how the apparatus shown in the diagram could be used to determine the **rate** of respiration of the bread mould, *Mucor*.

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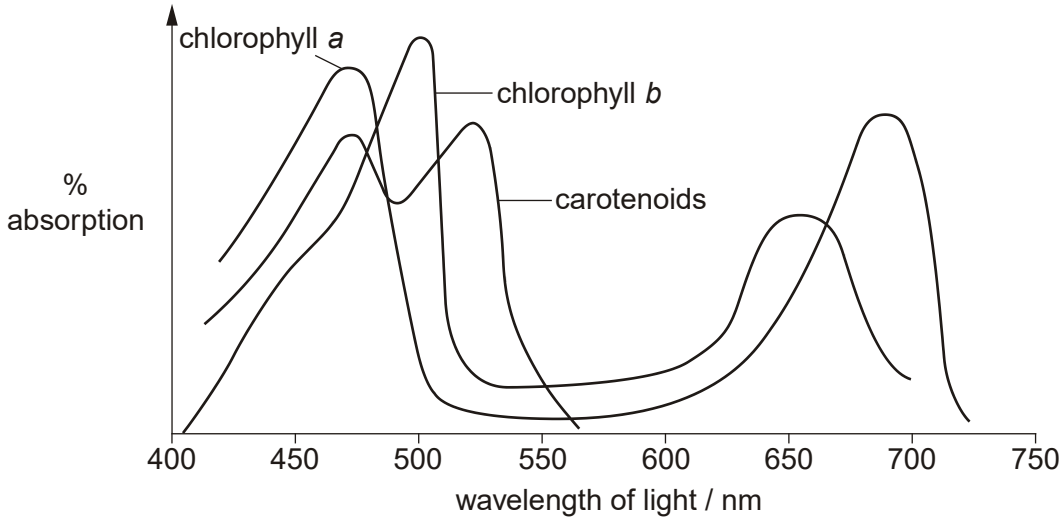
[Total 4 marks]

25. The figure below shows the absorption spectra for three different photosynthetic pigments.



(i) Explain what is meant by the term *photosynthetic pigment*.

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[3]

(ii) Using the figure above, describe the pattern shown by chlorophyll *a*.

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[2]

[Total 5 marks]

26. Photosynthetic pigments fall into two categories: primary pigments and accessory pigments.

Explain the difference between primary and accessory pigments.

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[Total: 2 marks]

27. In this question, one mark is available for the quality of the use and organisation of scientific terms.

Photosynthetic pigments are arranged in light-harvesting clusters called photosystems.

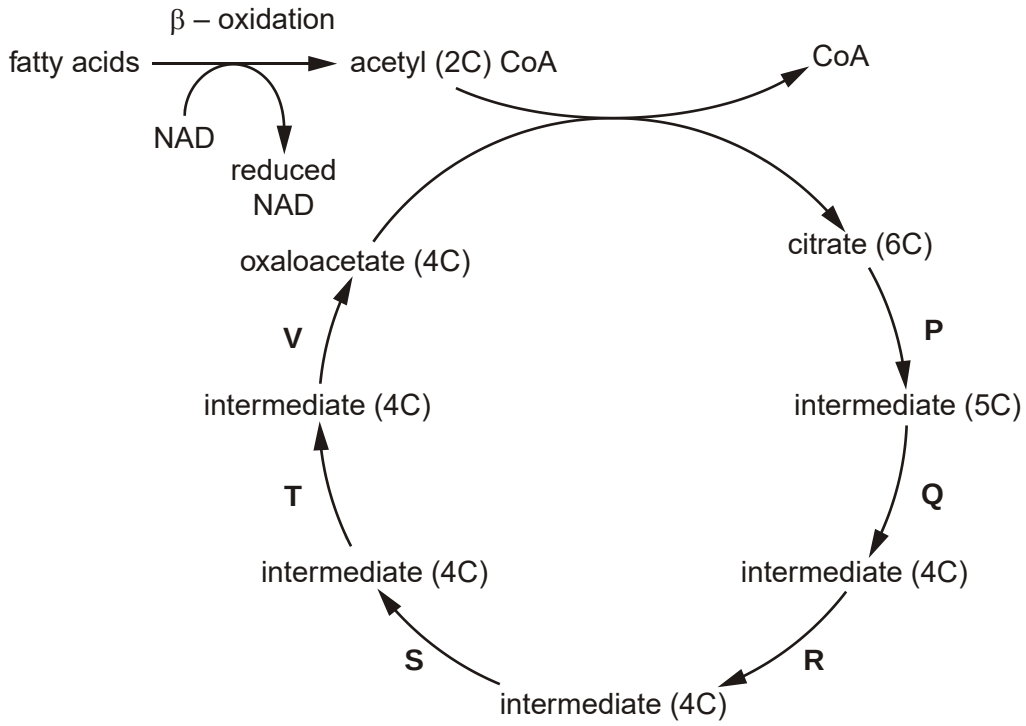
Describe how the light energy absorbed by these photosystems is converted into chemical energy in the **light dependent stage** of photosynthesis.

[8]

Quality of Written Communication [1]

[Total: 9 marks]

28. Below is an outline diagram of the Krebs cycle. A two carbon acetyl group enters the cycle by combining with a molecule of oxaloacetate. A molecule of citrate is formed which is decarboxylated and dehydrogenated to regenerate the oxaloacetate.



(a) (i) Explain the following terms:

decarboxylation .....

dehydrogenation .....

[2]

(ii) State the **letters** of the individual steps in the cycle where decarboxylation is taking place.

.....

[1]

(b) ATP is made directly by substrate level phosphorylation in the Krebs cycle.

State the number of ATP molecules that are made directly **per 'turn'** of the cycle.

.....

[1]

(c) The diagram also shows that fatty acids can be converted into acetyl CoA units by a process known as β-oxidation. Both this process and the Krebs cycle require NAD. The Krebs cycle also requires FAD. The hydrogen atoms released in β-oxidation and the breakdown of acetyl CoA in the Krebs cycle reduce the NAD and FAD molecules.

(i) State the number of reduced NAD and reduced FAD molecules that are formed in the Krebs cycle from **one** molecule of acetyl CoA.

reduced NAD .....

reduced FAD .....

[2]

(ii) State where the reduced NAD and reduced FAD molecules are reoxidised **and** describe what happens to the hydrogen atoms.

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[4]

(d) The liver is responsible for producing enzymes which detoxify alcohol by breaking it down into smaller units. This breakdown by enzymes uses NAD. This means that other reactions that use NAD are less likely to take place. The build up of fats in the liver is one of the first signs of liver damage due to excessive alcohol intake.

Using the information in the diagram above, explain why the build up of fats occurs in the liver of an individual who consumes large amounts of alcohol.

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[3]

[Total: 13 marks]

29. Fig.1 represents **some** of the changes that occur across the membrane of the axon. Three protein complexes are shown to be present in the membrane:

- sodium channels
- potassium channels
- sodium-potassium pumps.

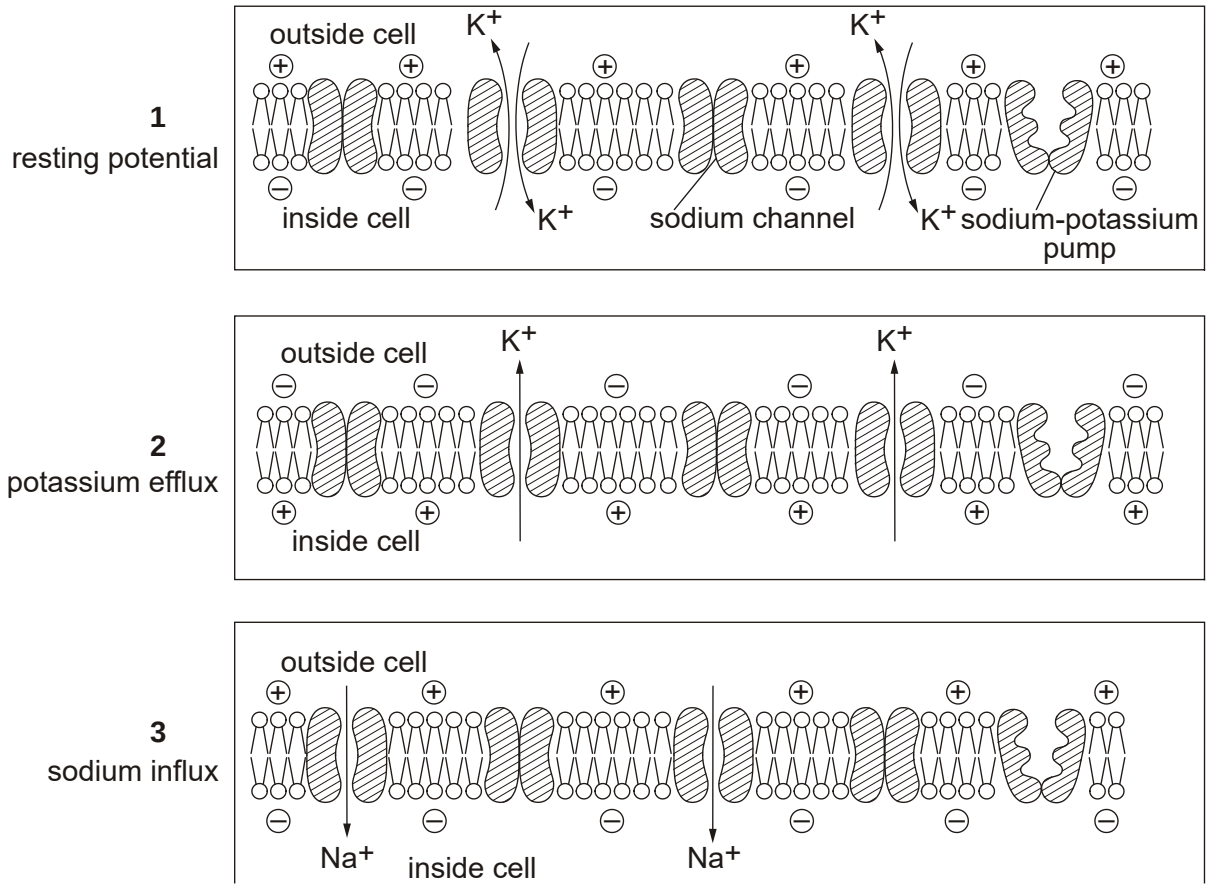

Fig. 1

Fig. 2 shows the change of membrane potential associated with an action potential.

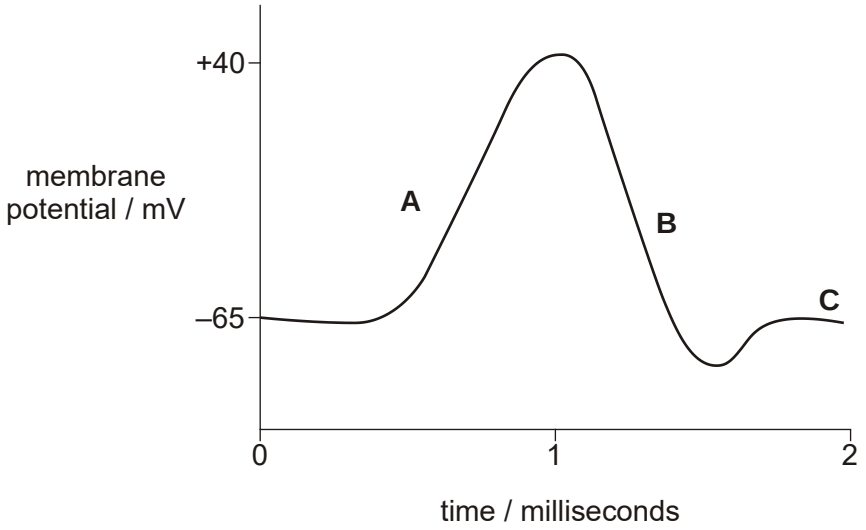

Fig. 2

(i) State which of the three diagrams of the axon membrane in Fig. 1 match up to the phases labelled in Fig. 2. Write your answers in the table below.

phase	number
A	
B	
C	

[1]

(ii) With reference to Fig. 1, explain the changes in membrane potential in Fig. 2.

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[5]

[Total 6 marks]

30. In this question, one mark is available for the quality of spelling, punctuation and grammar.

In order to transfer information from one point to another in the nervous system, it is necessary that action potentials be transmitted along axons. In humans, the rate of transmission is 0.5 m s^{-1} in a nonmyelinated neurone, increasing to 100 m s^{-1} in a myelinated neurone.

Explain how action potentials are transmitted along a nonmyelinated neurone **and** describe which parts of this process are different in myelinated neurones.

No credit will be given for reference to events at the synapse.

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[7]

Quality of Written Communication [1]

[Total 8 marks]

31. Many seeds contain food stores, including starch, proteins and lipids. A fully developed seed of *H. annuus* contains between 40% and 50% of unsaturated fatty acids, including oleic acid and linoleic acid. These fatty acids can be used as respiratory substrates for the production of ATP.

