AQA A-LEVEL · 7402

BIOLOGY



EXAM QUESTION PACK

3.6.4.3 OSMOREGULATION

SCORE	PERCENTAGE
/163	%

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Q1.

Furosemide and CVT are drugs used to remove excess fluid from the body. Scientists investigated the effect of these drugs on the volume of urine produced by human volunteers. The scientists used the following method.

- They divided volunteers into three groups, **A**, **B** and **C** at random.
- They gave all the volunteers the same food for 3 days.
- After 3 days, they gave the volunteers in group **A** a tablet containing furosemide, the volunteers in group **B** a tablet containing CVT and the volunteers in group **C** a placebo (a tablet that did **not** contain either drug).
- They then found the mean volume of urine produced by each group in the 4 hours after taking the tablets.

Some of the results the scientists obtained are shown in **Table 1**.
A value of ± 2 standard deviations from the mean includes over 95% of the data.

Table 1

Group	Mean volume of urine produced in 4 hours / cm^3 (± 2 standard deviations)
A (furosemide)	1980 (± 152)
B (CVT)	1201 (± 119)
C (placebo)	312 (± 57)

(a) All the volunteers were given the same food for 3 days.

Suggest and explain **one** reason why they were given the same food.

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(2)

(b) Using **Table 1**, what can you conclude about the effectiveness of furosemide and CVT in the removal of excess fluid from the body?

(2)

(c) Furosemide is sometimes used to treat high blood pressure.

Suggest how furosemide would cause a decrease in blood pressure.

(1)

(d) Furosemide inhibits the absorption of sodium and chloride ions from the filtrate produced in the nephrons.

Explain how furosemide causes an increase in the volume of urine produced.

(3)

The scientists also measured the mean rate of flow of blood plasma into the kidneys.

The results the scientists obtained are shown in **Table 2**.

Table 2

Group	Mean rate of flow of blood plasma into the kidneys / cm^3 min^{-1}

A (furosemide)	380
B (CVT)	342
C (placebo)	295

(e) The mean rate of flow of blood plasma is 60% of the mean rate of blood flow into the kidneys.

How much greater is the flow of blood into the kidneys with furosemide than with group **C** (placebo) over the 4 hours of the investigation? Give your answer in cm^3.

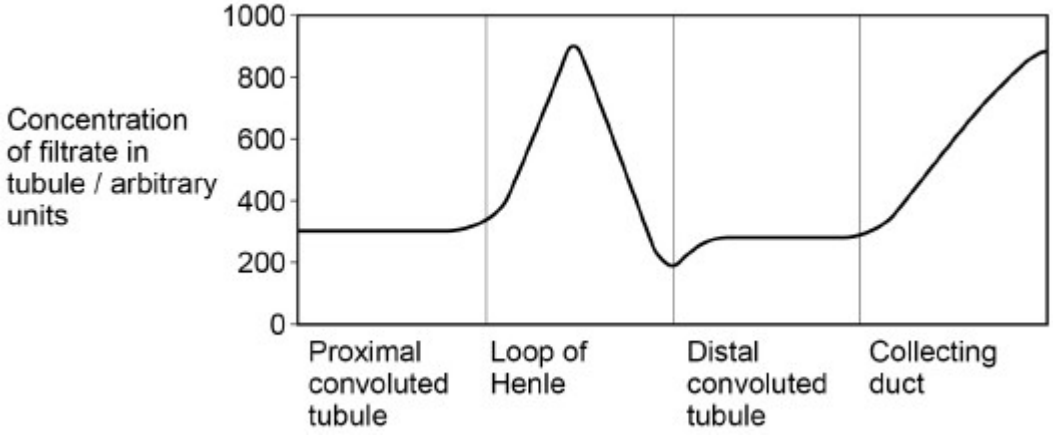
Answer = _____ cm^3

(1)

(Total 9 marks)

Q2.

The graph below shows the concentration of the filtrate in different parts of one kidney tubule.



(a) More than 99% of biological molecules are reabsorbed from the filtrate in the proximal convoluted tubule.

Despite this, the concentration of fluid in this tubule remains constant.

Explain why.

_____

_____

_____

(1)

(b) Explain the shape of the curve in the loop of Henle in the graph.

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(3)

(c) What is the evidence in the graph that this person was secreting antidiuretic hormone (ADH)?

