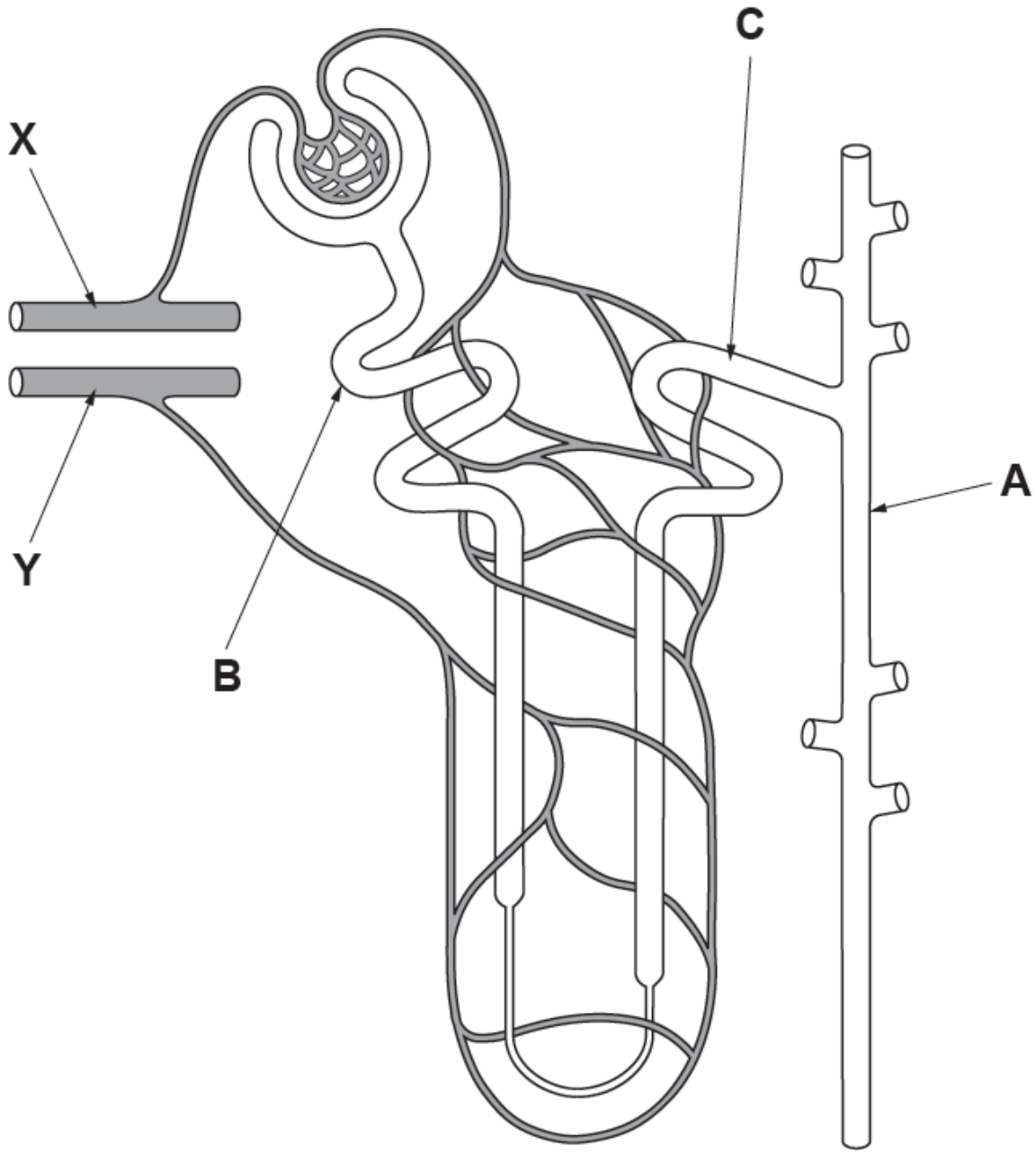
WJEC (Eduqas) Biology A-level Topic 3.4: Homeostasis and the Kidney
Questions by Topic

1. The diagram below shows a single nephron, with its blood supply, from a kidney.



(a) (i) Name **A**, **B** and **C** shown on the diagram above.

[3]

A . . . . . .

B . . . . . .

C . . . . . .

(ii) Use **two** arrows, clearly labelled, on the nephron above, to show where the following processes take place:

[2]

I ultrafiltration;

II selective reabsorption.

(b) Name the blood vessels supplying the kidney which would connect at points **X** and **Y** shown on the diagram opposite.

[1]

X . . . . . .

.

Y . . . . . .

.

(c) Explain the function of the Loop of Henle in osmoregulation.

[4]

(d) Describe how hormonal control affects the final concentration and volume of urine produced when someone is dehydrated.

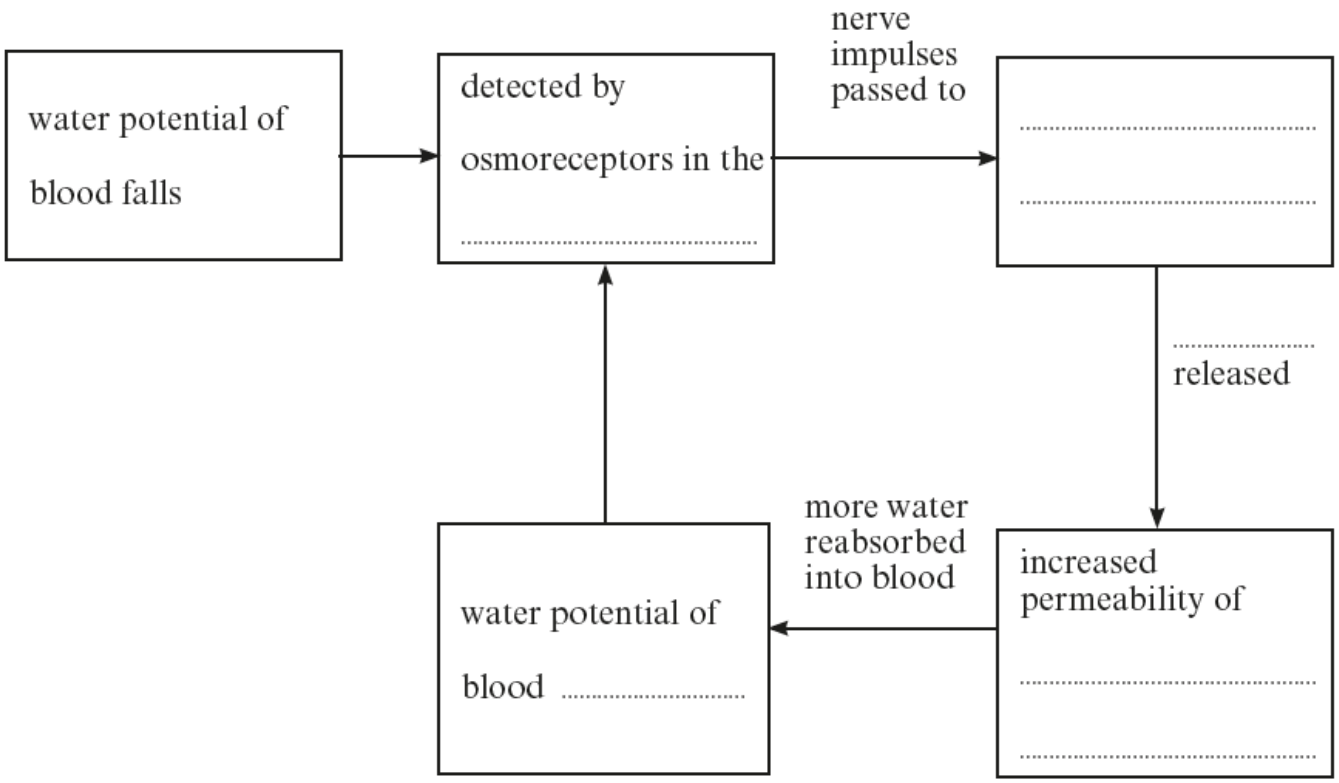
[4]

2. (a) Explain what is meant by the term *homeostasis.*

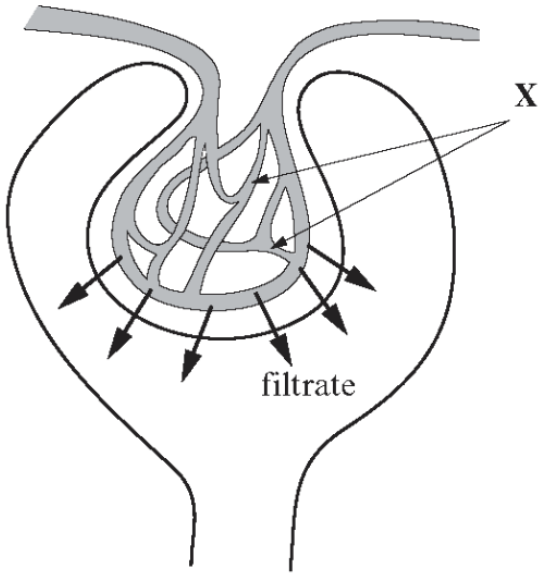
[2]

(b) Complete the diagram below showing the process of osmoregulation in the human body.

[6]



3. The diagram shows part of a kidney tubule or nephron.



(a) (i) Name the network of capillaries labelled **X**. [1]

.....

(ii) Apart from water and glucose, name **two** substances which will be present in the filtrate. [1]

.....

(iii) Name the process that separates these molecules from the blood plasma. [1]

.....

(iv) The filtration rate is the total volume of filtrate formed per minute.
Explain the effect of a large loss of blood from the body on the filtration rate. [2]

.....

.....

.....

(b) Much of the water in the kidney filtrate is reabsorbed from the collecting duct.

(i) Name the part of the nephron which provides the osmotic gradient for reabsorption. [1]

.....

(ii) Suggest **one** way in which this part of the nephron might be modified in desert animals. [1]

.....

(c) The environment in which an animal lives plays a part in the type of nitrogenous waste produced.

(i) For the animals listed in the table below name the excretory products and place the products in the appropriate boxes. [3]

Animal	*Main excretory product*	*Toxicity*	*Solubility*
Freshwater fish		high	high
Bird		low	low
Mammal		medium	medium

(ii) Which excretory product requires the least volume of water for its excretion? [1]

.....