(i) Explain why seeds need ATP.

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[2]

(ii) Explain the **advantages** of storing lipid for use as a respiratory substrate in seeds.

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[2]

[Total 4 marks]

32. After chasing prey, a cheetah breathes rapidly (pants) for half an hour before it can run again.

Explain why panting is necessary.

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[Total 4 marks]

33. The hypothalamus produces anti-diuretic hormone (ADH) that is released by the posterior pituitary gland into the blood.

Brain damage can occur due to trauma to the head. Traumatic brain injury (TBI) can cause many and varied malfunctions of parts of the brain. One condition that can arise from TBI is a lack of ADH in the blood.

Suggest the symptoms you would expect in a person with a lack of ADH.

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[Total: 3 marks]

34. Hummingbirds are very small. Typically their mass is between 3 and 5 g. They are able to hover at a fixed point in the air by beating their wings very rapidly. The rufous hummingbird, *Selasphorus rufus*, is a migratory species. It breeds in Canada and Alaska in the summer, migrates south to Mexico in the autumn and returns to high latitudes in spring after completing its annual moult (loss of feathers, which are then re-grown).

(a) Suggest why the rufous hummingbird has a very high requirement for energy.

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[4]

In order to save energy, rufous hummingbirds can enter a state called torpor during the night. This is when their metabolic rate and body temperature both drop to a very low level. An investigation into how rufous hummingbirds use, save and store energy at different times of year was carried out. Key findings of the study are given in Figs. 1, 2 and 3 below.

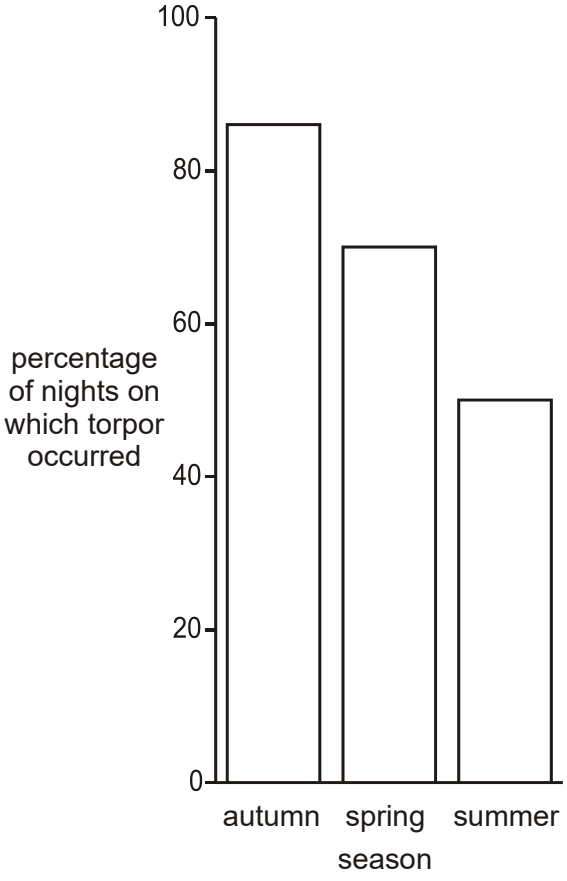

Fig. 1

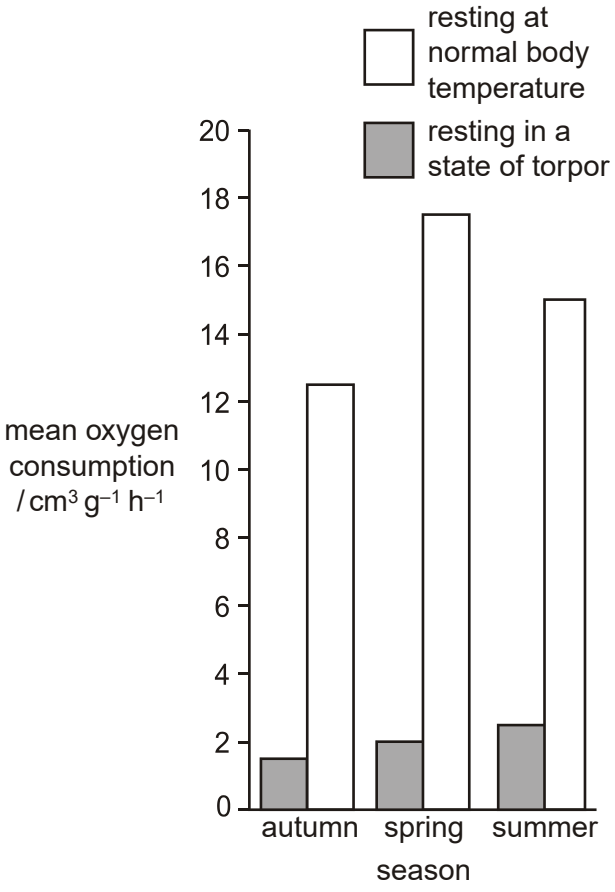

Fig. 2

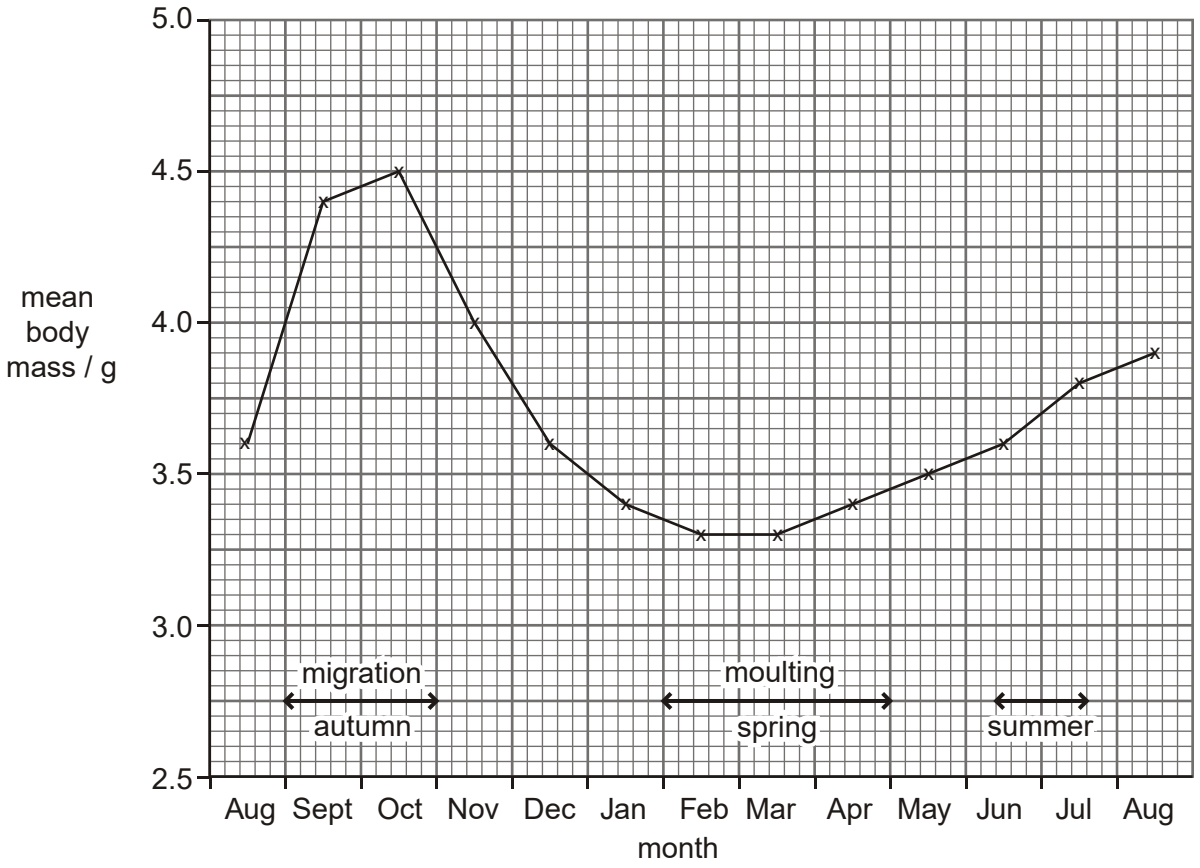

Fig. 3

- Fig. 1 shows how use of torpor by the birds varies according to season.
- Fig. 2 compares the oxygen consumption of birds resting at normal body temperature with that of birds resting in a state of torpor.
- Fig. 3 shows how body mass of the birds changes over the course of a year.

(b) Use Figs. 1, 2 and 3 to describe and explain the results for the birds in the September-October (autumn) period.

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[4]

(c) Suggest how the low body mass of the birds in spring may be related to enhancing the birds' survival during the moulting period, when the feathers are lost and regrown.

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[2]

(d) It is suggested that **smaller** birds, which have a larger surface area to volume ratio when compared to larger birds, require **more** oxygen per gram of their body mass.

Discuss whether the data given in Figs. 3.1, 3.2 and 3.3 support this hypothesis.

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[3]

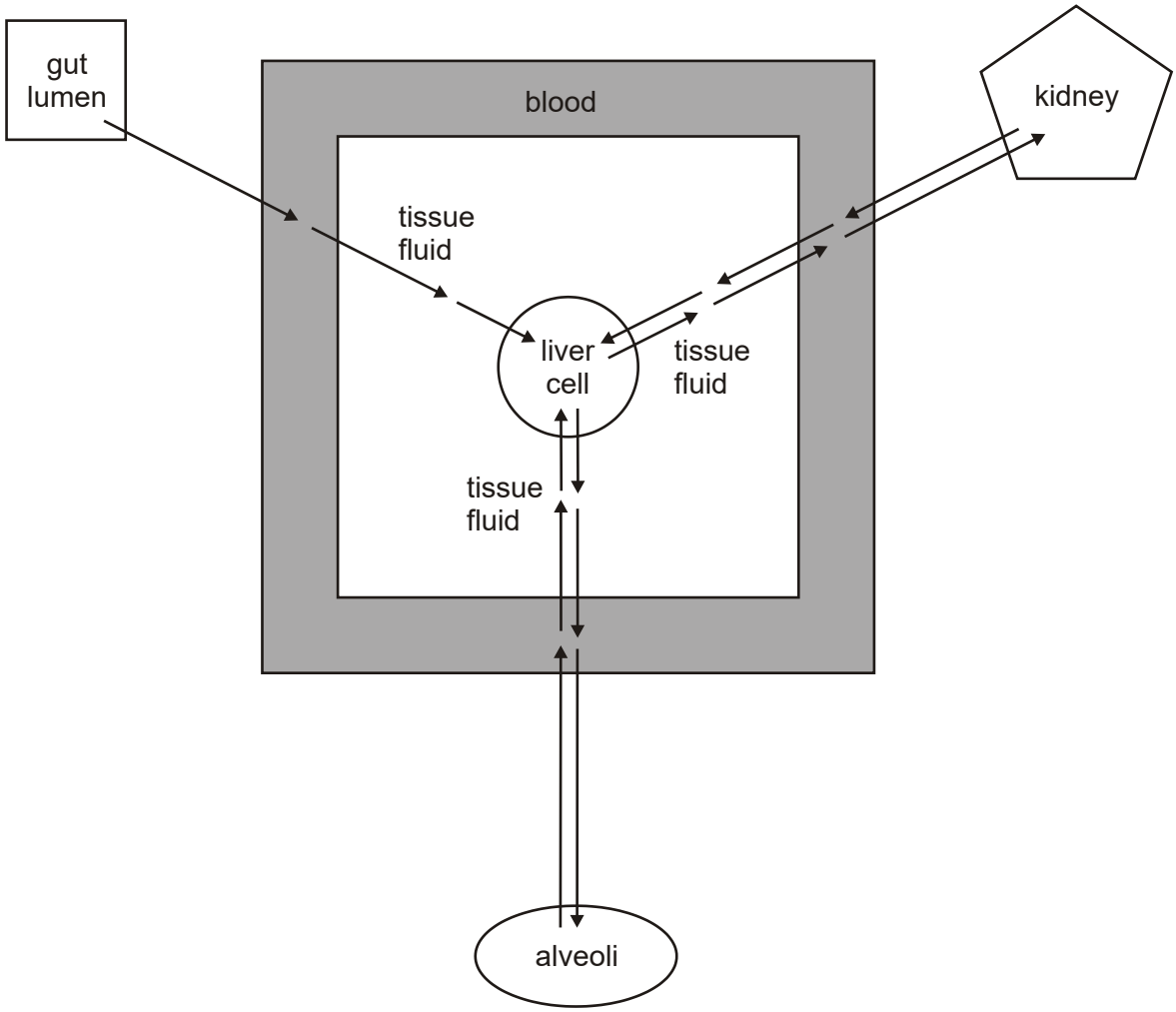
[Total: 13 marks]

35. In this question, one mark is available for the quality of spelling, punctuation and grammar.

Some of the key physiological areas of a mammal are the:

- blood
- alveoli
- gut
- kidney.