Explain your answer.

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(2)

(Total 6 marks)

Q3.

Osmoreceptors are specialised cells that respond to changes in the water potential of the blood.

(a) Give the location of osmoreceptors in the body of a mammal.

_____

_____

(1)

(b) When a person is dehydrated, the cell volume of an osmoreceptor decreases. Explain why.

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(2)

(c) Stimulation of osmoreceptors can lead to secretion of the hormone ADH. Describe and explain how the secretion of ADH affects urine produced by the kidneys.

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(4)

The efficiency with which the kidneys filter the blood can be measured by the rate at which they remove a substance called creatinine from the blood. The rate at which they filter the blood is called the glomerular filtration rate (GFR).

In 24 hours, a person excreted 1660 mg of creatinine in his urine. The concentration of creatinine in the blood entering his kidneys was constant at 0.01 mg cm^{-3}.

(d) Calculate the GFR in cm^3 $minute^{-1}$.

Answer = _____

(1)

(e) Creatinine is a breakdown product of creatine found in muscle tissues. Apart from age and gender, give **two** factors that could affect the concentration of creatinine in the blood.

1. _____

2. _____

(1)

(Total 9 marks)

Q4.

In a mammal, urea is removed from the blood by the kidneys and concentrated in the filtrate.

(a) Describe how urea is removed from the blood.

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(2)

(b) Explain how urea is concentrated in the filtrate.

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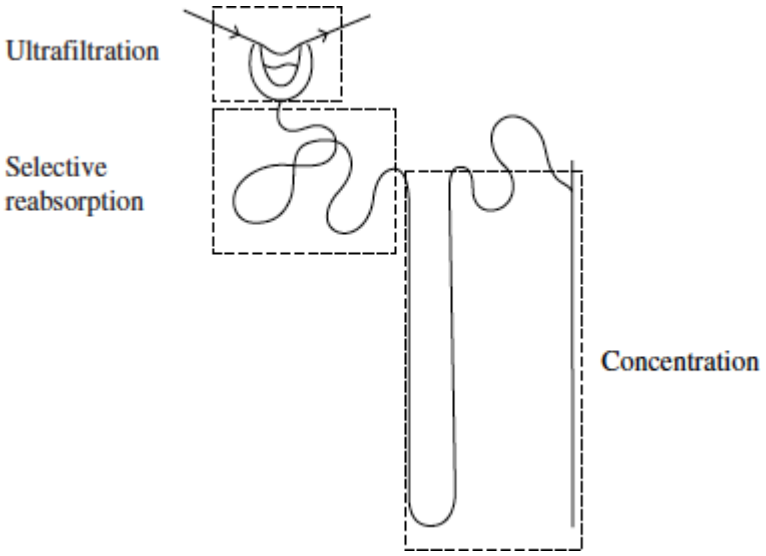
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(3)

(Total 5 marks)

Q5.

Three processes are involved in the formation of urine in a mammalian kidney. These are ultrafiltration, selective reabsorption and concentration. The diagram shows where these processes take place in a nephron.



(a) Describe how ultrafiltration produces glomerular filtrate.

(5)

(b) Some people who have diabetes do not secrete insulin. Explain how a lack of insulin affects reabsorption of glucose in the kidneys of a person who does not secrete insulin.

_____

(4)

(c) Some desert mammals have long loops of Henle and secrete large amounts of antidiuretic hormone (ADH). Explain how these two features are adaptations to living in desert conditions.

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(6)

(Total 15 marks)

Q6.

(a) A diabetic person and a non-diabetic person each ate the same amount of glucose. One hour later, the glucose concentration in the blood of the diabetic person was higher than that of the non-diabetic person. Explain why.

_____

_____

_____

_____

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_____

(3)

(b) (i) The urine of a non-diabetic person does **not** contain glucose. Explain why.

_____

_____

_____

_____

(2)

(ii) A high blood glucose concentration could cause glucose to be present in the urine of a diabetic person. Suggest how.

_____

_____

_____

_____

(2)

(c) A test for glucose in urine uses immobilised enzymes on a plastic test strip. One of these enzymes is glucose oxidase. Explain why the test strip detects glucose and no other substance.

_____

_____

_____

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(2)

(d) If the glomerular filtrate of a diabetic person contains a high concentration of glucose, he produces a larger volume of urine. Explain why.