(iii) Explain **one** *further* advantage of the excretory product you have named in *(c)* (ii) [1]

.....

.....

(Total 12 marks)

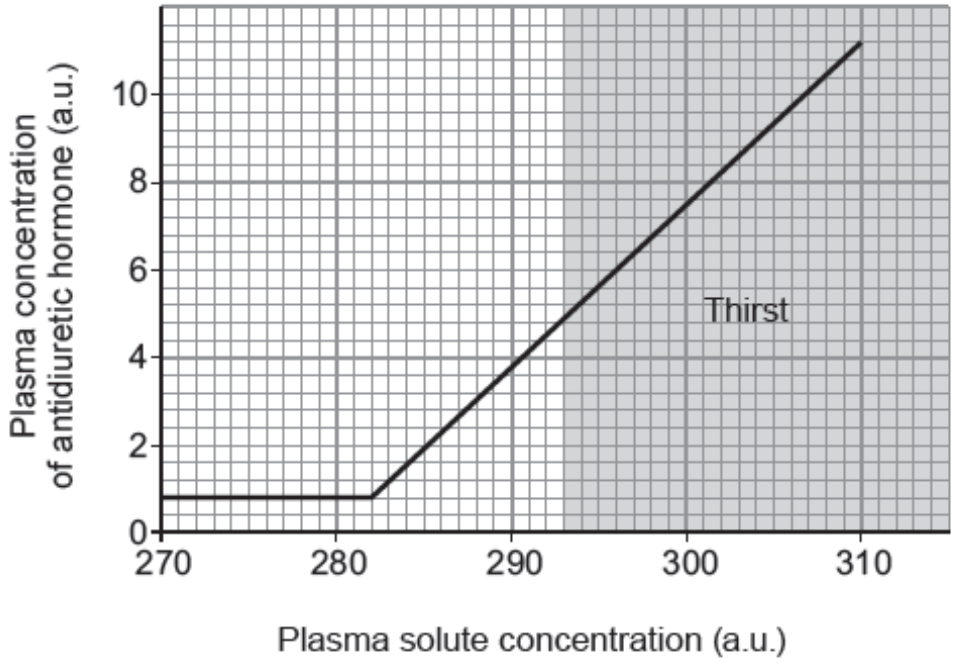
[6]

4. Roughly 60% of the mass of the body is water and despite wide variation in the quantity of water taken in each day, body water content remains incredibly stable.

One hormone responsible for this homeostatic control is antidiuretic hormone (ADH).

(a) Describe the mechanisms that are triggered in the mammalian body when water intake is reduced.

(b) The graph below shows how the plasma concentration of antidiuretic hormone changes as plasma solute concentration rises.



(i) Describe the relationship shown in the graph opposite.

[2]

(ii) Suggest why a person only begins to feel thirsty at a plasma solute concentration of 293 AU.

[2]

Secretion of antidiuretic hormone is stimulated by decreases in blood pressure and volume.
These are conditions sensed by stretch receptors in the heart and large arteries. Severe diarrhoea is one condition which stimulates ADH secretion.

(c) Suggest another condition which might stimulate ADH secretion.

[1]

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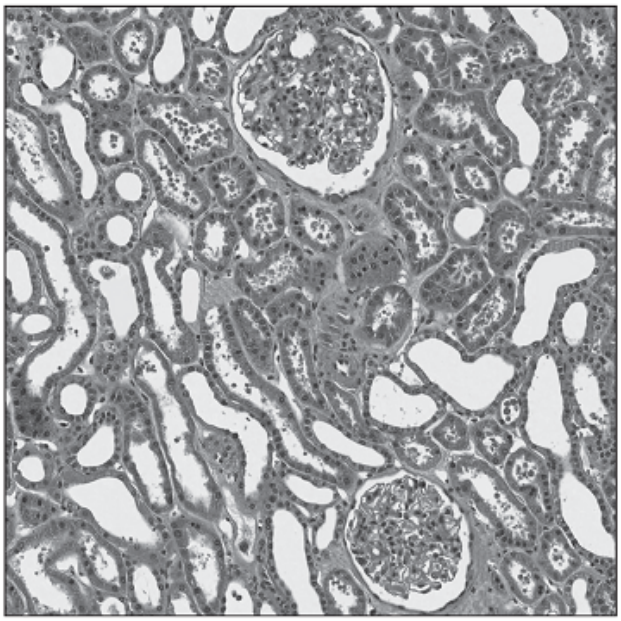
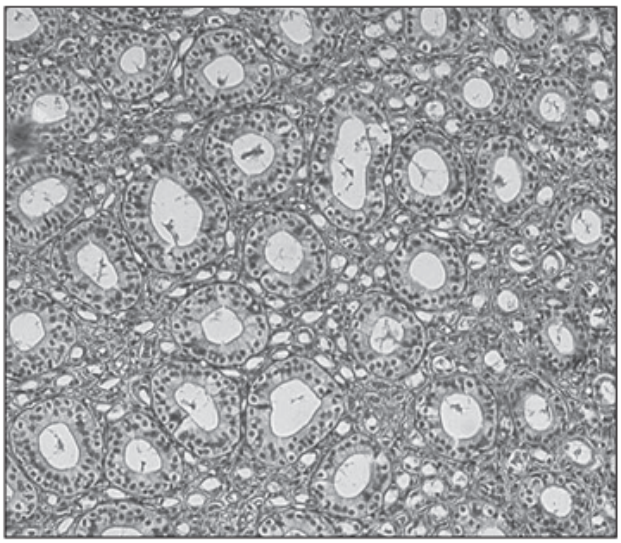
5. The two sections below were taken from different regions of a kidney.

A



B



(a) Identify the regions from which these two sections were taken, giving a reason for each answer. [2]

	Region of kidney	Reason
A		
B		

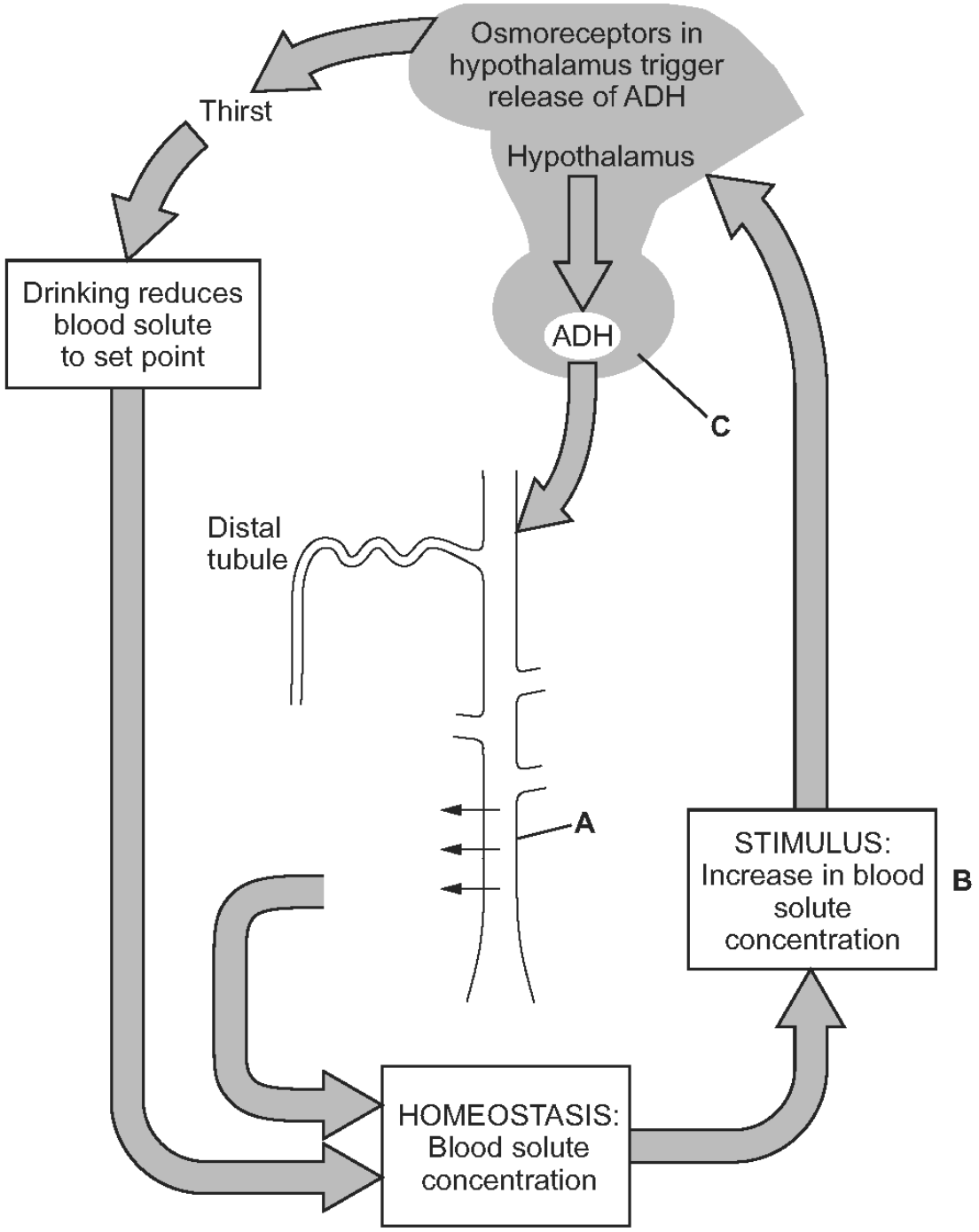
(b) Explain how the nephron and its blood supply is adapted for **ultrafiltration**. [5]

(c) Patients with severe kidney disease may be told to follow a protein controlled diet with low sodium chloride (salt) intake. Using your knowledge of the role of the kidney, suggest why this diet is recommended. [3]

Protein controlled diet

Low sodium chloride (salt) intake

(d) The following diagram shows the feedback mechanisms involved in controlling blood solute concentration.



(i) Name structures **A** and **C** on the diagram above. [2]

A .....

C .....

(ii) Give **two** examples of what might cause a rise in blood solute concentration as shown in box **B**. [1]

I .....

II .....

(iii) From your knowledge of the kidney, what would be the result of higher levels of ADH at **A**? [1]

.....