The figure below shows some of the pathways where biochemicals are exchanged between these areas, the tissue fluid (extracellular fluid) and a liver cell.



Use the diagram to describe how these exchange pathways function to maintain relatively constant concentrations of biochemicals **in the liver cell**.

[7]

Quality of Written Communication [1]

[Total 8 marks]

36. The bulb of the onion plant, *Allium cepa*, is widely used in food preparation. It has a strong smell and flavour when raw due to sulphur-containing chemicals that are released when an onion is cut. The precursor of these flavour molecules is in the cytoplasm of the onion bulb cells. This precursor is acted on by an enzyme called alliinase, which is stored in the cell vacuole. Alliinase breaks the precursor molecule into two volatile flavour molecules, which enter the air, and into a third product, pyruvate, which remains dissolved in the onion tissue.

(a) Explain why the strong smell of an onion is only released when the onion is cut or damaged.

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[3]

The strength of an onion's flavour can be estimated by measuring the concentration of pyruvate in cut onions. The table below shows the pyruvate concentration of fresh onions, onions from the previous season that have overwintered, and onions of a new variety called Supasweet.

type of onion	pyruvate concentration / μmol g^{-1}
fresh	7
overwintered	4
Supasweet	3

(b) Suggest why the concentration of pyruvate is lower in an overwintered onion.

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[2]

(c) The mild Supasweet onions were produced by a process of artificial selection. The growing environment also needs to be manipulated to decrease the concentration of flavour molecules.

(i) Explain how artificial selection was used to produce the mild Supasweet onions.

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[3]

(ii) Use the information given about the biochemistry of the onion smell and flavour to suggest an environmental change that would enable a milder onion to be grown.

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[1]

(d) It is claimed that strong onions, with a more pungent smell and flavour, are able to resist rotting over the winter better than milder onions.

Describe how you would test this claim.

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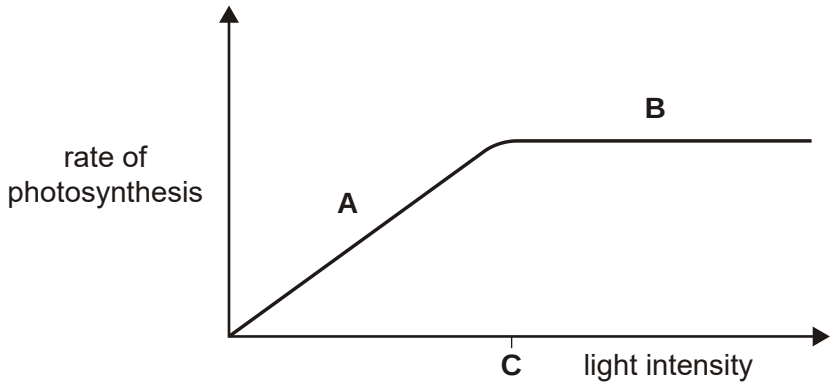
[3]

[Total: 12 marks]

37. The rate of photosynthesis is affected by a number of environmental factors. The figure below shows the effect of light intensity on the rate of photosynthesis.



(i) State the limiting factor in region **A** of the graph.

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[1]

(ii) Explain why there is no further increase in the rate of photosynthesis beyond point **C**.

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[2]

[Total 3 marks]

38. For many plants living in temperate regions the optimum temperature for photosynthesis is approximately 25°C.

Explain why the rate of photosynthesis decreases at temperatures above 25°C.

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[Total 4 marks]

39. Plants that live in the Arctic have a relatively short growing season in which the light intensity is always relatively low. Many species growing in these conditions have a high level of anthocyanin pigments in their leaves. The combined effect of these red pigments with the green chlorophyll makes the leaves appear dark purple or black.

Suggest why this adaptation is useful in increasing photosynthetic rates.

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[Total: 3 marks]

40. All organisms require energy in order to remain alive. Plants use solar energy to combine water and carbon dioxide into complex organic molecules. Both plants and animals then break down organic molecules in respiration. Energy released in this process is used in the formation of ATP.

Describe the structure of ATP.

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[Total: 4 marks]

41. In this question, one mark is available for the quality of use and organisation of scientific terms.

There are a number of organic molecules in cells whose role is to transfer hydrogen atoms from one compound to another. Examples include NAD, FAD and NADP.

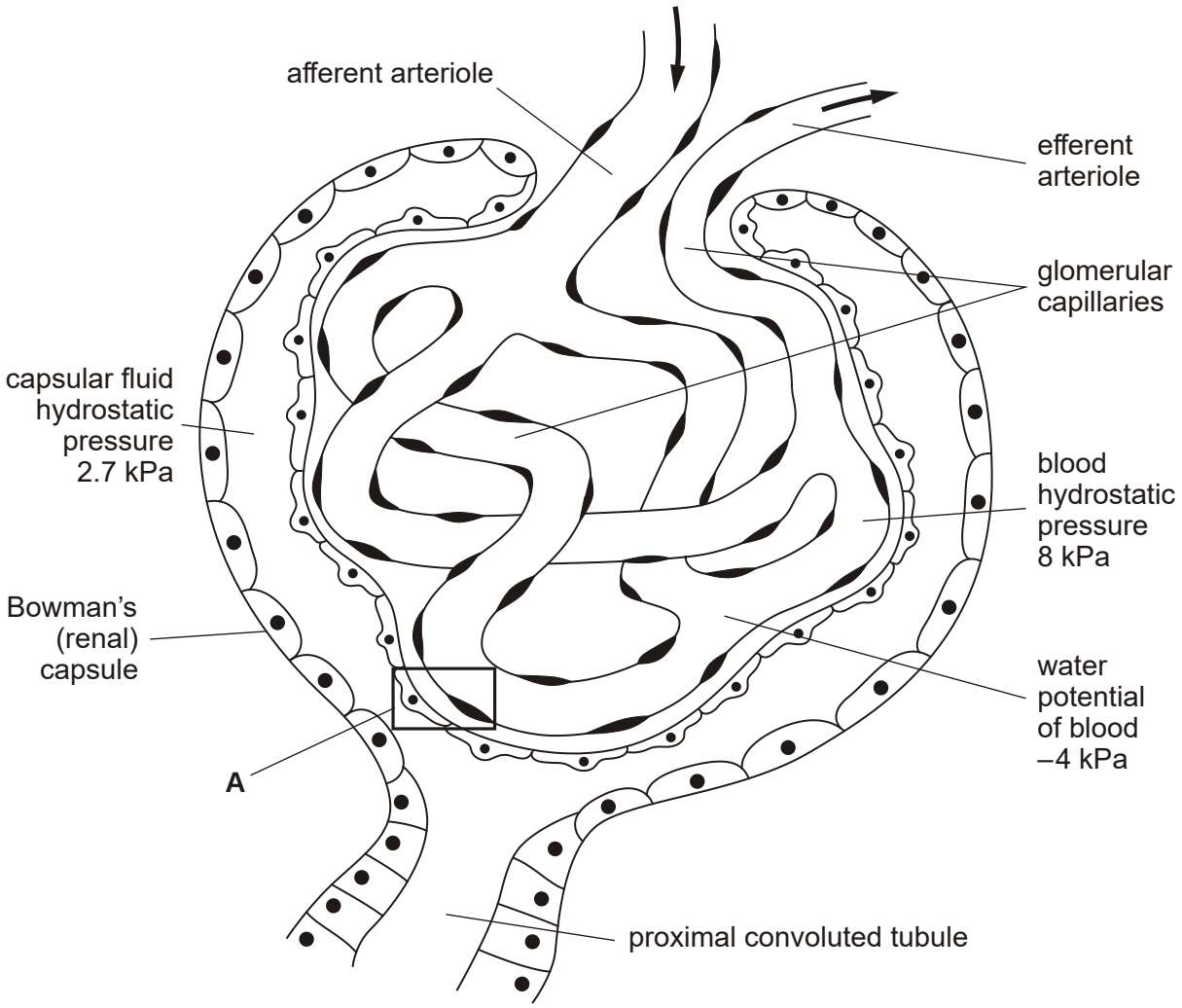
NAD, FAD and NADP are important molecules in plant cells. Describe, in detail, the role of these molecules within a **palisade mesophyll cell**.

[7]

Quality of Written Communication [1]

[Total 8 marks]

42. The first stage in the formation of urine is glomerular filtration. This results in the production of glomerular filtrate in the Bowman's (renal) capsules. Below is a diagram that shows the structures and forces involved in the filtration process.



(a) The normal blood hydrostatic pressure in other capillaries is 3.3 kPa.

(i) Using the diagram, explain why the blood pressure in the glomerular capillaries is considerably higher than in other capillaries.

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[2]

(ii) Using the data given in the diagram, calculate the effective filtration pressure.

Answer = ...kPa

[2]

(b) The presence of protein molecules in the urine of an individual is a sign of kidney disease or kidney damage.

(i) Explain why it is unusual for protein molecules to appear in the urine.

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[2]

(ii) Explain why protein in the urine is often a symptom of chronic high blood pressure.

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[2]

(c) A complex barrier exists between the blood plasma in the glomerular capillaries and the fluid in the renal capsule.

Describe in detail the structure of the region labelled **A** on the diagram above.

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[4]

(d) Coffee contains the drug caffeine, which inhibits the release of ADH.

Describe **and** explain the effect of drinking coffee on the volume **and** concentration of urine produced.

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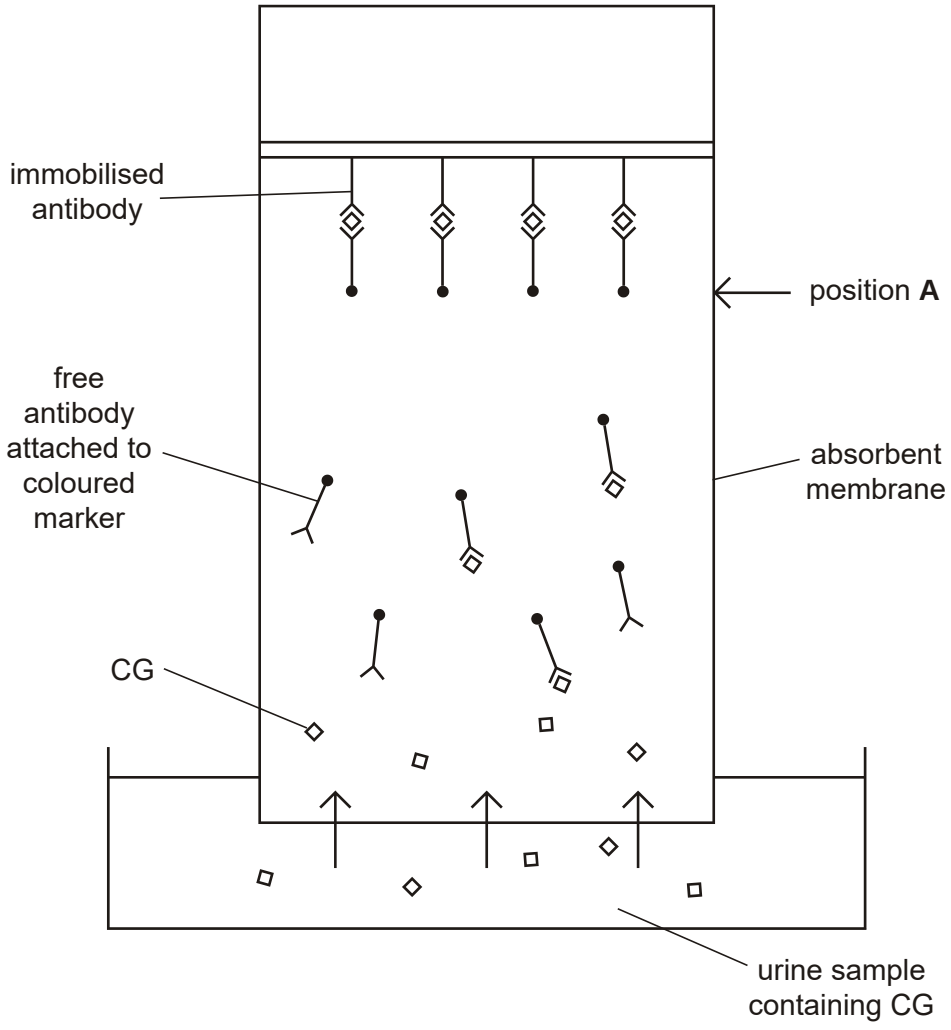
[4]

[Total: 16 marks]

43. The presence of CG in the urine can be used in pregnancy testing. Information about a pregnancy testing kit is given below and in the figure.

- An absorbent membrane is dipped into urine.
- The membrane contains free antibodies that are specific to CG.
- The free antibodies are attached to coloured markers.
- There is a line of immobilised antibodies above position **A**.
- A positive result is shown by a coloured line at position **A**.