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(3)

(e) In some forms of kidney disease, proteins from the blood plasma are found in the urine. Which part of the nephron would have been damaged by the disease to cause proteins from blood plasma to be present in the urine? Explain your answer.

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(3)

(Total 15 marks)

Q7.

The kangaroo rat is a small desert mammal. It takes in very little water in its food and it rarely drinks. Its core body temperature is 38 °C.

The kangaroo rat takes in some water by feeding and drinking. Describe another method by which the kangaroo rat could obtain water.

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(Total 2 marks)

Q8.

(a) The control of water balance in the body involves negative feedback.

(i) Describe what is meant by *negative feedback*.

_____

_____

_____

(1)

(ii) Water is removed from the body via the kidneys. Give **two** other ways in which water is removed from the body.

1. _____

2. _____

(2)

(iii) Name the part of the brain which acts as the coordinator in the control of water balance.

_____

(1)

(b) **Figure 1** shows the cells lining the collecting duct in a human kidney. ADH molecules bind to the receptor proteins and this triggers the vesicles containing aquaporins to bind with the plasma membrane next to the lumen. **Figure 2** shows an aquaporin which is a large channel protein.

Figure 1

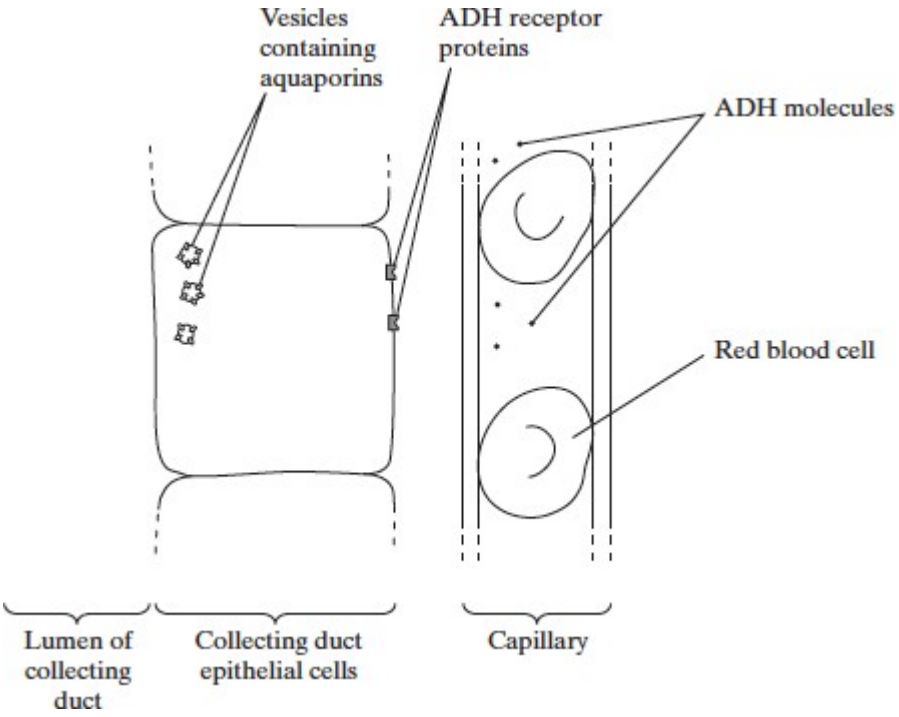
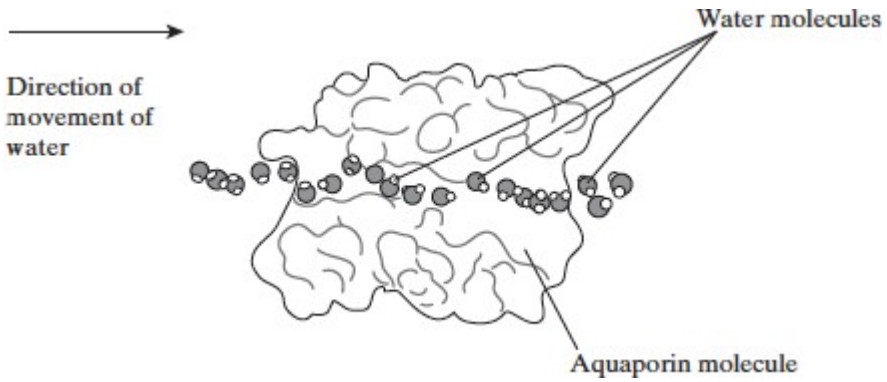


Figure 2



(i) From which gland is ADH released?