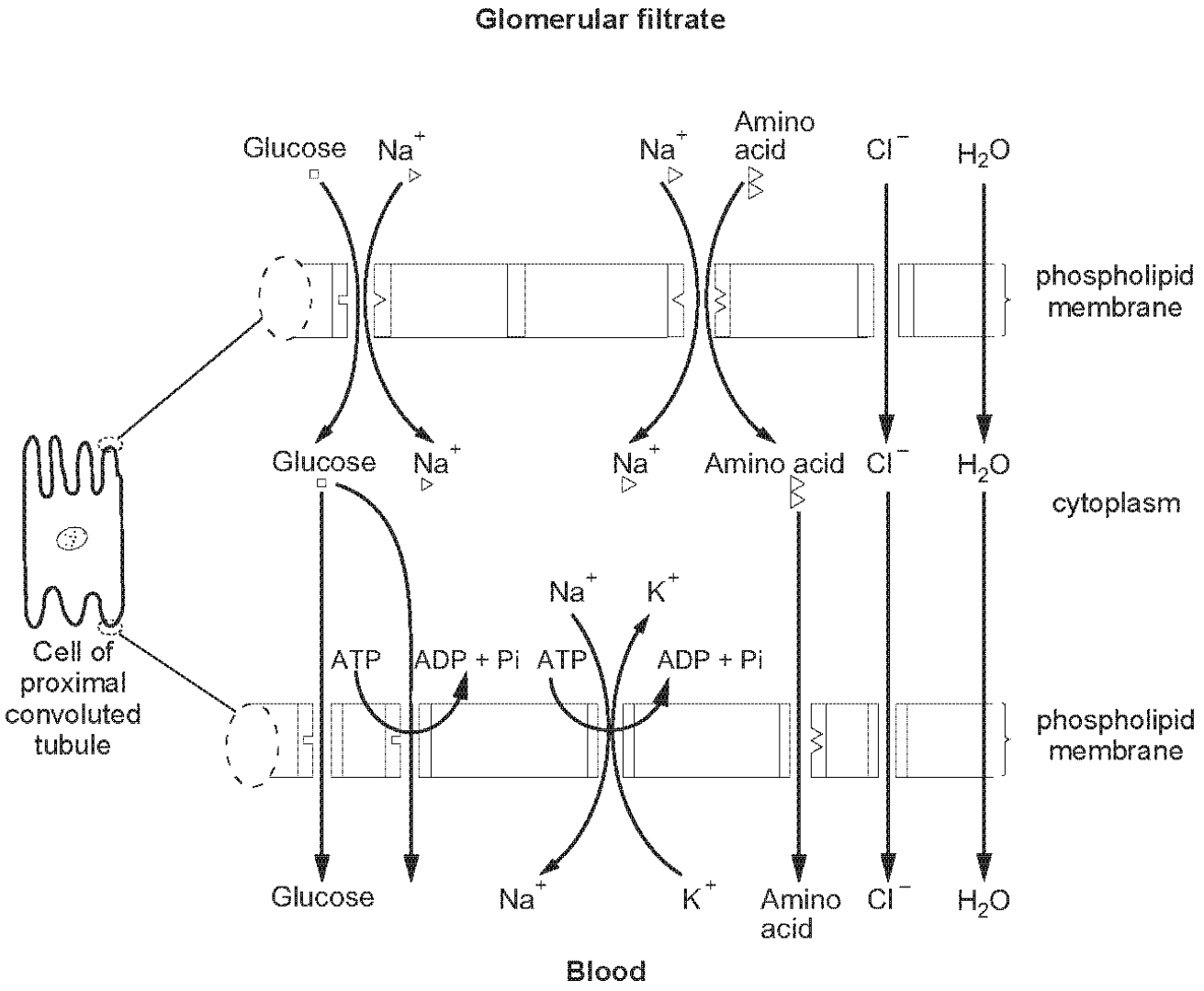
.....

.....

.....

14

6. The diagram represents selective reabsorption by the cells of the proximal convoluted tubule in the kidney.



(a) Sodium ions are essential for the uptake of glucose and amino acids by a mechanism called co-transport. Both glucose and amino acids attach to sodium ions to move through a membrane protein. Using the information shown in the diagram, explain how the following molecules and ions are selectively reabsorbed.

(i) Chloride ions. [2]

.....

.....

.....

.....

.....

(ii) Water. [3]

(iii) Sodium ions. [3]

(iv) Glucose and amino acids. [3]

(b) People suffering from diseases such as cholera suffer from chronic diarrhoea which can lead to dehydration. To help prevent dehydration, water containing sodium chloride and glucose is given to the patient. Suggest why the sodium chloride and glucose improve water reabsorption by the kidneys. [3]

14

7. *(a)* Name the functional unit of the mammalian kidney shown in the diagram. [1]

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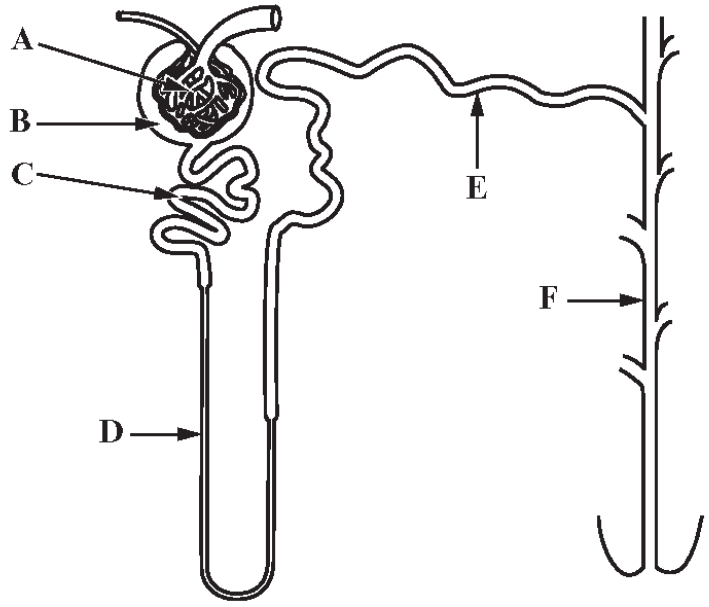


(b) (i) Name the parts labelled **A-F**. [3]

A .....

B .....

C .....

D .....

E .....

F .....

(ii) State the function of part **D**. [1]

.....

(iii) How is part **D** adapted in the kidneys of desert mammals such as the kangaroo rat? [1]

.....

(c) Parts **E** and **F** have restricted permeability which is subject to hormonal control.

(i) Which hormone controls the permeability of parts **E** and **F**? [1]

.....

(ii) Which part of the mammal's body releases this hormone into the blood? [1]

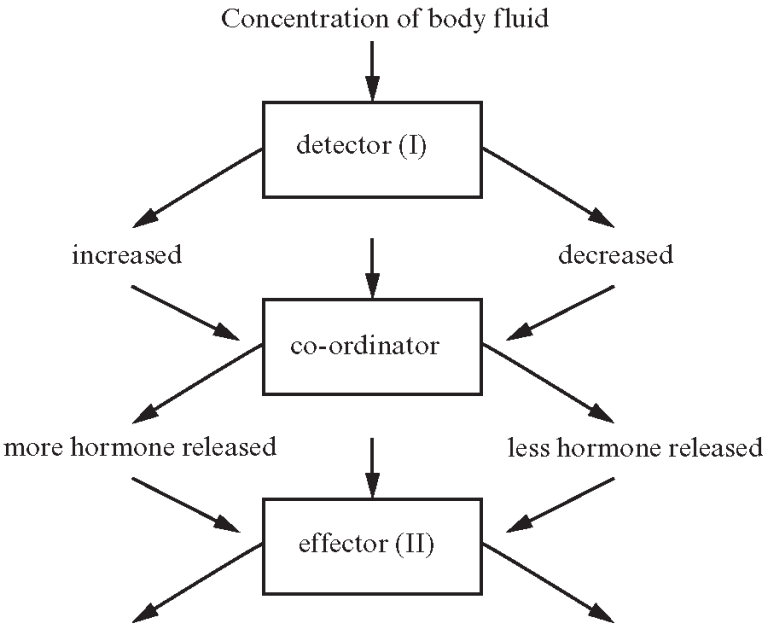
.....

(iii) Use your answer to parts (i) and (ii) to identify, on the diagram of the Osmoregulatory Feedback Loop below [1]

(I) the detector; .....

(II) the effector. .....

(iv) Complete the diagram below, of an Osmoregulatory Feedback Loop, to explain the mechanism for adjusting urine during osmoregulation. [3]



..... How hormone changes the effector .....

..... How concentration of urine changes .....

..... How volume of urine changes .....

Concentration of body fluid returns to normal

(d) (i) The environment in which an animal lives plays a part in excretion of nitrogenous waste. Mammals release it as urea. In what form is it released in the following?[2]

(I) Freshwater fish .....

(I) Insects .....

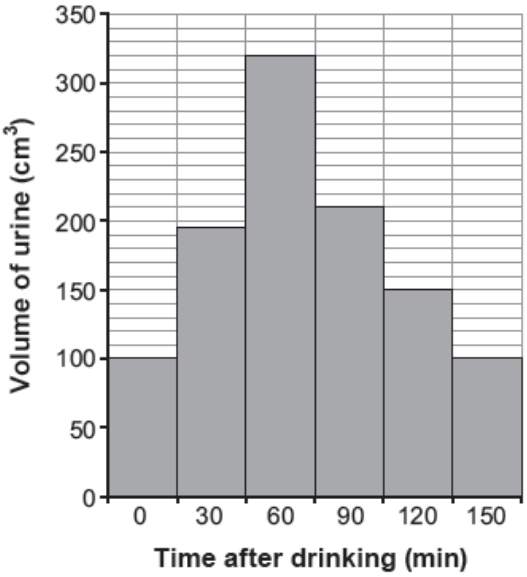
(ii) Suggest **one** advantage to insects of excreting nitrogenous waste in this form. [1]

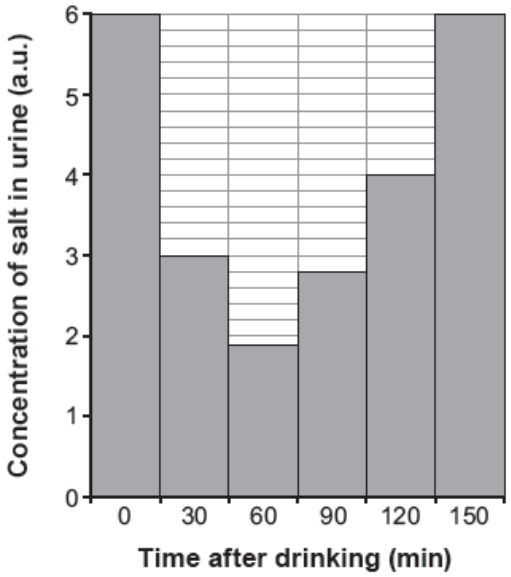
.....