Using information from the figure, explain how the presence of CG in the urine results in a coloured line at position **A**.

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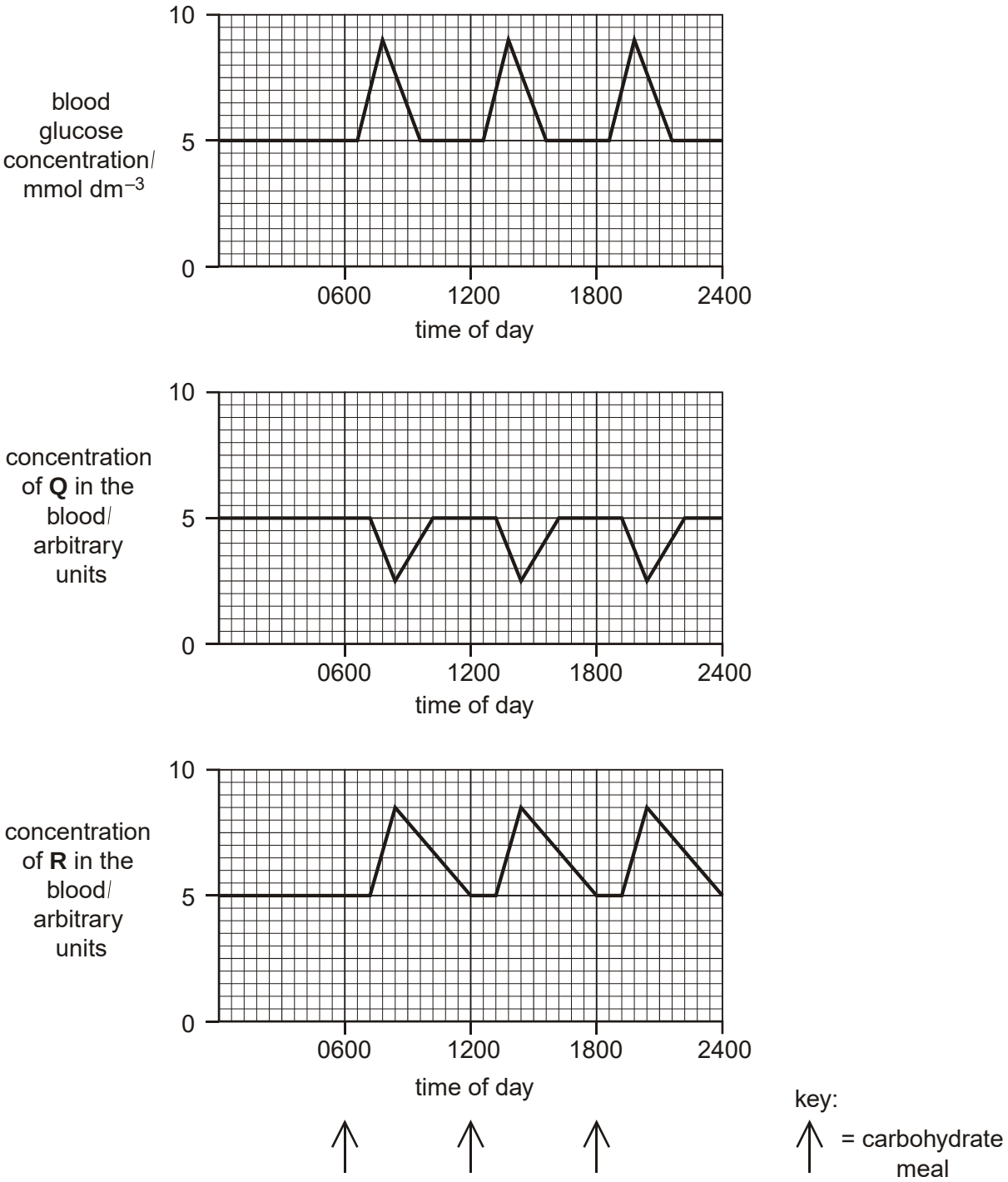
[Total 4 marks]

44. An investigation was carried out into the effect of consuming meals rich in carbohydrate on two hormones in the blood.

The figure below shows the relationship between glucose concentration in the blood and the concentrations in the blood of the two hormones, **Q** and **R**.



Name hormones **Q** and **R**.

Q .....

R .....

[Total 2 marks]

45. The liver is responsible for many aspects of protein metabolism, such as transamination and deamination.

What is transamination **and** why is it necessary?

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[Total 2 marks]

46. In this question, one mark is available for the quality of the use and organisation of scientific terms.

The medulla oblongata controls breathing, heart rate and blood pressure.

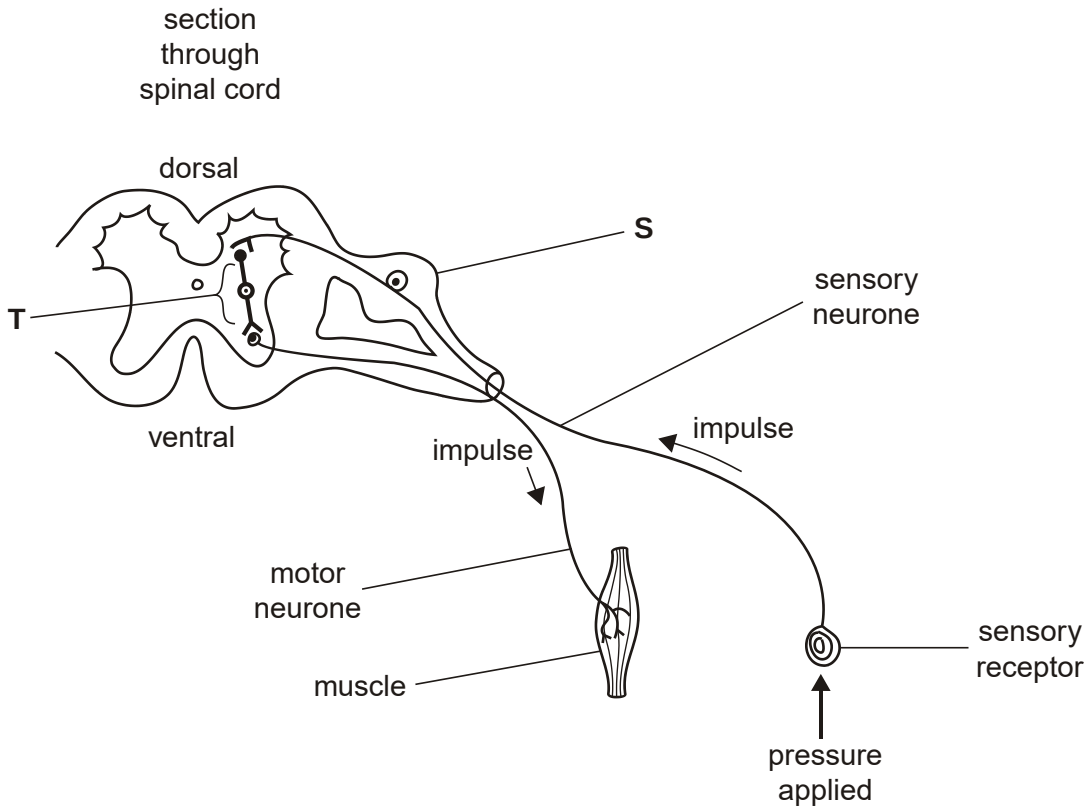
Describe how the medulla oblongata responds to an increase in carbon dioxide concentration in the blood during exercise. Explain how this response leads to a decrease in the concentration of carbon dioxide in the blood.

[7]

Quality of Written Communication [1]

[Total 8 marks]

47. The figure below shows a simplified diagram of a mammalian reflex arc.



(i) Name **S** and **T**.

S .....

T .....

[2]

(ii) Explain why the withdrawal of a hand, which has been subjected to pressure, is an example of a reflex action.

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[3]

(iii) In this reflex, when pressure is applied to the receptor, impulses are generated in the sensory neurone.

Outline what happens in the membrane of the sensory receptor in response to pressure.

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[3]

(iv) Explain why, in the reflex arc shown in the figure above, impulses can only travel in the direction shown.

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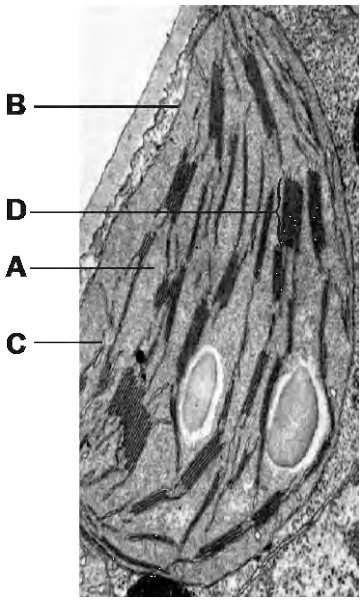
[2]

[Total: 10 marks]

48. The figure below is an electronmicrograph of a chloroplast.



Identify the structures labelled **A** to **D**.

A .....

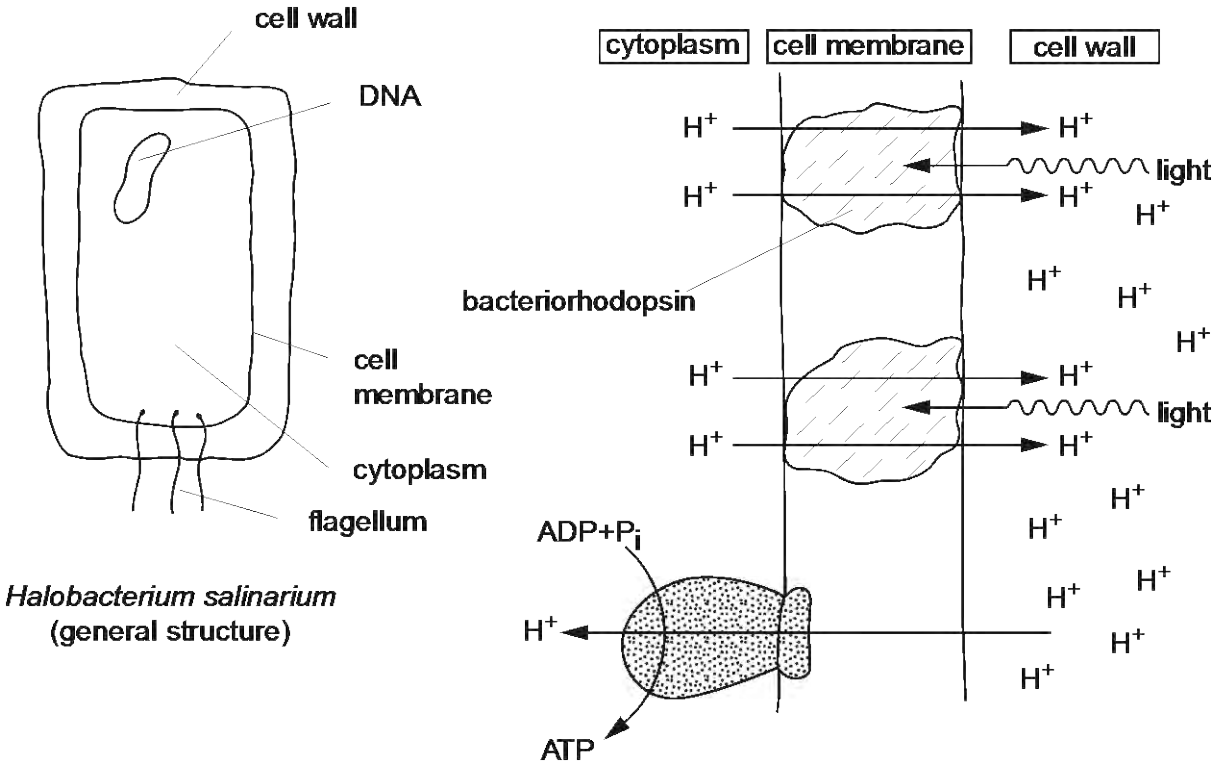
B .....

C .....

D .....

[Total 4 marks]

49. Some bacteria can survive in anaerobic conditions by utilising light energy to drive the production of ATP in the cell membrane. In such conditions, *Halobacterium salinarium* makes the protein bacteriorhodopsin. When this protein absorbs light, protons (H^+) are pumped outwards across the cell membrane. This is shown in the figure below.



Using the information above together with your knowledge of photophosphorylation and oxidative phosphorylation, explain how *H. salinarium* makes ATP in anaerobic conditions.

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[Total 4 marks]

50. Define the term *excretion.*

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[Total 2 marks]

51. Name **two** groups of macromolecules that are broken down to form nitrogenous excretory products in mammals.

1 .....

2 .....

[Total 2 marks]

52. The table below shows the amount of different substances excreted by a volunteer during two 24 hour periods. During the first 24 hour period the volunteer was fed a protein-deficient diet; during the second 24 hour period the volunteer was fed a protein-rich diet. All other variables were kept constant.

substance excreted	protein-deficient diet	protein-rich diet
urea / g	2.20	14.70
uric acid / g	0.09	0.18
ammonium ions / g	0.04	0.49
creatinine / g	0.60	0.58

(i) Calculate the percentage increase in urea excreted when the volunteer switched from a protein-deficient to a protein-rich diet. Show your working.