_____

(1)

(ii) Use the information given to explain how ADH increases the movement of water from the lumen of the collecting duct into the blood.

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(4)

(c) The gene for the ADH receptor proteins is found on the X chromosome. One allele of this gene causes a non-functioning receptor protein to be made. This allele is recessive and is one cause of the condition called diabetes insipidus.

(i) What would be the most obvious symptom of diabetes insipidus?

_____

(1)

(ii) Suggest why diabetes insipidus is more common in males.

_____

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(2)

(iii) A recessive allele which has harmful effects is able to reach a higher frequency in a population than a harmful dominant allele. Explain how.

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(3)

(Total 15 marks)

Q9.

(a) The table shows the concentrations of dissolved substances in different regions of a nephron in a kidney in the presence and in the absence of antidiuretic hormone (ADH).

Region of nephron	**Concentration of dissolved substances / arbitrary units**	
	ADH present	**ADH absent**
First convoluted tubule	300	300
Bend of loop of Henle	1000	1000
Start of second convoluted tubule	150	150

Middle of second convoluted tubule	250	90
Start of collecting duct	300	50
End of collecting duct	1000	50

Describe and explain the effect of ADH on the volume and concentration of urine produced by the kidney. Give evidence from the table to support your answer.

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(3)

(b) Glomerulosclerosis is a disease in which the glomeruli of the kidney are damaged. Explain why protein is not normally present in the urine of a healthy person but may be present in the urine of a person with glomerulosclerosis.

_____

_____

_____

_____

(2)

(Total 5 marks)

Q10.

Mammals and fish remove nitrogenous waste from their bodies in different forms.

(a) Name **two** polymers present in mammals and fish that contain nitrogen.

1. _____

2. _____

(2)

(b) In a mammal urea is removed from the blood by the kidneys and concentrated in the filtrate.

(i) Describe how urea is removed from the blood.

_____

_____

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(2)

(ii) Explain how urea is concentrated in the filtrate.

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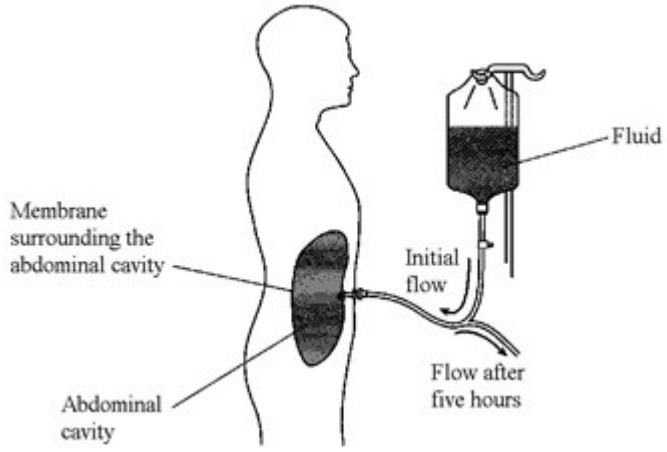
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(4)

(c) The diagram shows one way in which a person who has kidney disease can have the condition managed. In the process a fluid is put into the abdominal cavity. Exchange of materials takes place across the membrane that surrounds the abdominal cavity. This removes waste products from the blood. After five hours the fluid is drained out of the cavity and discarded. The cavity is then refilled with fresh fluid.



The table shows the concentration of solutes in the fresh fluid.

Solute	Concentration / mmol dm^{-3}
Sodium ions (Na^+)	132
Chloride ions (Cl^-)	96
Calcium ions (Ca^{2+})	1.25

Magnesium ions (Mg^{2+})	0.25
Glucose	76
Urea	0

(i) By what process does urea enter the fluid in the abdominal cavity from the blood?

_____

(1)

(ii) Explain why the fluid is changed every five hours.

_____

_____

(1)

(iii) Fluid of the composition shown in the table is used instead of distilled water. Explain why.

_____

_____

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(2)

(Total 12 marks)

Q11.