.....

(Total 15 marks)

8. A student gave a sample of urine and then drank 1000 cm^3 of distilled water rapidly. Urine was then collected at regular intervals and measurements made of the volume of each sample and its salt concentration. The results are shown on the following graphs.





(a) (i) Using your knowledge of osmoregulation, explain the change in the volume of urine between 0 - 60 minutes. [4]

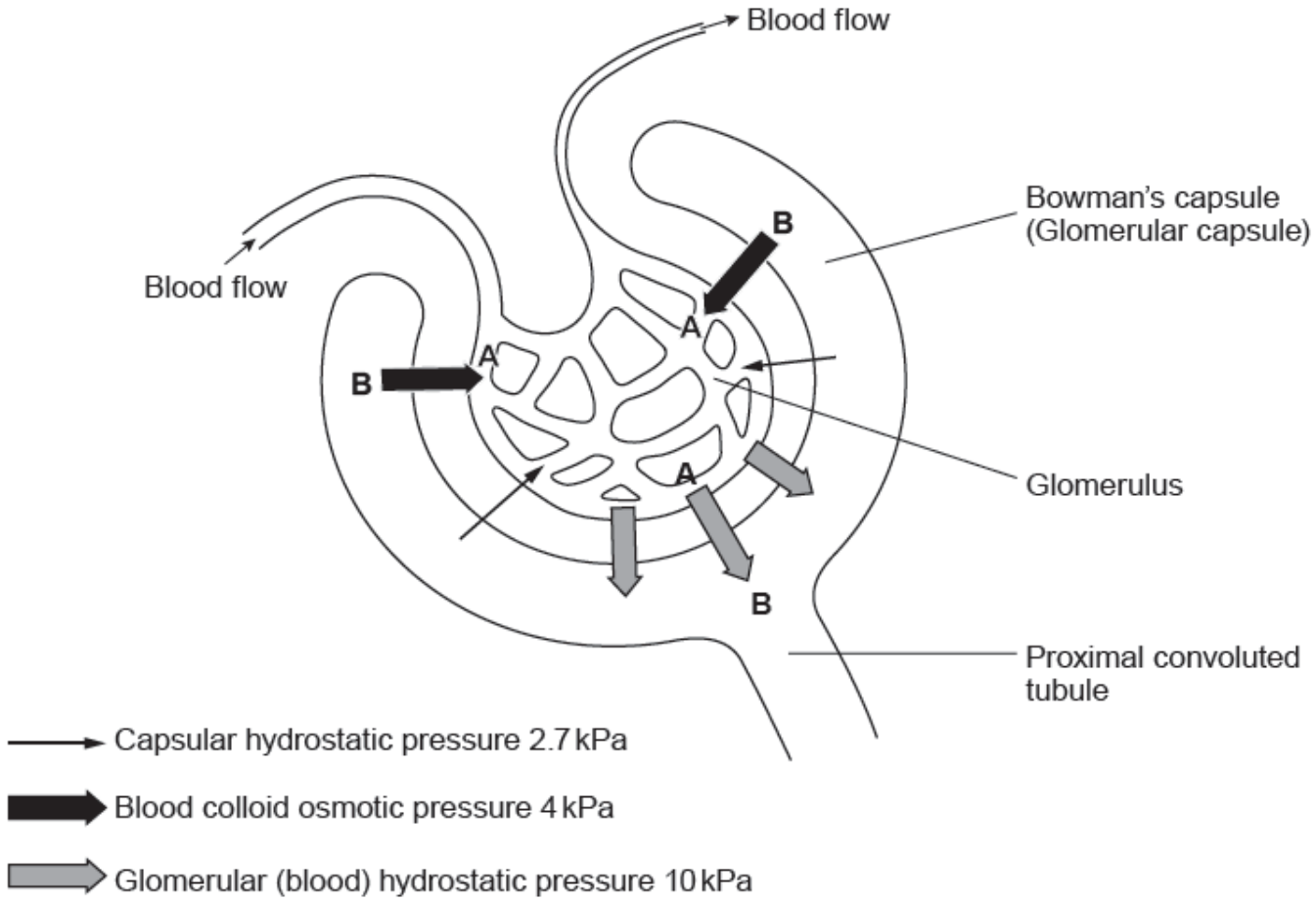
(ii) Explain the change of concentration of salt in the urine between 0 and 60 minutes.

[1]

(iii) State **two** variables which would need to be considered when comparing results from a number of people who had drunk similar volumes of water.

[2]

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



(i) Explain how the high hydrostatic pressure (10 kPa) is achieved in the glomerulus

[1]

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

[1]

(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**.

[2]

(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 include units with your answer.

[2]

Answer . . . . . .

(c) There is a feedback system in the kidneys which maintains the hydrostatic pressure in the glomerulus at a constant level despite changes in the arterial blood pressure. The regulatory mechanism involves the contraction of the circular muscles in the afferent arteriole.

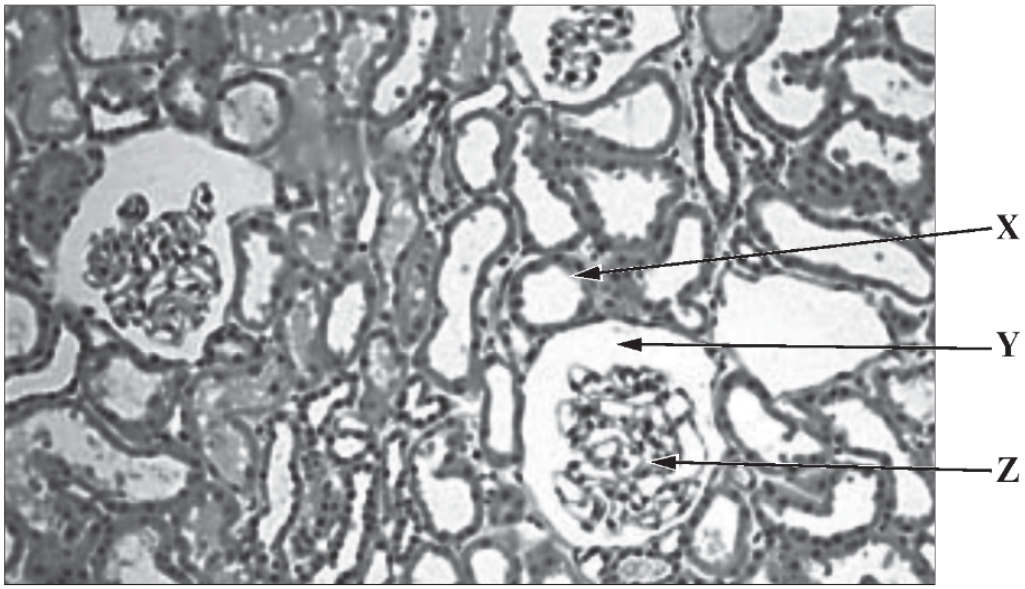
(i) Explain how this prevents changes in the hydrostatic pressure in the glomerulus.

[2]

(ii) Suggest what would happen in the body if the arterial blood pressure increased and the feedback system in the kidney described did not function.

[1]

9. The following photomicrograph shows part of a kidney.



(a) (i) From which part of the kidney is the photomicrograph above taken? [1]

.....

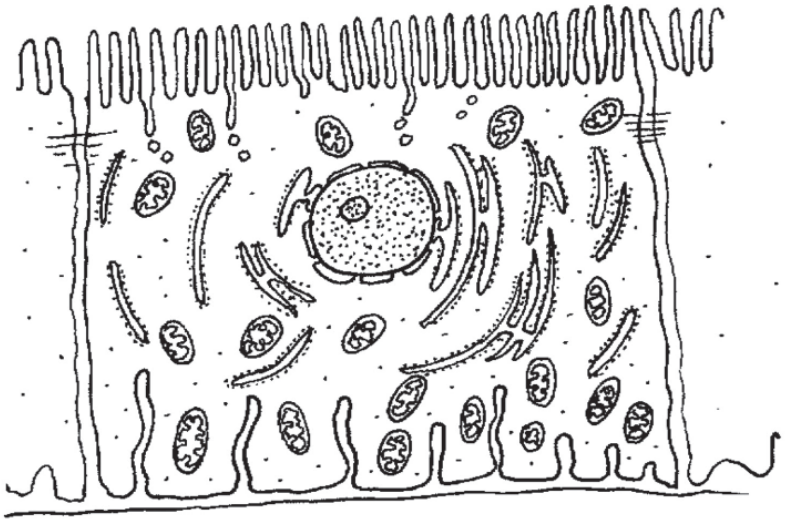
(ii) Name the structures X - Z shown in the photomicrograph above. [3]

X .....

Y .....

Z .....

(iii) The following is a diagram of a cell from structure **X** opposite.



State **three** structural features visible in this cell which help in selective reabsorption. [3]

1 .....

2 .....

3 .....

(b) Describe how ultrafiltration takes place in the kidney. [4]

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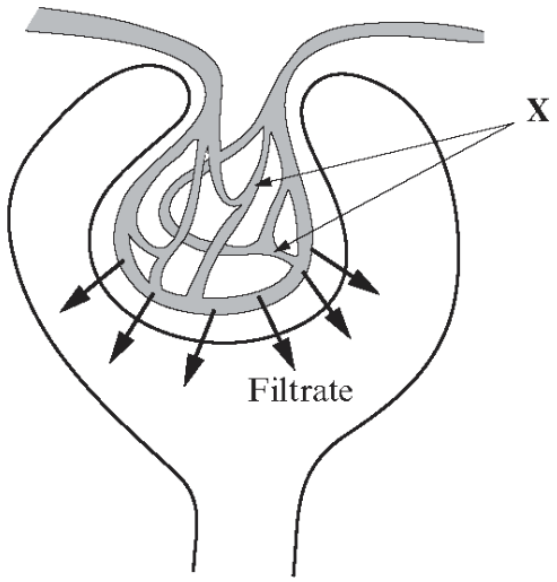
10. The diagram shows part of a kidney tubule or nephron.