Answer = ……..%

[2]

(ii) Explain why more urea is produced when eating a protein-rich diet.

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[2]

[Total 4 marks]

53. Explain why the main nitrogenous excretory product of humans is urea rather than ammonia.

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[Total 2 marks]

54. The following table shows the concentrations of glucose and urea in the renal artery and renal vein.

	concentration / mg 100 cm^{-3} plasma	
	renal artery	renal vein
glucose	90	80
urea	30	16

Both substances are present in lower concentration in the renal vein than in the renal artery. However, urea appears in the urine of a healthy individual but glucose does not.

Explain why this is so.

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[Total 5 marks]

55. In both plants and animals, chemical messengers help to transfer information from one part of the organism to another to achieve coordination.

The table below lists some of these chemicals together with their functions.

Complete the table.

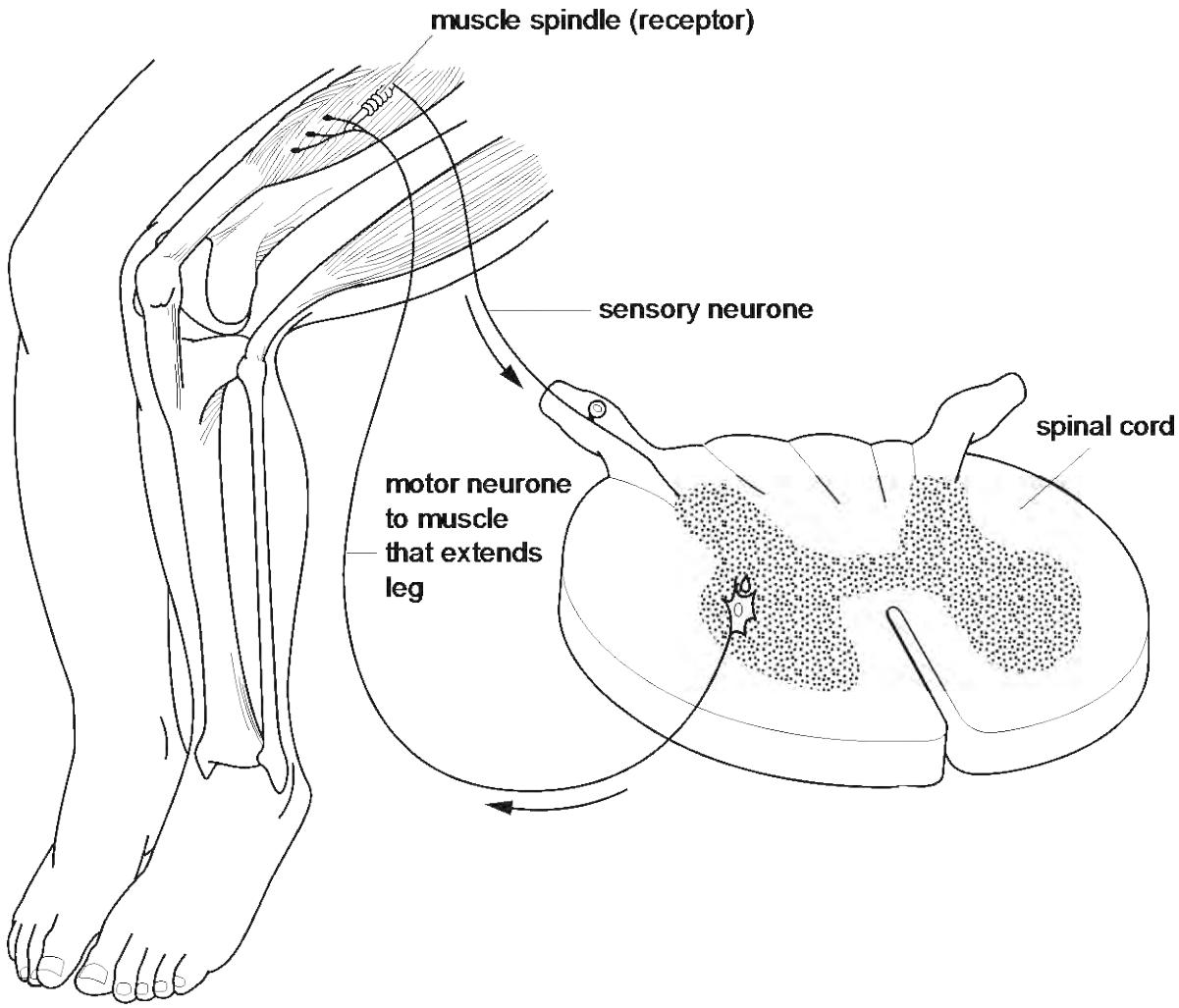
name of chemical messenger	function
.....	controls water permeability of collecting ducts in kidney
insulin	....
glucagon	....
.....	stimulates stomatal closure during water stress
.....	controls apical dominance

[Total 5 marks]

56. In this question, one mark is available for the quality of spelling, punctuation and grammar.

Mammals also rely on nerves to transfer information in the form of electrical impulses.

Using the information shown in the figure below, outline how impulses are transmitted from receptor to effector.

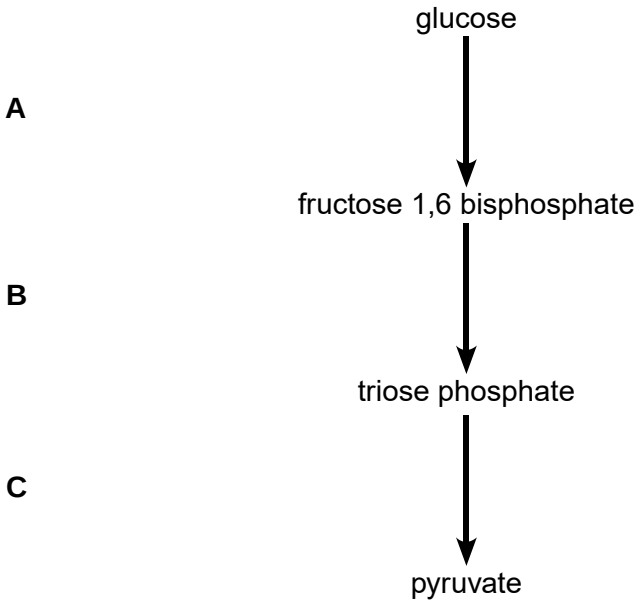


[8]

Quality of Written Communication [1]

[Total 9 marks]

57. The following figure is an outline of the glycolytic pathway.



With reference to the figure, state the letter, **A**, **B** or **C**, in the glycolytic pathway where the following processes occur.

phosphorylation using ATP ……..

dehydrogenation ……..

formation of ATP ……..

splitting of a hexose ……..

[Total 4 marks]

58. Explain why, under **aerobic** conditions, lipids have a greater energy value per unit mass than carbohydrates or proteins.

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[Total 2 marks]

59. Many chemicals will 'uncouple' oxidation from phosphorylation. In this situation, the energy released by oxidation of food materials is converted into heat instead of being used to form ATP. One such compound is dinitrophenol, which was used in munition factories for the manufacture of explosives during the First World War. People working in these factories were exposed to high levels of dinitrophenol.

Suggest **and** explain why people working in munitions factories during the First World War became very thin regardless of how much they ate.

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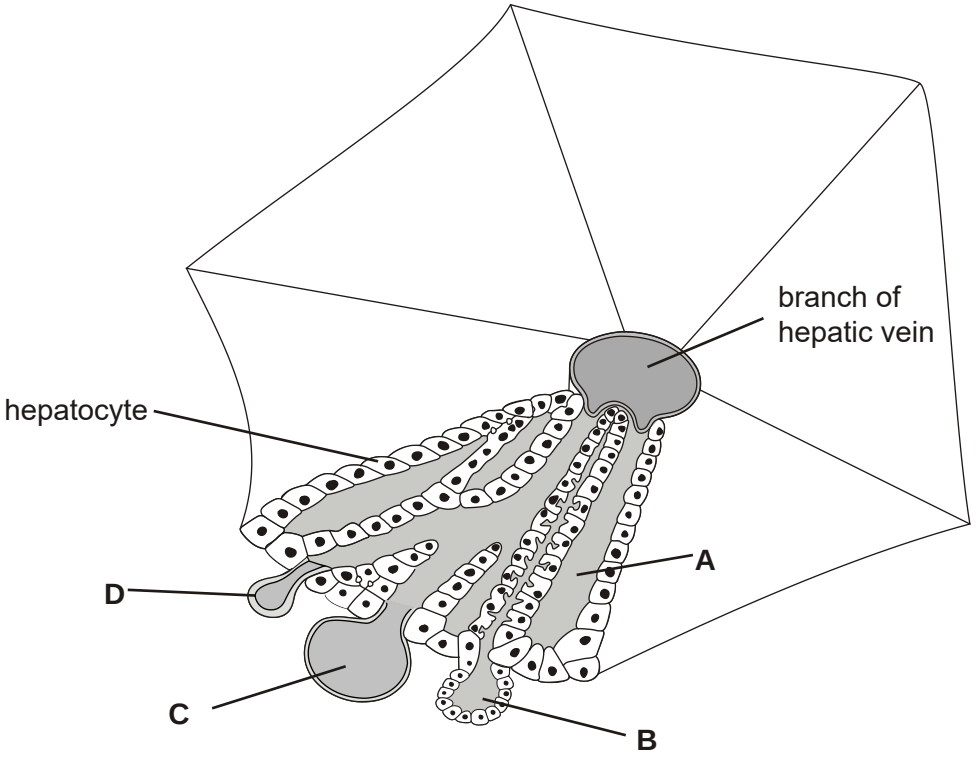
[Total 3 marks]

60. The mammalian liver is made up of lobules that consist of liver cells (hepatocytes) arranged in plates.

The figure below shows a section of a liver lobule and its associated blood vessels.



Name structures **A** to **D**.

A .....

B .....

C .....

D .....

[Total 4 marks]

61. Sometimes the liver does not function normally. This may result in a condition known as jaundice. The symptoms of jaundice include yellowing of the sclera at the front of the eyes, yellow skin, orange coloured urine and white faeces.

Suggest what abnormal events are happening in the liver to produce these symptoms.

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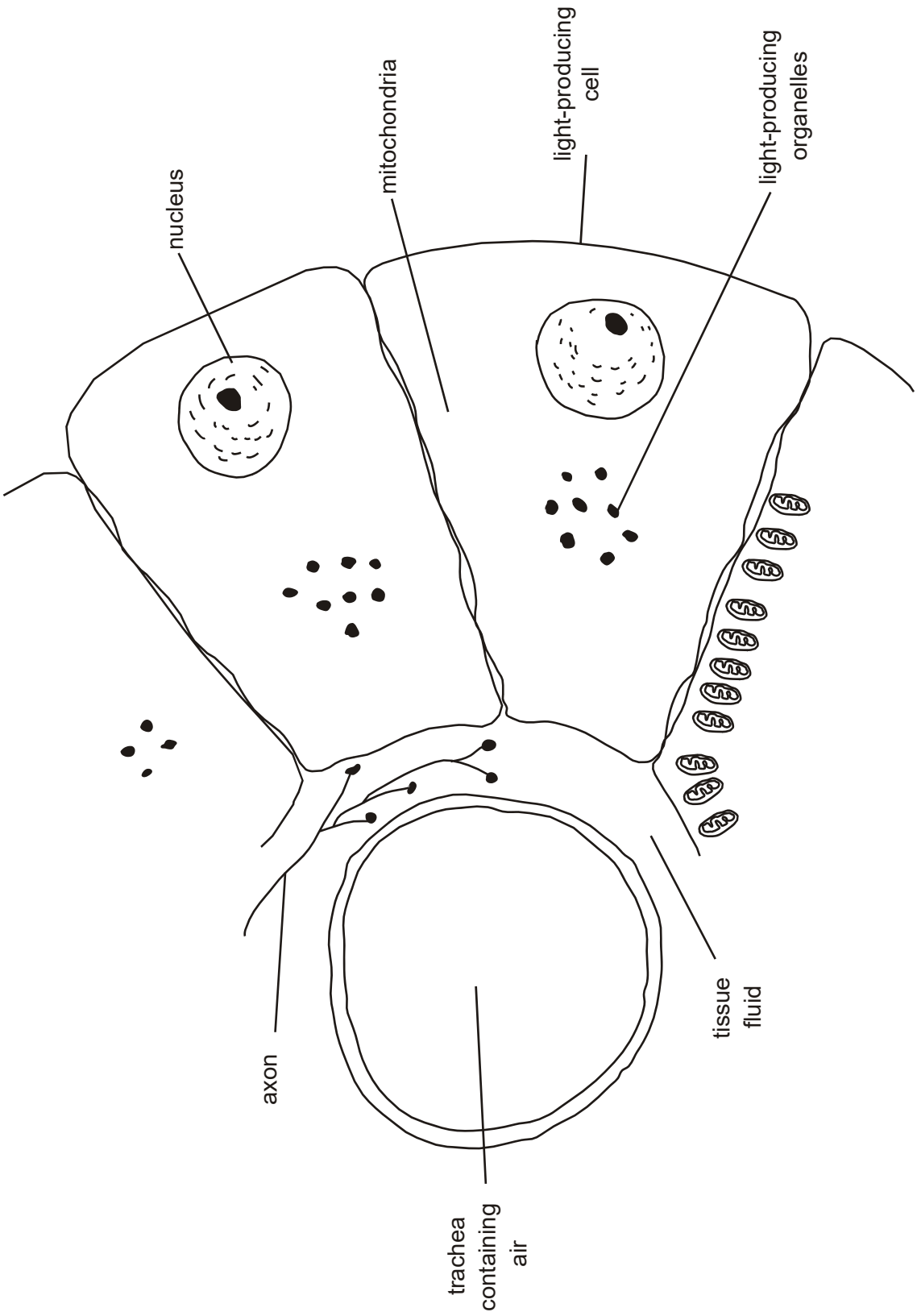
[Total 2 marks]