Anti-diuretic hormone (ADH) is released into the blood in response to a shortage of water in the body. ADH enters the collecting duct cells in nephrons and causes the increased synthesis of one type of protein molecule. These protein molecules are inserted into the plasma membranes of the collecting duct cells where they act as channels. Only water molecules can pass through these channels, increasing the reabsorption of water from the kidney filtrate.

(a) Name the gland which releases ADH.

_____

(1)

(b) (i) Explain how the structure of protein molecules allows them to form channels through which only water molecules can pass.

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(2)

(ii) Explain how the cells of the collecting duct are able to absorb water from the filtrate through the protein channels in their plasma membranes.

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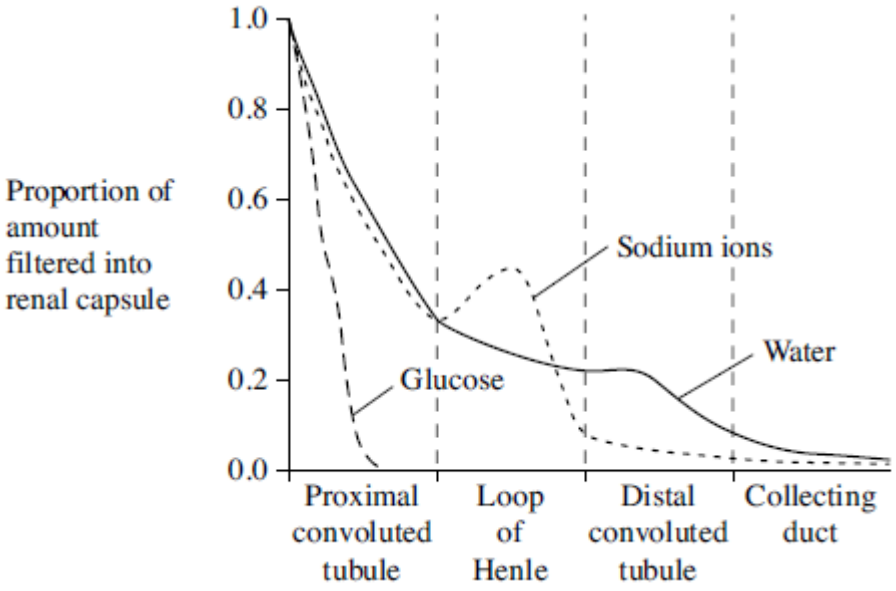
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(2)

(Total 5 marks)

Q12.

The graph shows changes in the amounts of water, glucose and sodium ions as fluid passes along a kidney tubule from the renal capsule to the collecting duct.



(a) Which hormone causes the decrease in the water content in the distal convoluted tubule?

_____

(1)

(b) Explain the change in the amount of glucose.

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(2)

(c) Explain the shape of the curve for sodium ions in the loop of Henle.

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(3)

(Total 6 marks)

Q13.

In the kidney, ultrafiltration and selective reabsorption are two of the processes involved in the formation of urine.

(a) (i) Where does ultrafiltration occur?

_____

(1)

(ii) Give **one** component of the blood which is not normally present in the filtrate.

_____

(1)

(b) The kidneys remove a substance called creatinine from the blood. The rate of creatinine removal is a measure of the rate of filtration of the blood.

In one hour, a person excreted 75 mg of creatinine in his urine. The concentration of creatinine in the blood entering his kidneys was constant at 0.01 mg cm^{-3}.

Calculate the rate at which the blood was filtered in cm^3 min^{-1}. Show your working.

Filtration rate = _____ cm^3 min^{-1}

(2)

(c) Reabsorption of glucose takes place in the proximal tubule. Explain how the cells of the proximal tubule are adapted for this function.

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(2)
(Total 6 marks)

Q14.

(a) What is homeostasis?

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(1)

(b) Describe the role of the hormone glucagon in the control of blood sugar concentration.

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(4)

(c) The kidney removes various substances from the blood plasma. The clearance value for a substance is the volume of blood cleared of that substance by the kidney in one minute. This clearance value can be calculated using the equation.

$$C = \frac{U \times V}{P}$$

where the concentration of a substance in the blood is	P g cm^{-3}
the concentration of a substance in the urine is	U g cm^{-3}
the volume of urine produced is	V cm^3 per minute

(i) Use the equation to work out the clearance value of glucose.