(a) (i) Name the network of capillaries labelled **X**. [1]

.....

(ii) Apart from water and glucose, name **two** substances which will be present in the filtrate. [1]

.....

(iii) Name the process that separates these molecules from the blood plasma. [1]

.....

(iv) The filtration rate is the total volume of filtrate formed per minute.
Explain the effect of a large loss of blood from the body on the filtration rate. [2]

.....

.....

.....

(b) (i) Selective reabsorption occurs in the proximal convoluted tubule. Describe **two** ways in which the cells of the proximal convoluted tubule are adapted for reabsorption. [2]

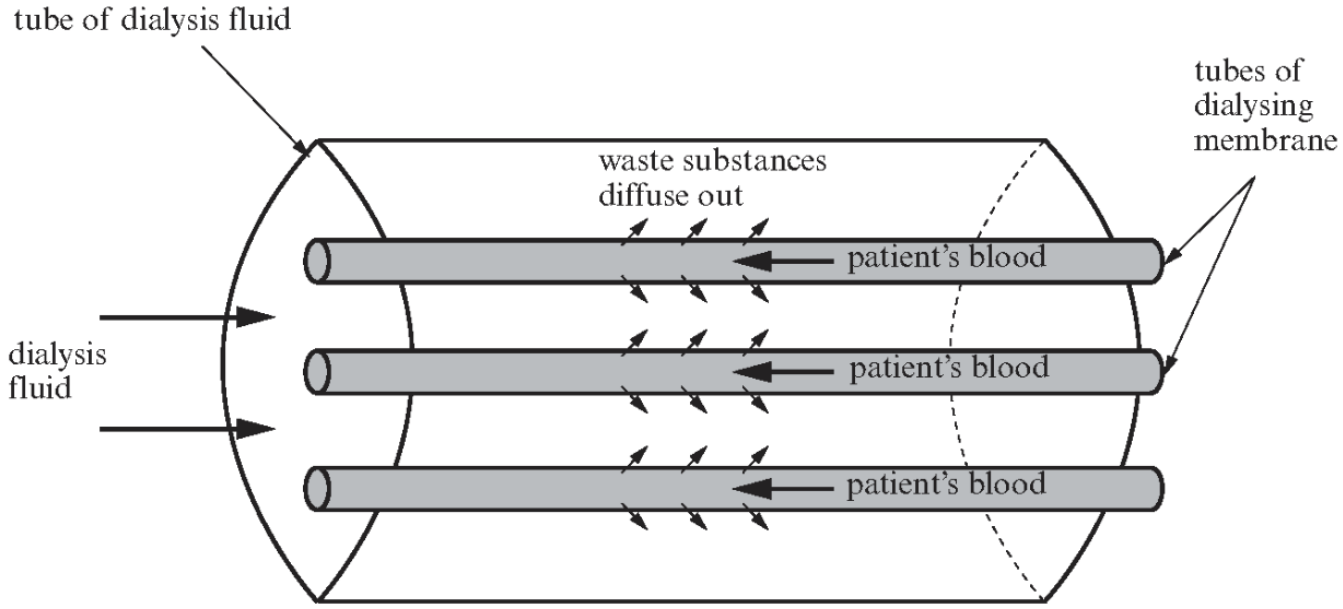
1. .....

2. .....

(ii) Much of the water in the kidney filtrate is reabsorbed from the collecting duct. Name the part of the nephron which provides the osmotic gradient for reabsorption. [1]

.....

(c) (i) With reference to the diagram below, explain the principle of dialysis as used in kidney machines. [4]



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.....

(ii) Suggest what would happen if the glucose concentration of the dialysis fluid were to be a **lower** concentration than in the patient's blood. [1]

.....

(iii) State **one** advantage of providing patients with transplanted kidneys compared with providing them with kidney dialysis machines. [1]

.....

(iv) State **two** problems associated with kidney transplants. [2]

1. .....

2. .....

(Total 16 marks)

11. The glomerulus and Bowman's capsule of the kidney nephron are the site of ultrafiltration.

Image 1 shows the main structures of this part of the nephron. **Image 2** shows an electron micrograph of part of the same structures.

Image 1

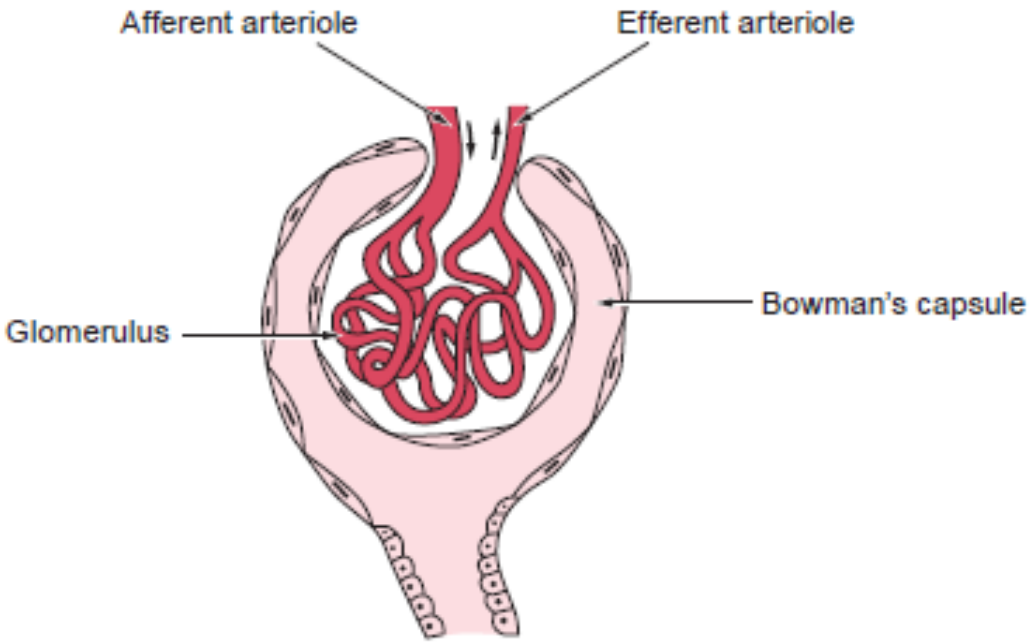
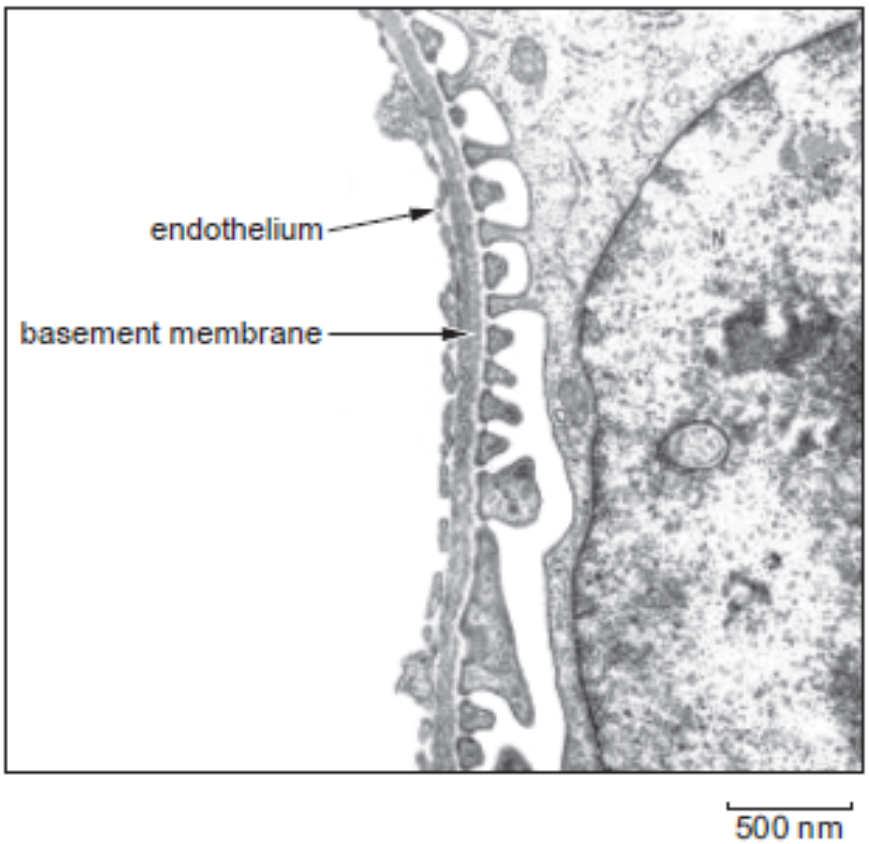


Image 2



(a) (i) On **Image 1**, label with a **P** the part of the nephron where the structures shown in **Image 2** would be found. [1]

(ii) Using the scale bar on **Image 2** only, calculate the magnification of this electron micrograph. [2]

magnification = x .....

(b) The effective pressure which forms the glomerular filtrate is due to several different pressures.

They are:

- the hydrostatic pressure in the glomerulus capillaries
- the osmotic pressure due to plasma proteins
- the intra-renal pressure (the pressure of the fluid already present in the Bowman's capsule and the tubules)

The pressures can be connected using the following formula:

pressure forming glomerular filtrate = hydrostatic pressure in glomerulus − osmotic pressure of plasma − intra-renal pressure

In a healthy adult the osmotic pressure of the plasma is 4 kPa, the intra-renal pressure is 2.6 kPa and the hydrostatic pressure in the glomerulus is 8 kPa.

(i) Calculate the pressure forming the glomerular filtrate. [1]

.....

(ii) Use the information provided to suggest how a low protein diet could affect the rate at which glomerular filtrate is formed. [3]

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(iii) The pressure forming the glomerular filtrate can be regulated. The muscles in the walls of the afferent and efferent arterioles are under hormonal and nervous control.

Describe how changes in the afferent and efferent arterioles could increase the pressure forming the filtrate. [2]

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(c) In diseases such as diabetes mellitus and glomerulonephritis the membranes in the glomerulus and Bowman's capsule are damaged and they become more permeable to proteins.