62. Read the passage below and answer the questions that follow, which relate to this passage.

How fireflies light up

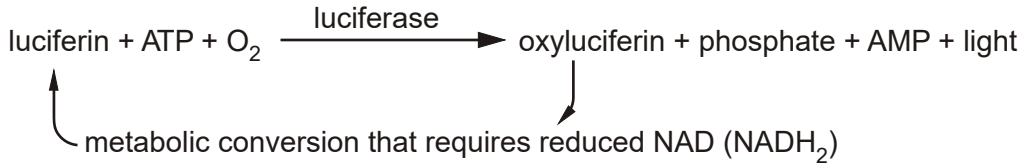
Fireflies are insects which have organs producing flashes of light. Fireflies are active at night and the light flashes are an important part of their sexual behaviour.

Within their light-producing organs are tubes, filled with air, called tracheae. These tracheae supply oxygen to light-producing cells. The figure below shows the arrangement of light-producing cells around a trachea.


nucleus
mitochondria
light-producing cell
light-producing organelles
axon
tissue fluid
trachea containing air

Light is produced by organelles situated well away from the surfaces of the cells nearest the trachea.

The reaction that produces light requires **both** oxygen **and** ATP.



When the organ is not producing any light, the numerous mitochondria use oxygen very fast. These mitochondria lie between the tracheae and the light-producing organelles, just under the cell membrane, so that no oxygen is available for the oxidation of luciferin.

A flash of light is produced when nerve impulses stimulate the walls of the tracheae and the cytoplasm of the light-producing cells, to produce nitrous oxide. Nitrous oxide diffuses rapidly through the cells. It enters mitochondria and inhibits oxidative phosphorylation, so the oxygen concentration increases in the cytoplasm of the light-producing cells.

Nitrous oxide is very unstable and breaks down quickly, so its effects are temporary.

An extract of crushed fireflies was found to be an extremely sensitive test for the presence of ATP in foods, such as milk and meat. The more bacteria there are in the food, the more light is produced, provided the mixture of food and firefly extract is well oxygenated.

Fortunately for fireflies, luciferin can be synthesised artificially and luciferase has been produced by gene technology, using methods similar to those for producing human insulin.

(a) Different species of firefly often live in the same habitat. The frequency with which a firefly flashes its light organ on and off, is a characteristic of a species.

Suggest an advantage, for fireflies, of flashing at a characteristic frequency.

.....

.....

[1]

(b) (i) State the process by which oxygen reaches the light-producing organelles.

.....

[1]

(ii) Explain why the light-producing organelles are located well away from the plasma (cell surface) membrane.

.....

[1]

(c) Suggest why it is important for the effects of nitrous oxide to be temporary.

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[2]

(d) Light-producing cells in fireflies do not divide. State **three** ways in which these cells might use ATP **other** than in the production of light.

1 .....

2 .....

3 .....

[3]

(e) If a firefly is suddenly crushed, for example by hitting a car windscreen, it produces a prolonged and unusually bright flash of light after which all light production ceases.

Suggest an explanation for these observations.

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[3]

(f) A solution containing luciferin, luciferase and oxygen glows when painted onto the surface of meat contaminated by live bacteria, but not if the meat is contaminated by dead bacteria.

Explain this observation.

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[1]

(g) What substance would be extracted and purified from light-producing cells of fireflies in order to produce luciferase by gene technology?

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[1]

[Total 13 marks]

63. An investigation was carried out into photosynthesis and respiration in a leaf. The net uptake of carbon dioxide by the leaf in bright light, and the mass of carbon dioxide released in the dark were determined at different temperatures. The results are shown in the following table.

temperature / °C	5	10	15	20	25	30
net uptake of CO_2 in bright light / mg g^{-1} dry mass h^{-1}	1.3	2.4	3.0	3.3	3.0	2.2
release of CO_2 in dark / mg g^{-1} dry mass h^{-1}	0.4	.07	1.0	1.4	1.9	2.8
true rate of photosynthesis / mg CO_2 g^{-1} dry mass h^{-1}						

(i) State **two** types of tissue in a leaf where there is a net uptake of carbon dioxide in bright light.

1 .....

2 .....

[2]

(ii) Assuming the rate of respiration in the light is equal to the rate of respiration in the dark, calculate the true rate of carbon dioxide uptake in photosynthesis at each temperature and **add the figures to the table above**.

[1]

(iii) The term temperature coefficient (Q_{10}) is used to express the effect of a 10 °C rise in temperature on the rate of a chemical reaction. It is calculated in the following way:

$$Q10 = \frac{\text{rate of reaction at } \mathbf{t} + 10\ °C}{\text{rate of reaction at } \mathbf{t}\ °C}$$

where **t** = any given temperature.

Between 5 °C and the optimum temperature for enzyme-catalysed reactions, the Q_{10} is approximately 2.

Discuss whether the data in the table above supports this statement for both respiration and photosynthesis.

respiration .....

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photosynthesis .....

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[4]

(iv) When plants are grown in glasshouses during autumn and winter, when the natural light intensities are low, it is important that temperatures are kept relatively low.

With reference to respiration **and** photosynthesis, explain why it is essential to do this.

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[3]

[Total 10 marks]

64. The carbon dioxide taken up by a leaf enters the chloroplasts.

Name and describe the **biochemical pathway** which fixes the carbon dioxide into hexose sugars in the chloroplasts.

name of pathway .....

description .....

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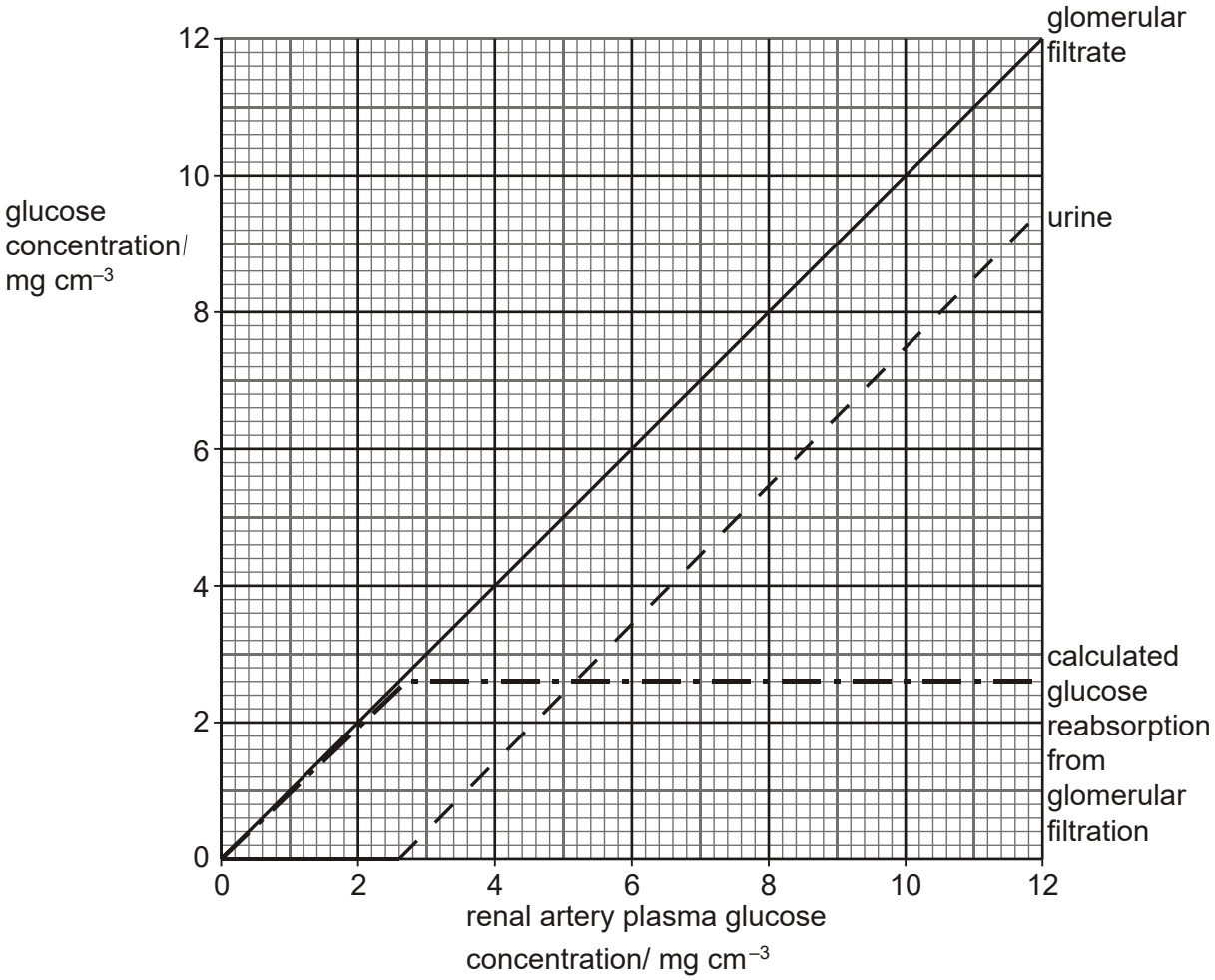
[Total 5 marks]

65. An investigation was conducted into the filtration and reabsorption of glucose in the kidney of a mammal.

The glucose concentration in the plasma of the renal artery was increased. The glucose concentrations were measured in the following fluids:

- glomerular filtrate
- urine.

From the measurements obtained, the concentration of glucose in the fluid reabsorbed from the glomerular filtrate was calculated. The results of this investigation are shown below.



Use the data in the figure above to answer the following questions.

(i) Describe the relationship between plasma glucose concentration in the renal artery and the concentration of glucose in the glomerular filtrate.

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[1]

(ii) State the plasma glucose concentration in the renal artery above which the kidney is unable to reabsorb all the glucose from the glomerular filtrate.

Answer = ... mg cm^{-3}

[1]

(iii) Explain why plasma glucose concentrations in the renal artery greater than the figure you have given in **(ii)** would result in the presence of glucose in the urine.

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[3]

[Total 5 marks]

66. Following a meal rich in carbohydrates, the plasma glucose concentration rises.

Describe the homeostatic mechanisms that would normally prevent glucose appearing in the urine.

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[Total 5 marks]

67. The kangaroo rat, *Dipodomys spectabilis*, is common in the deserts of North America. It does not need to drink water and feeds mostly on seeds and other dry plant material. It produces very little urine.

(i) Suggest how the kidney of this mammal is adapted to reduce the volume of urine produced.

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[3]

(ii) Suggest how desert mammals, such as the kangaroo rat, are able to obtain water from dry seeds.