_____

_____

(1)

(ii) Explain how the activity of the kidney results in this clearance value for glucose.

_____

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(3)

(Total 9 marks)

Q15.

(a) Humans can produce urine which is more concentrated than their blood plasma.

(i) Explain the role of the loop of Henle in the absorption of water from the filtrate.

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(6)

(ii) Explain the role of ADH in the production of concentrated urine.

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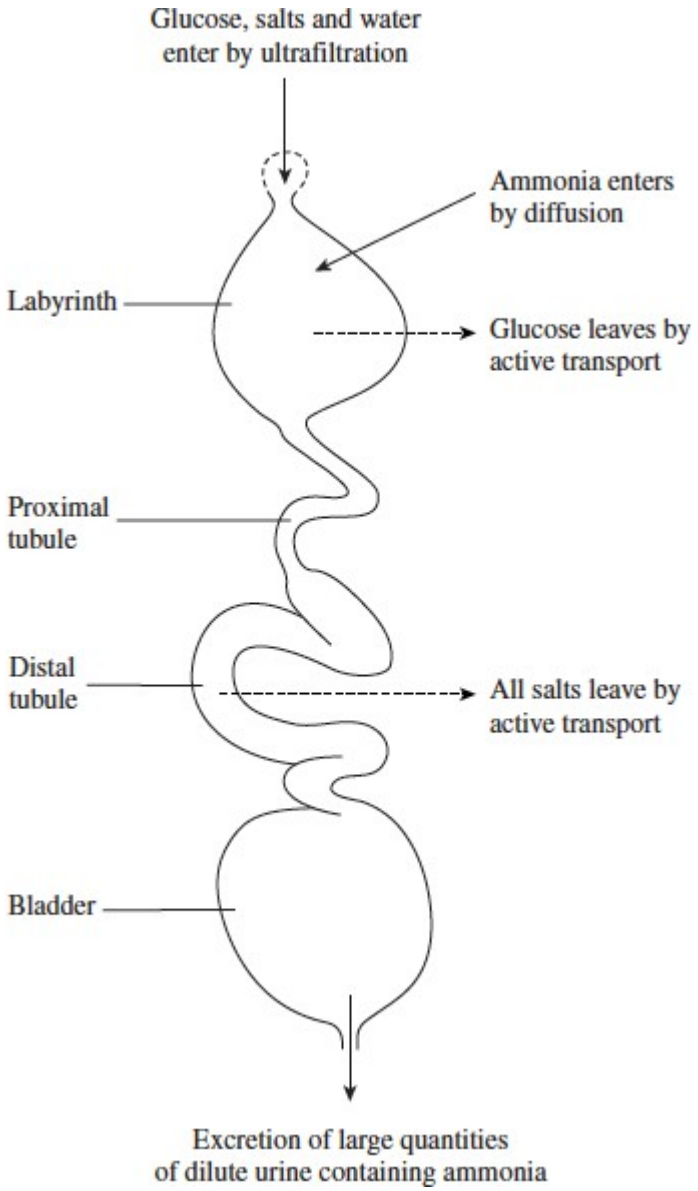
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(4)

(b) A species of crayfish lives in fresh water. This crayfish does not have kidneys but it does have an organ which excretes nitrogenous waste and controls the amount of water in its body. The diagram shows this excretory organ.



(i) Describe how excretion in this organ differs from excretion in a human nephron.

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(3)

(ii) Suggest how the production of large amounts of dilute urine enables the crayfish to survive in fresh water.