Suggest **two** reasons why the proteins are not usually reabsorbed back into the bloodstream. [2]

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(d) The urea concentration increases as the filtrate moves along the proximal convoluted tubule. However the mass of urea remains constant.

(i) Explain why the urea concentration increases. [1]

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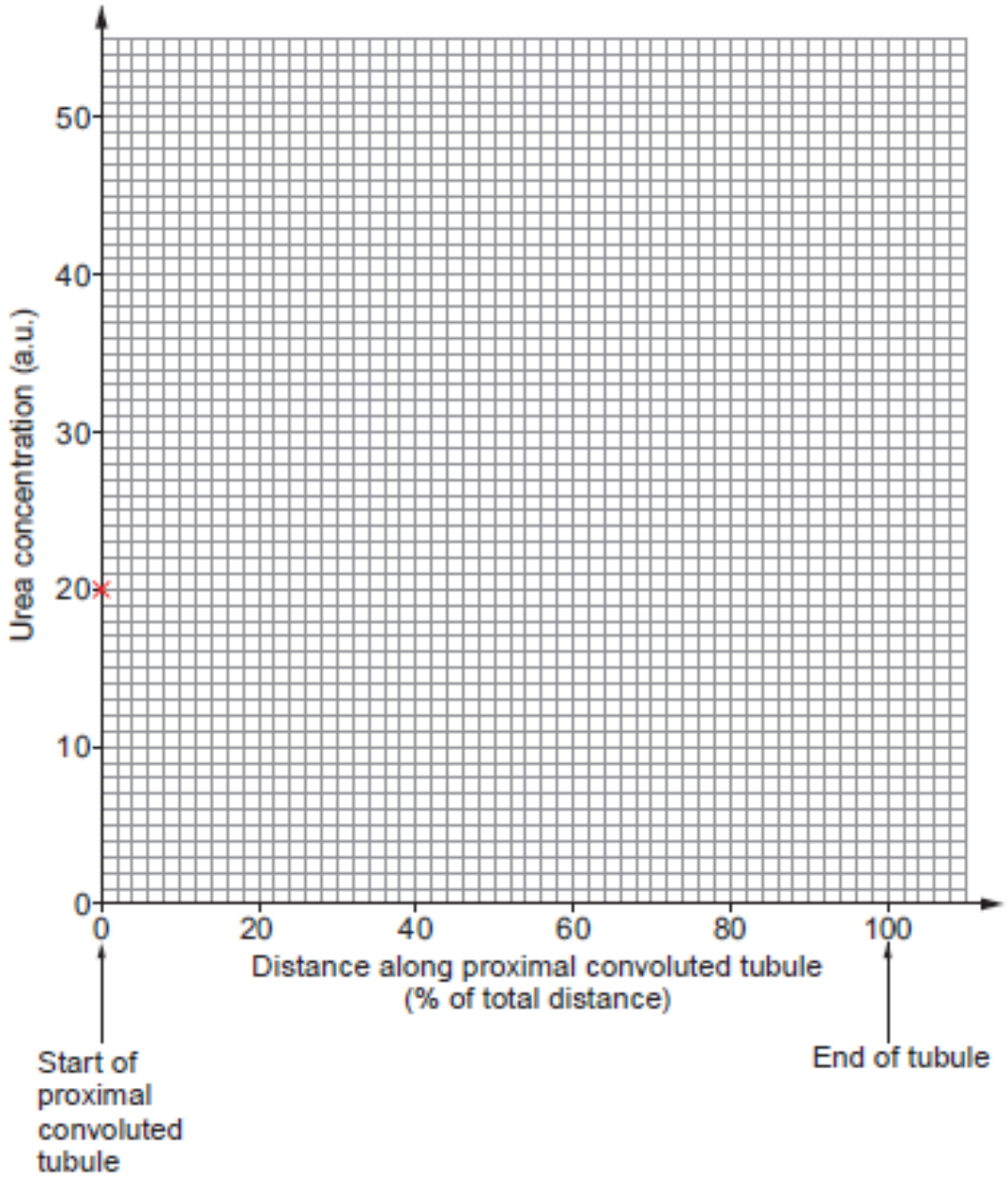
(ii) If the concentration of urea along the proximal convoluted tubule is plotted on a graph, the line of best fit would follow the equation shown below:

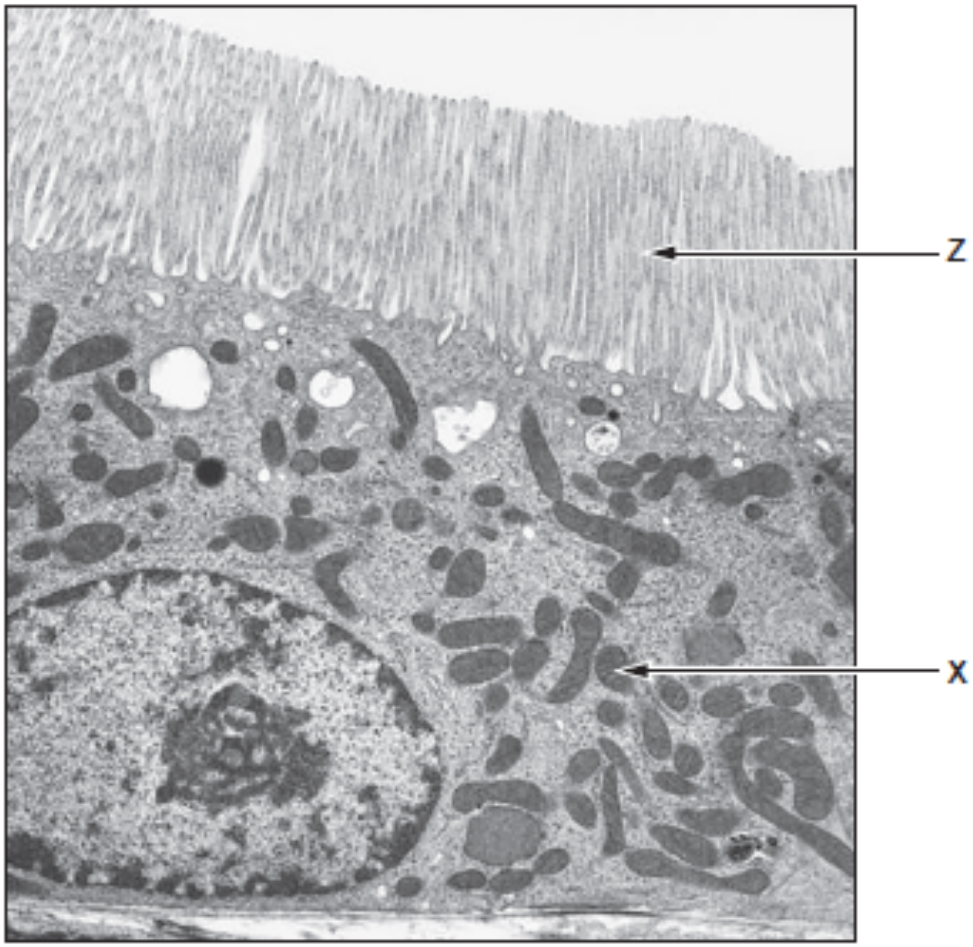
$y = mx + c$

The concentration of urea in the filtrate at the start of the proximal convoluted tubule is 20 arbitrary units (a.u.) and the value of m (the gradient) is 0.2 a.u./%.

Use the values provided to calculate the concentration of urea at the end of the tubule and draw a line on the axes below for the concentration of urea along the length of the proximal tubule. The concentration at the start of the proximal convoluted tubule has been plotted for you. [2]



(e) The electron micrograph below shows a section through the wall of the proximal convoluted tubule.



(i) Explain why there are many of the organelles labelled **X** in the cells shown. [2]

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.....

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.....

(ii) Explain the presence of structures Z on the cell surface. [1]

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(f) Lungfish survive the drying out of their habitats by burrowing into the mud and decreasing their metabolic rate. Explain why, when in water, they release the products of deamination as ammonia but when they are in the dried-out mud, they convert the products to urea. [4]

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12. (a) Kidneys can become damaged by injury or disease.

(i) Give four possible effects of kidney failure.

[4]

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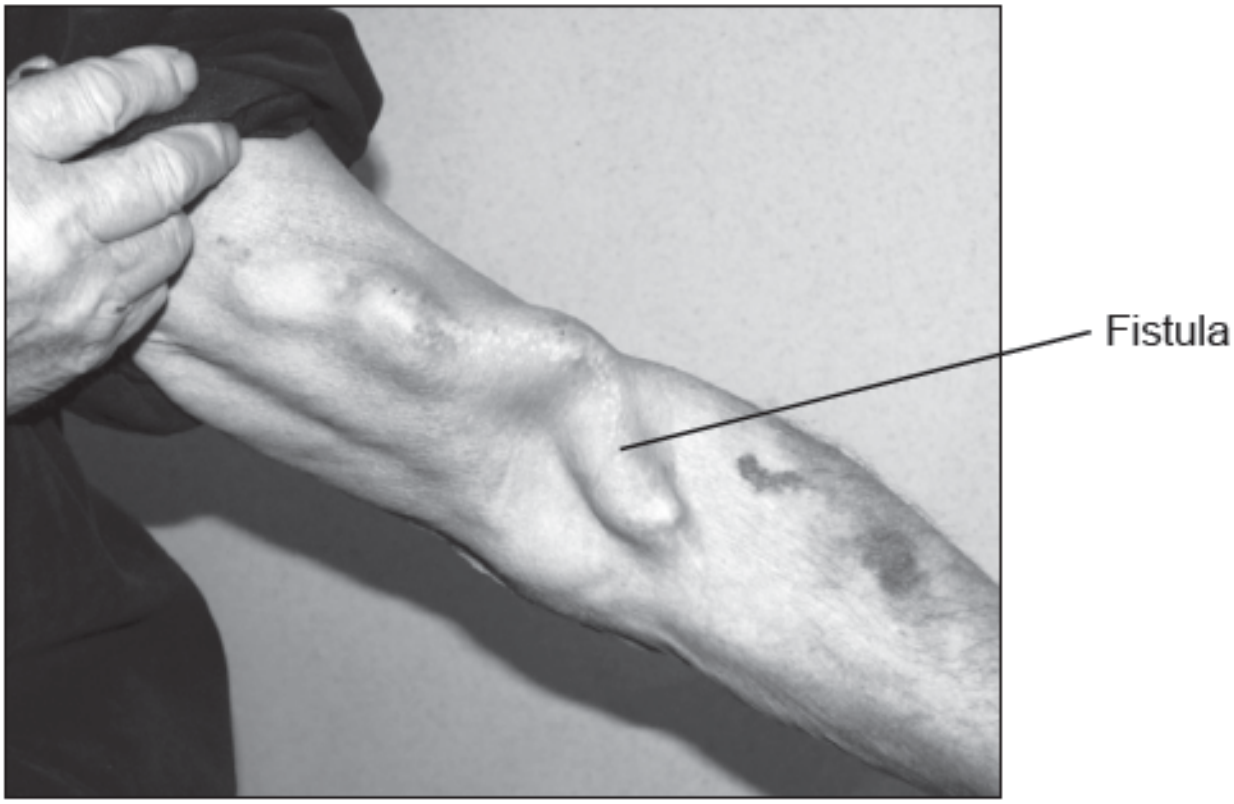
(ii) Suggest why heart disease or the loss of a large volume of blood can lead to kidney failure.