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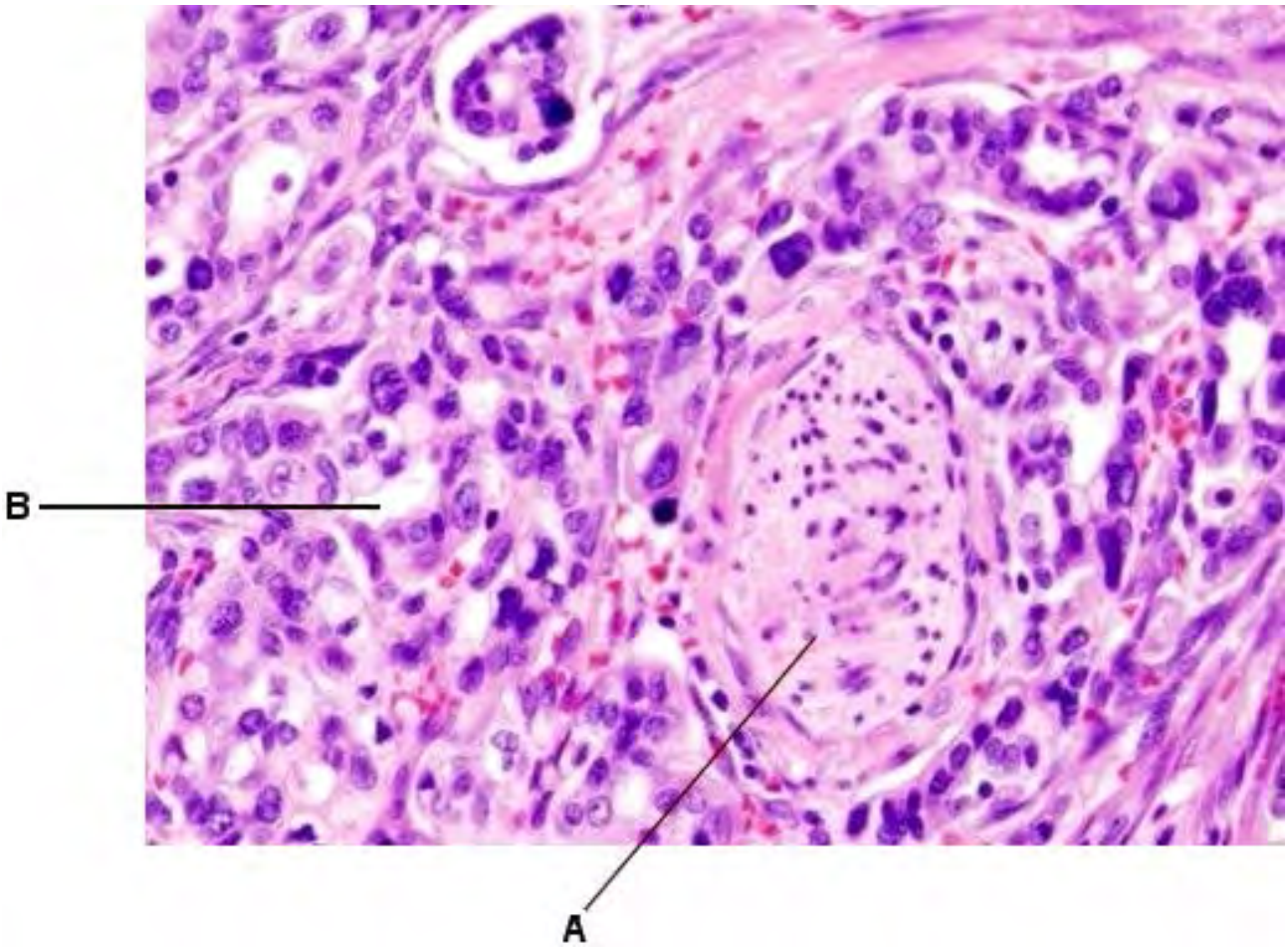
[3]

[Total 6 marks]

68. The pancreas is a gland that has both endocrine and exocrine functions.

The figure below shows a section through part of the pancreas.



magnification × 400

(i) Name **A** and **B**.

A .....

B .....

[2]

(ii) Explain the difference between the terms *endocrine* and *exocrine* with regard to the pancreas.

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[4]

[Total 6 marks]

69. In this question, one mark is available for the quality of spelling, punctuation and grammar.

The autonomic nervous system contains neurones that carry impulses to the internal organs.

Describe the role of the autonomic nervous system in the control of the heart beat.

[7]

Quality of Written Communication [1]

[Total 8 marks]

70. *Tradescantia* is a genus of plants that is found in North and South America. The genus has many species which are found in different types of habitat. *Tradescantia sillamontana* and *Tradescantia fluminensis* are two of these species.

Fig 1 shows typical shoots of these plants. The photographs of the shoots are life size. Fig 1 **A** is *T. sillamontana* and **B** is *T. fluminensis.*

Tradescanita fluminensis

Tradescanita sillamontana

Fig 1

(a) Describe **two** ways in which the shoot of *T. sillamontana* differs from the shoot of *T. fluminensis*, as shown in Fig.1.

1 .....

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2 .....

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[2]

Table 1 shows the numbers of stomata in six random microscope fields of view of the lower epidermis from each of the species.

Table 1

number of stomata seen in microscope fields of view	
T. sillamontana	*T. fluminensis*
13	16
12	21
13	19
17	21
16	18
14	19
mean	mean

(b) (i) Calculate the mean number of stomata per field of view for each species **to the nearest whole number**. Insert your answers in Table 1.

[1]

(ii) State **two** precautions that should be taken to ensure that the data in Table 1 is a valid comparison between the two species.

1 .....

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2 .....

.....

[2]

T. sillamontana originates in Mexico and *T. fluminensis* in Brazil. Table 2 shows climate data for the areas from which the plants originate.

Table 2

month		Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mexico	mean monthly temperature / °C	14	17	20	23	26	27	28	28	26	22	18	15
	mean monthly rainfall / mm	18	23	16	29	40	68	62	76	151	78	26	20
Brazil	mean monthly temperature / °C	26	26	26	26	26	26	26	27	28	28	28	27
	mean monthly rainfall / mm	300	347	407	384	352	220	185	98	43	36	58	143

(c) *T. sillamontana* is found growing in the open, where there is no shade, whilst *T. fluminensis* is found growing in the shade of trees.

Use the information provided by Fig.1 and Tables 1 and 2 to explain how each species is adapted to its natural habitat.

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[5]

(d) Explain how the data in Fig. 2 provide information about the adaptations of *T. sillamontana* and *T. fluminensis* to their environments.

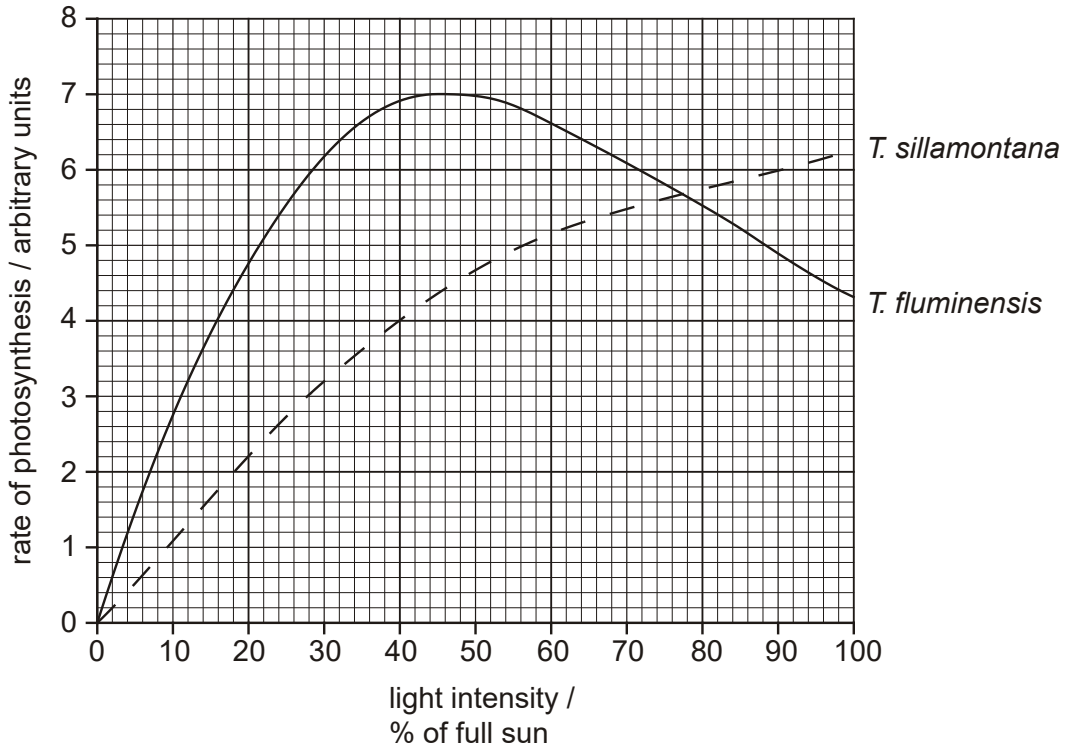

Fig. 2

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[3]

[Total 13 marks]

71. After a lawn had been cut using a mower, the grass cuttings were piled up in a corner of the garden.

Ten days later, the heap of grass cuttings had steam rising from it.

A tube was pushed into the heap and an air sample was obtained from near its centre. This air sample was dried and then analysed to find the percentages of oxygen and carbon dioxide present. These concentrations could be measured to an accuracy of ±1 %.

A thermometer was also inserted into the centre of the heap and the temperature was recorded.

The results of the investigation are shown in the table below, which also shows data for the air above the ground near the heap.

sampling point	oxygen concentration / %	carbon dioxide concentration / %	temperature / °C
near the centre of the heap of grass	13	8	42
above the ground near the heap	21	0	16

As the heap of grass was in the shade for several hours before the readings were taken, it could **not** have become warm by absorbing solar radiation.

Explain the results shown in the table.

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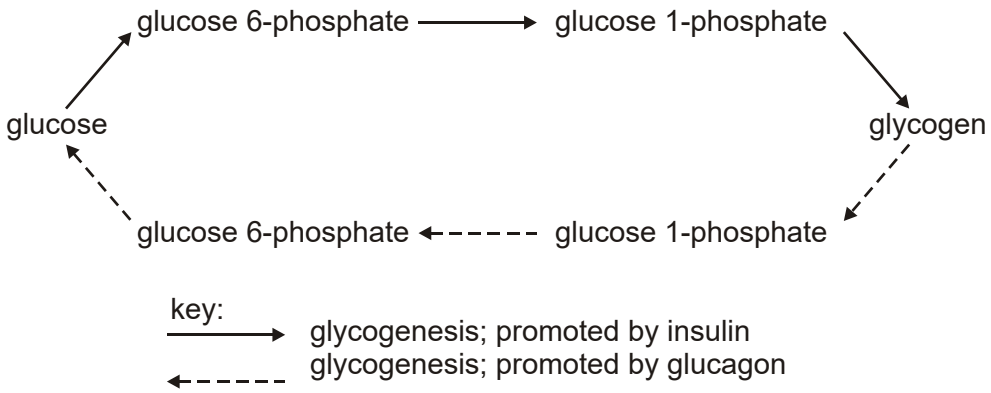
[Total 5 marks]

72. The liver plays an important role in carbohydrate metabolism. The balance between the processes of glycogenesis and glycogenolysis helps to regulate the concentration of glucose in blood plasma. The figure below shows some of the stages of these processes.



(a) (i) Name **one** other hormone that promotes **glycogenolysis**.

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[1]

(ii) Explain why glycogen is suitable for energy storage in cells.

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[3]

The last step in **glycogenesis** is catalysed by the enzyme glycogen synthetase. The first step in **glycogenolysis** is catalysed by the enzyme glycogen phosphorylase.

Glucose molecules have direct effects on glycogen synthetase and on glycogen phosphorylase. These effects do **not** require the presence of insulin and glucagon.

The table below shows the rate of activity of glycogen synthetase and glycogen phosphorylase inside liver cells, during exposure of the cells to a concentrated solution of glucose.

time after addition of glucose solution / s	rate of activity of glycogen synthetase / arbitrary units	rate of activity of glycogen phosphorylase / arbitrary units
0	28	410
30	28	280
60	32	140
90	49	65
120	94	42
150	136	40
180	189	40
210	272	40

(b) Explain how a high concentration of glucose causes the storage of glycogen in liver cells. You will gain credit if you use the data in the table in your answer.

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[5]

(c) After a prolonged period of fasting, glycogen levels in the liver are depleted. However, the liver can still produce glucose by the process of **gluconeogenesis**.

Describe **one** way in which this is done.