[2]

Patients with kidney failure can be treated using dialysis.

During dialysis blood can be taken from an artery, large vein or a fistula which is created by surgically connecting an artery directly to a vein. The picture below shows the appearance of such a fistula.



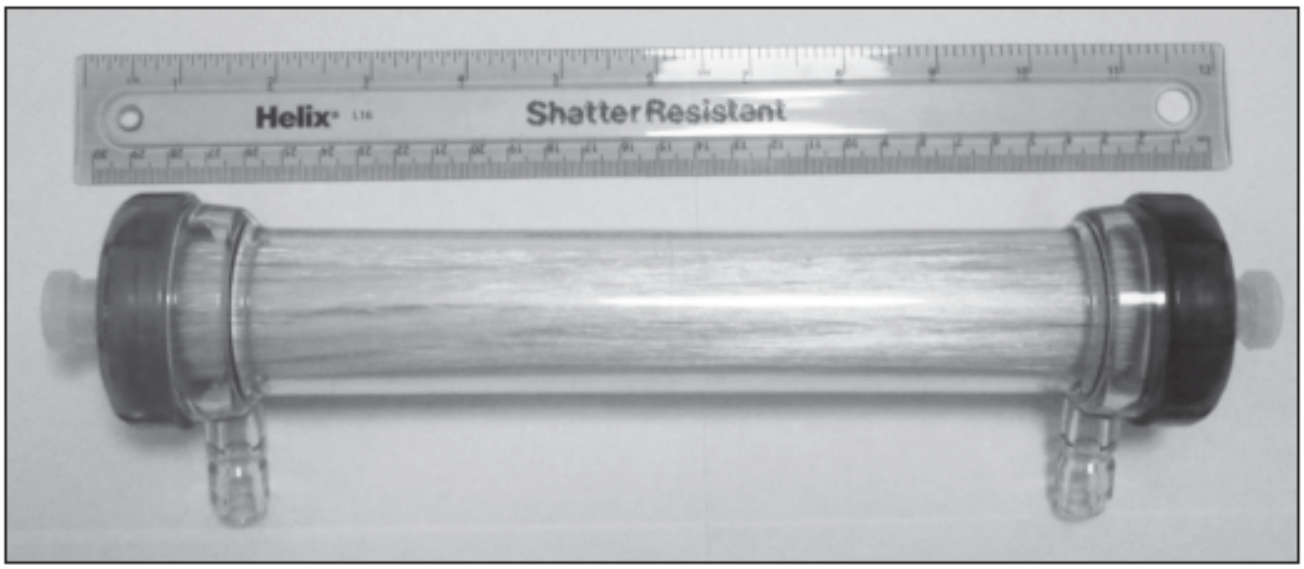
(b) Explain the appearance of the vein shown in the photograph above which forms the fistula.

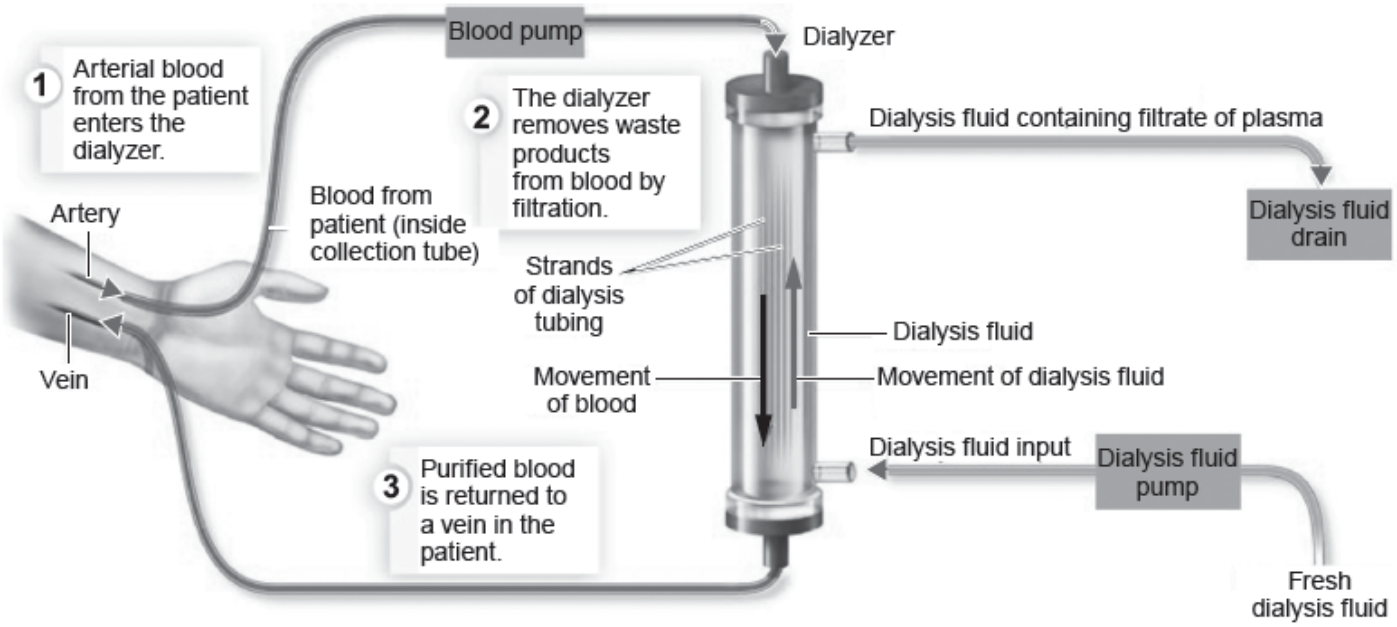
[2]

(c) The blood from the patient is passed through a haemodialysis tube. The tube is made from thousands of very small hollow fibres each made from a partially permeable membrane with pores of various sizes. The partially permeable membrane blocks the passage of cells, platelets and large proteins but will allow solute molecules

through. The dialysisfluid lacks substances such as urea, contains the same concentration of ions such as potassium and calcium and has the same water potential as blood from a person who has functional kidneys.

The following show a picture of a haemodialysis tube and a diagram representing how it is used.





(i) State why the dialysis fluid has to be constantly replaced.

[1]

.....

.....

(ii) Explain why the dialysis fluid moves in the opposite direction to the flow of blood.

[1]

(iii) Explain why during some dialysis treatments calcium ions diffuse from the patient's blood into the dialysis fluid but during others they diffuse from the dialysis fluid into the patient's blood.

[1]

(d) Transplanted kidneys are more efficient than dialysis but there are some issues concerning the technique.

Suggest two reasons against the use of kidney transplants.

[2]

(e) The kidney also acts as an endocrine organ. What is meant by the term endocrine organ?

[1]

13. (a) Name the vessel that brings blood to the kidney.

[1]

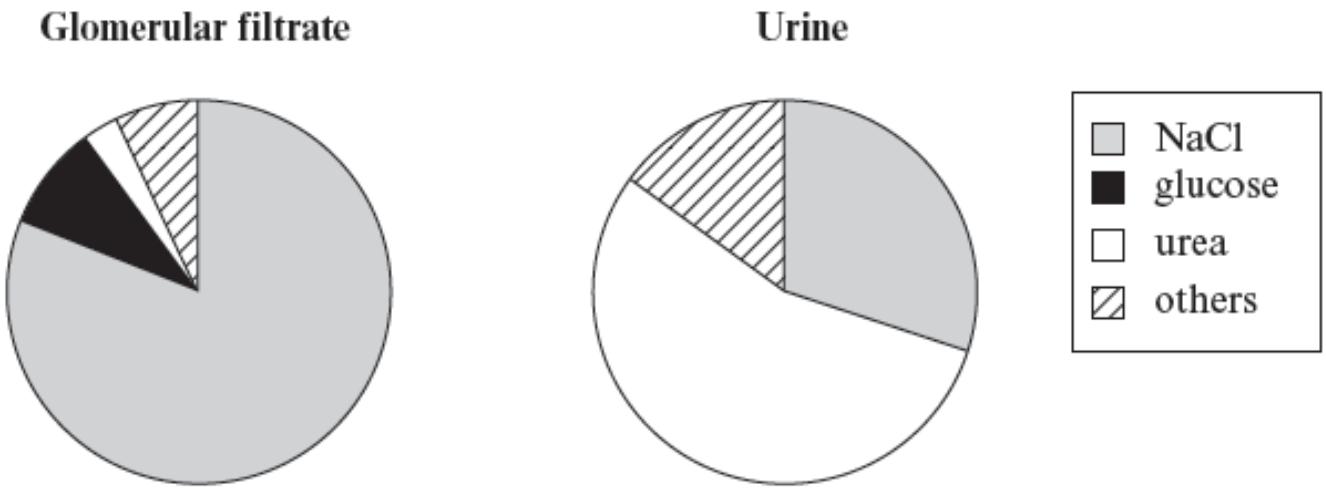
(b) Describe **two structura**l features of glomeruli that allow ultrafiltration to occur.

[2]

1.

2.

Ultrafiltration in the glomerulus results in the production of glomerular filtrate. The pie charts below show the percentage composition of solutes in human glomerular filtrate and in urine.



(c) Using your knowledge of processes occurring in the nephron, explain the difference in glucose concentration between glomerular filtrate and urine shown in the pie charts.

[2]

(d) (i) The urea concentration of urine is much higher than that of glomerular filtrate.

Describe the role of the nephron and collecting duct in achieving this increase in concentration.

[5]

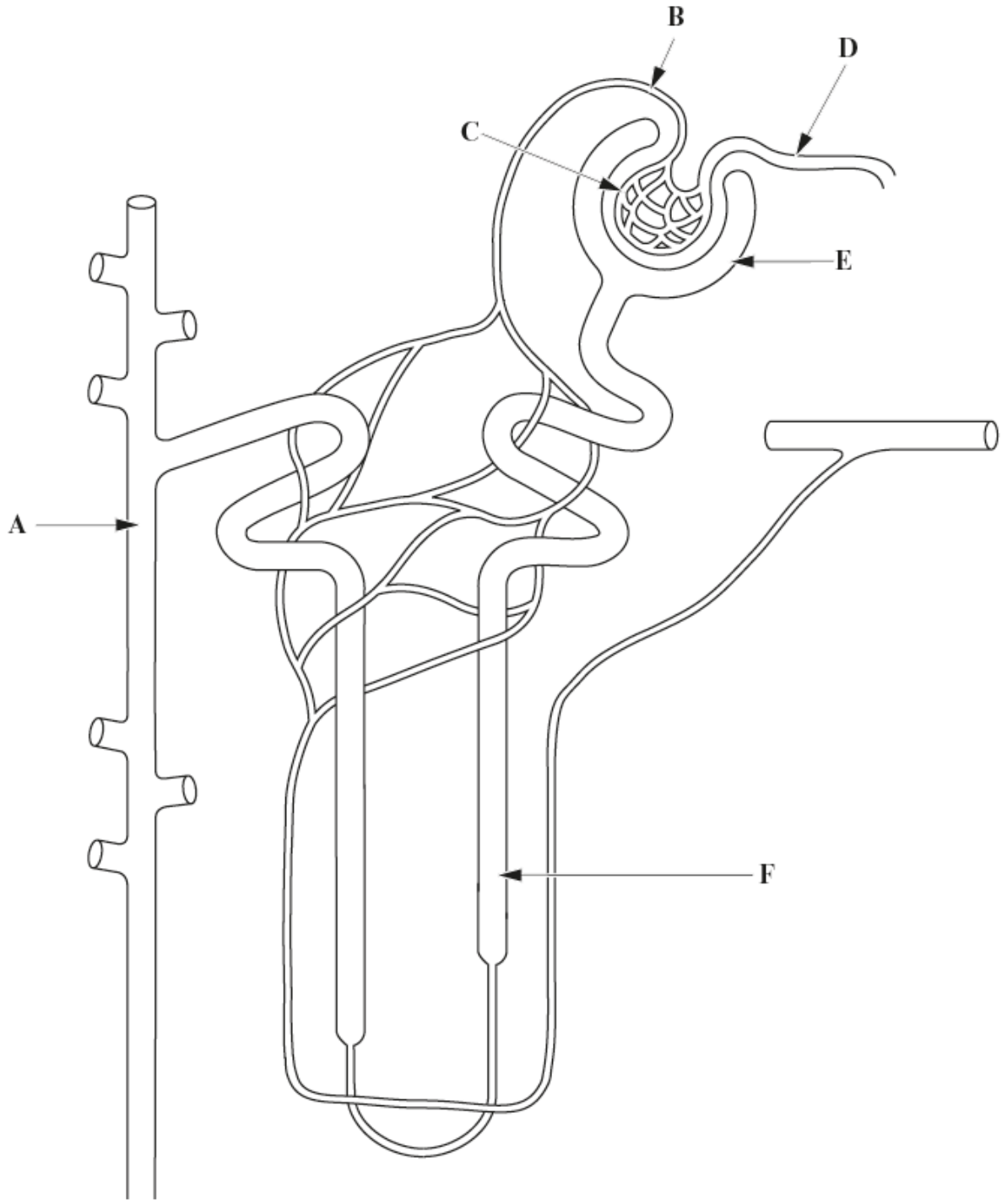
(ii) Suggest an advantage to mammals of excreting urine with a high concentration of urea.

[2]

(e) The concentration of sodium ions in the urine of a person varies. The concentration is affected by the level of a hormone. Name this hormone and explain how it affects the concentration of ions in urine.

[2]

14. The diagram below shows a kidney nephron and part of its blood supply.



(a) (i) Name the structures labelled A-F in the diagram opposite. [3]

A = ...

B = ...

C = ...

D = ...

E = ...

F = ...

(ii) Draw a line labelled **X** on the diagram opposite, to show the part of the nephron where most of the water is reabsorbed.

[1]

(iii) Draw a line labelled **Y** on the diagram opposite, to show the part of the nephron where glucose is reabsorbed.

[1]

(iv) Explain the significance of the differences in diameter between structure **B** and structure **D**.

[2]

(b) The composition of filtrate for a particular substance in a nephron can be expressed as its renal : plasma ratio. This compares the concentration of a substance in the filtrate with that in the blood plasma.

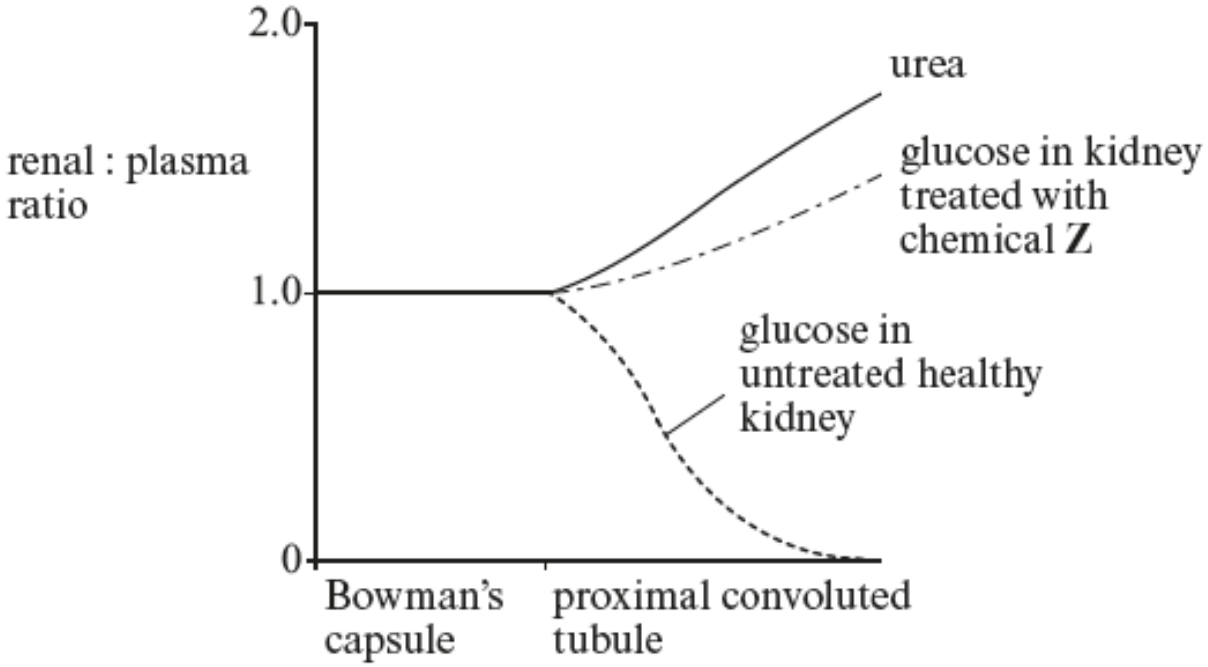
This can be calculated by using the following formula.

$$\text{renal : plasma ratio} = \frac{\text{concentration of substance in filtrate}}{\text{concentration of substance in plasma}}$$

Samples of filtrate were taken from different parts of a nephron and the concentrations of glucose and urea were measured. Their renal : plasma ratios were then calculated.

The kidney was treated with a chemical **Z** and the process was repeated.

The results of this investigation are shown in the graph below.



(i) Explain why urea and glucose have a renal : plasma ratio of 1.0 in the Bowman's capsule.

[3]

(ii) Use figures from the graph opposite to explain why the renal : plasma ratio of urea increases in the proximal convoluted tubule.

[4]

(iii) Use figures from the graph opposite to describe and explain the renal : plasma ratio for glucose in both the untreated healthy kidney and the kidney treated with chemical **Z**.

[3]

(iv) Suggest how chemical **Z** could have caused the effect described in part (iii) above.

[1]

15. *(a)* What is meant by the term excretion? [1]

.....

.....

(b) The table below shows mean fluid intake and urine produced in astronauts studied before and during space flights.

sampling period	mean water intake (cm^3)	mean urine produced (cm^3)	percentage of mean water intake that passes into the urine (%)
day before flight	3800	2700	71.0
during flight	2500	1700	.....

(i) Calculate the percentage of mean water intake that passes into the urine during a flight. Write your answer in the table above. Use the space below for your working out. [1]

(ii) During space flights, the kidneys remove unusually high levels of salts from the blood.

I. What happens to salts removed from the blood by the kidneys? [1]

.....

II. Use data in the table and the information above to describe and explain how the concentration of urine changes during a space flight. [2]

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.....

(iii) Suggest why astronauts are given drinks containing high levels of salts when they return to Earth. [1]

.....

.....

6

16. Explain how anti-diuretic hormone (ADH) helps the kidneys regulate the water content of the blood. [6 QWC]

6

17. **MDMA** (Ecstasy) is an illegal recreational drug which has side-effects including:

- increased body temperature and sweat production
- increased ADH secretion
- increased thirst
- decreased urine output

Furosemide is a prescription drug used to reduce hypertension (high blood pressure) by lowering blood volume. It acts as an inhibitor of sodium ion transport proteins in the ascending limb of the loop of Henle and increases urine output.

Hyponatraemia (low plasma concentration of Na^+) is a condition where the concentration of sodium ions in the plasma falls below normal levels. This can disrupt the transmission of action potentials and lead to muscle weakness, seizures and even coma.

Using your knowledge of urine production, explain how ecstasy reduces urine output and furosemide increases urine output and how misuse of both drugs can result in hyponatraemia.

[9 QER]