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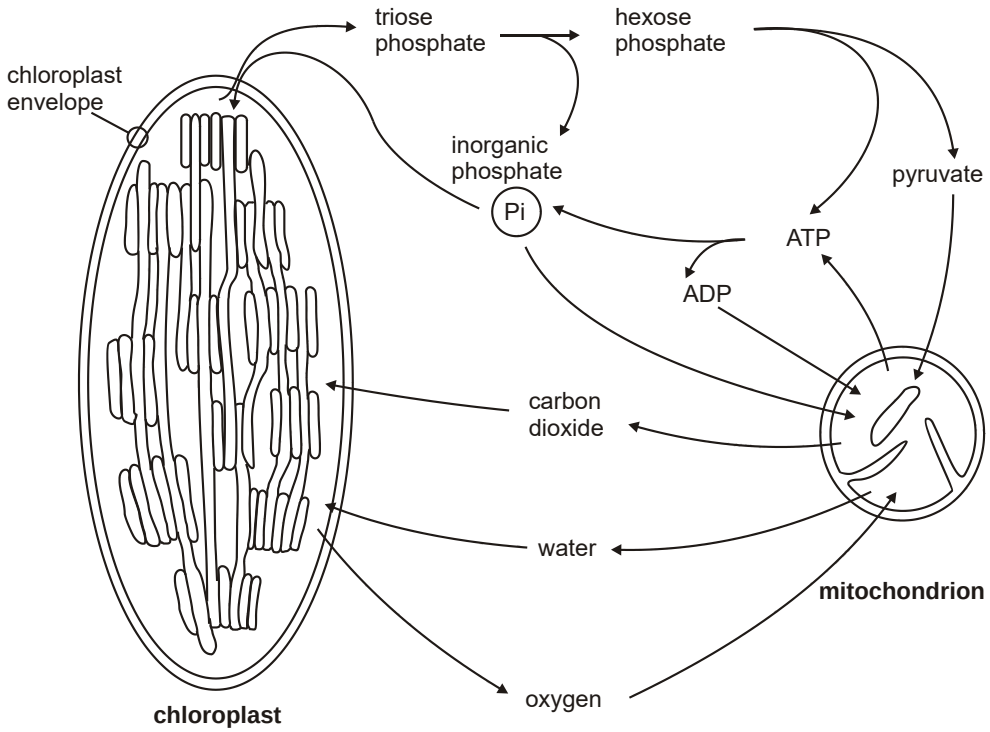
[3]

[Total 12 marks]

73. Palisade cells have both chloroplasts and mitochondria. Exchanges between a mitochondrion, a chloroplast and the cytoplasm surrounding them are shown in the figure below.



(a) A leafy shoot can be sealed inside a transparent container. The concentration of oxygen in the atmosphere within this container can be measured. In the dark, the oxygen concentration falls. At high light intensities, the oxygen concentration increases. At a particular light intensity, the oxygen concentration in the container remains constant.

Use the figure above to explain how it is possible for the oxygen concentration to remain constant.

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[4]

(b) Explain why there is no build up in the concentration of phosphate ions inside mitochondria as a result of the inward passage of phosphate ions.

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[2]

(c) Triose phosphate moves out of chloroplasts by passing through carrier proteins that are part of the chloroplast envelope. These proteins allow an inorganic phosphate ion to pass inwards at the same time as triose phosphate moves outwards.

Suggest why the movement of triose phosphate out of chloroplasts is an example of facilitated diffusion rather than active transport.

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[2]

(d) Many biologists believe that both mitochondria and chloroplasts evolved, at an early stage in the history of the earth, from prokaryotic organisms that inhabited the cytoplasm of eukaryotic host cells.

State **two** structural features of mitochondria and chloroplasts that are also present in prokaryotic cells.

1 .....

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2 .....

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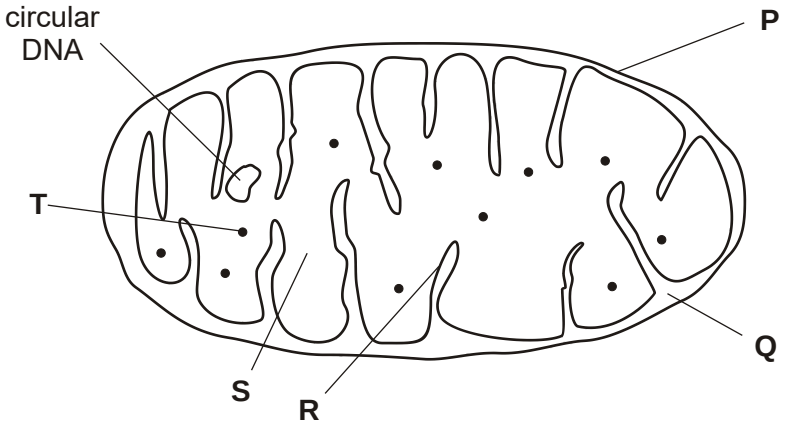
[2]

[Total 10 marks]

74. The figure below is a diagram of a section through a mitochondrion.



In each case, state the letter which indicates the site of:

the Krebs cycle …….

oxidative phosphorylation …….

decarboxylation …….

[Total 3 marks]

75. Name a hydrogen carrier that links the Krebs cycle to the electron transport chain.

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[Total 1 mark]

76. There are several different pigments involved in the light-dependent reactions of photosynthesis in flowering plants.

Name **two** photosynthetic pigments found in flowering plants.

1 .....

2 .....

[Total 2 marks]

77. In this question, one mark is available for the quality of spelling, punctuation and grammar.

In the palisade cells of a leaf, the fixation of carbon dioxide occurs in the Calvin cycle.

Describe the main features of this cycle. **No credit will be given for a flow diagram of the cycle**.

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[7]

Quality of Written Communication [1]

[Total 8 marks]

78. Explain the term *endocrine gland*.

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[Total 2 marks]

79. Untreated diabetes is a condition that can lead to blood glucose concentrations often rising above 120 mg 100 cm^{-3} of blood. Genetic engineering has been used to improve the treatment of diabetes.

Explain the advantages of using genetic engineering in the treatment of diabetics.

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[Total 3 marks]

80. The table below shows how the speed of nerve impulse conduction varies with the diameter of myelinated and non-myelinated axons in different organisms.

organism	type of axon	axon diameter /μm	speed of impulse /m s^{-1}
crab	non-myelinated	30	5
squid	non-myelinated	500	25
cat	myelinated	20	100
frog	myelinated	16	32

Describe the trends shown in the table above.

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[Total 2 marks]

81. Explain the term *refractory period* **and** outline its importance in nerve impulse conduction.

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[Total 4 marks]

82. (a) During winter, the brown bear, *Ursus arctus*, enters a long period of inactivity. Whilst inactive, the brown bear undergoes various physiological changes, for example a decrease in core body temperature and a decrease in resting heart rate. There are also changes in the brown bear's metabolism of protein and lipids.

Explain the role of the autonomic nervous system in achieving a decrease in resting heart rate.

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[3]

During periods of inactivity, the brown bear reabsorbs all urea molecules from the filtrate in its kidneys and from the bladder. Urea is then transported in the bloodstream to the large intestine. Bacteria in the large intestine convert urea to ammonia and carbon dioxide, which diffuse back into the blood. When the ammonia reaches the liver, it is converted into amino acids. These newly produced amino acids are then used to synthesise proteins in the body, especially in the liver and muscle cells.

(b) Name **two** plasma proteins that will be produced by the liver.

1 .....

2 .....

[2]

(c) Describe the **similarities** and **differences** between the metabolism of nitrogen-containing compounds in inactive brown bears, **as described in the passage**, and in humans.

similarities

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differences

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[5]

The blood plasma cholesterol concentration of inactive brown bears rises to twice the concentration found in normally active bears and in humans. However, brown bears do not suffer any of the cardiovascular diseases associated with high cholesterol concentrations in humans, as their liver produces a protective substance, which prevents these diseases from developing.

(d) Explain the importance of cholesterol in the metabolism of mammals.

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[3]

(e) Suggest how the protective substance produced by their liver prevents brown bears developing cardiovascular diseases.

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[2]

[Total 15 marks]

83. In an investigation of photosynthesis, the rate of carbon dioxide absorption by leaves of two plants, barley and sugar cane, was measured. The leaves were provided with air, moving at a constant rate, through an apparatus that is illustrated by Fig. 1.

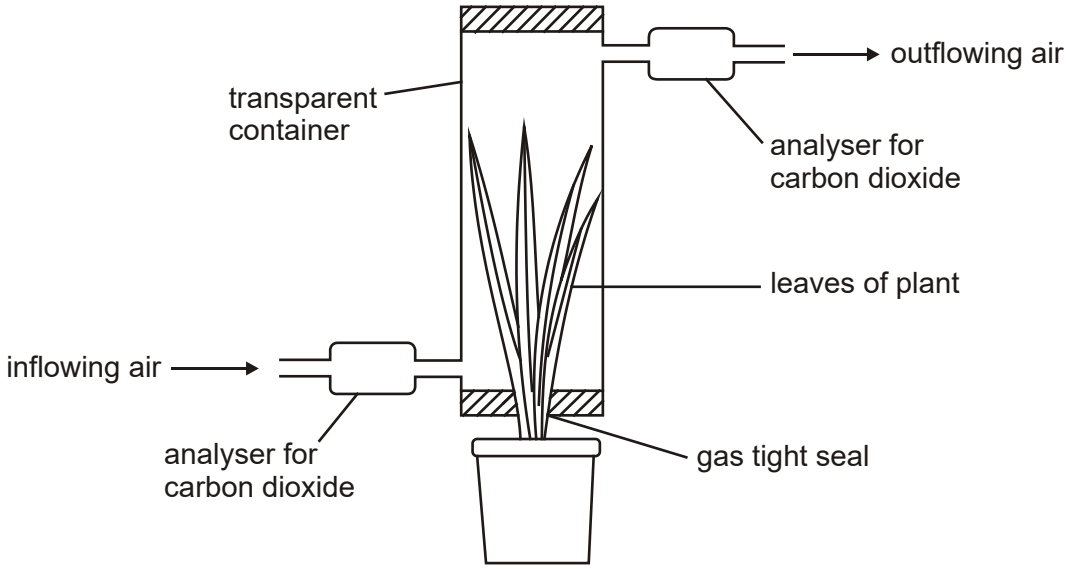

Fig. 1

- The light intensity was kept constant and high, equivalent to full sunlight.
- The concentration of carbon dioxide in the air entering the apparatus could be varied.
- The carbon dioxide taken up or given out by the leaves was determined by calculating the **difference** between the concentration in the inflowing and outflowing air.
- The leaves remained attached to the plants during the investigation.
- Two different temperatures, 10 °C and 25 °C, were used for each type of plant.

The results of the investigation are shown in Fig. 2.

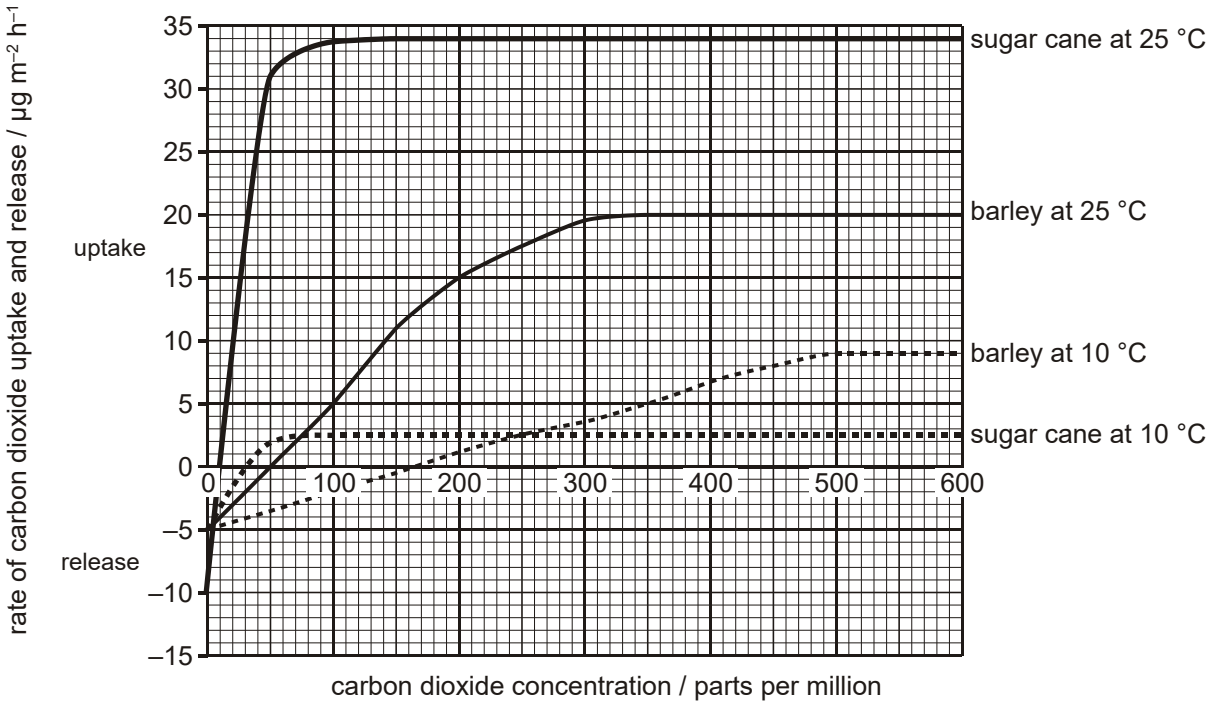

Fig. 2

(a) In all four experiments, the rate of carbon dioxide uptake reached a maximum and became constant.

Suggest why.

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[2]

(b) Explain why carbon dioxide was released when the carbon dioxide concentrations were low.

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[2]

(c) Explain why all the measurements were made at the same light intensity.

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[1]

(d) Suggest why it was important that the leaves remained attached to the plants while the measurements were made.

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[2]

(e) Comment on the similarities and differences in response of the two species, sugar cane and barley, to differences in carbon dioxide concentration and temperature.

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[5]

[Total 12 marks]