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_____

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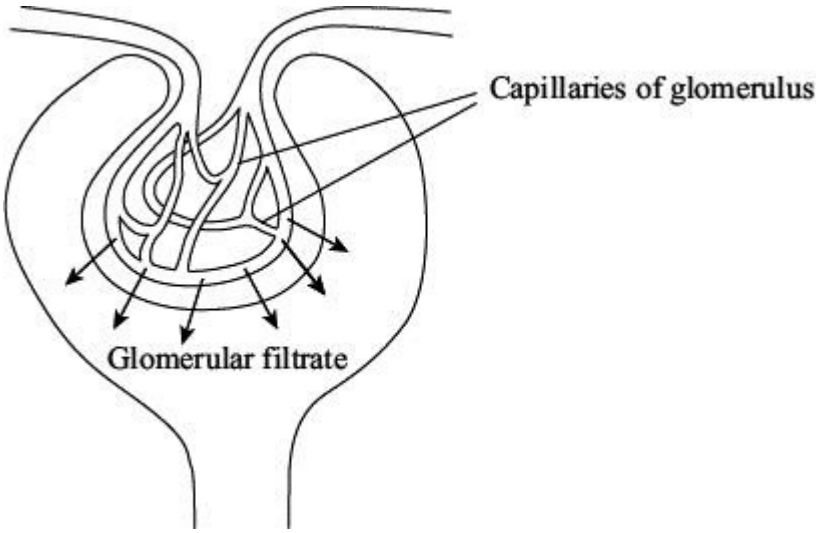
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(2)

(Total 15 marks)

Q16.

The diagram shows a renal capsule where ultrafiltration occurs in the kidney.



(a) Apart from water and glucose, name **two** substances which will be present in the glomerular filtrate.

1. _____

2. _____

(1)

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

_____

_____

_____

_____

(2)

(c) Selective reabsorption from the glomerular filtrate occurs in the proximal convoluted tubule. Explain **two** ways in which the cells of the proximal convoluted tubule are adapted for reabsorption.

1. _____

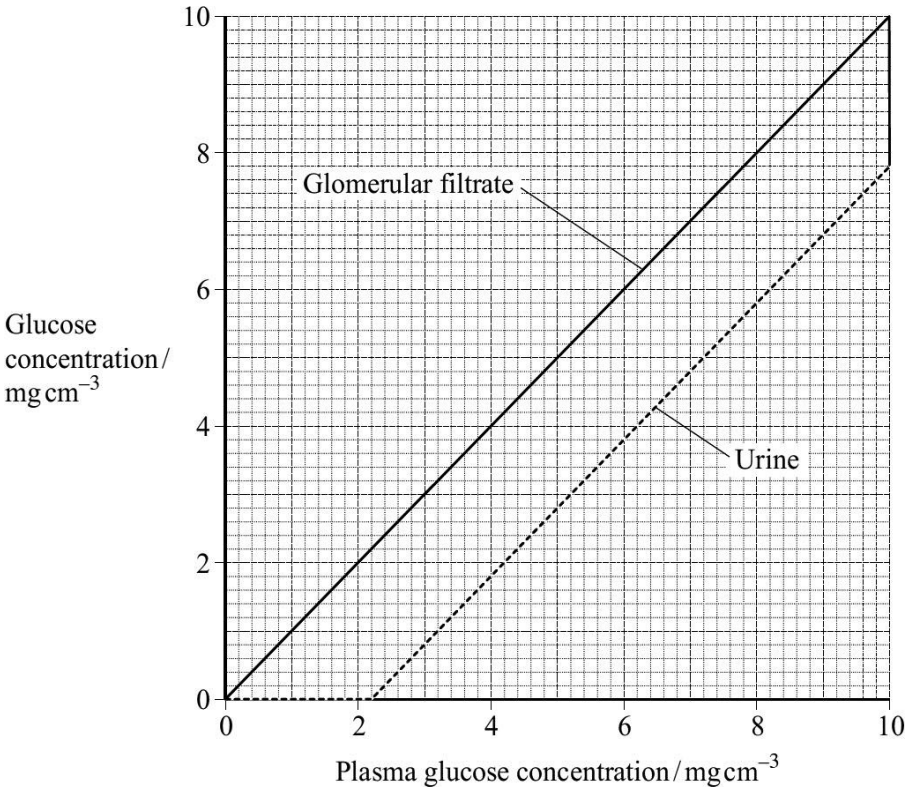
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2. _____

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(2)

(d) The threshold value is the maximum plasma glucose concentration at which all the glucose can be reabsorbed from the filtrate. An investigation was carried out to determine the threshold value for glucose reabsorption in the kidneys of a mammal.The graph shows the results.



(i) Explain the change in the glucose concentration in the urine as the plasma glucose concentration increases from 0 to 4 mgcm^{-3}.

_____

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(2)

(ii) A person with diabetes may have a plasma glucose concentration greater than the threshold value for glucose reabsorption. Explain what causes this raised plasma glucose concentration.

_____

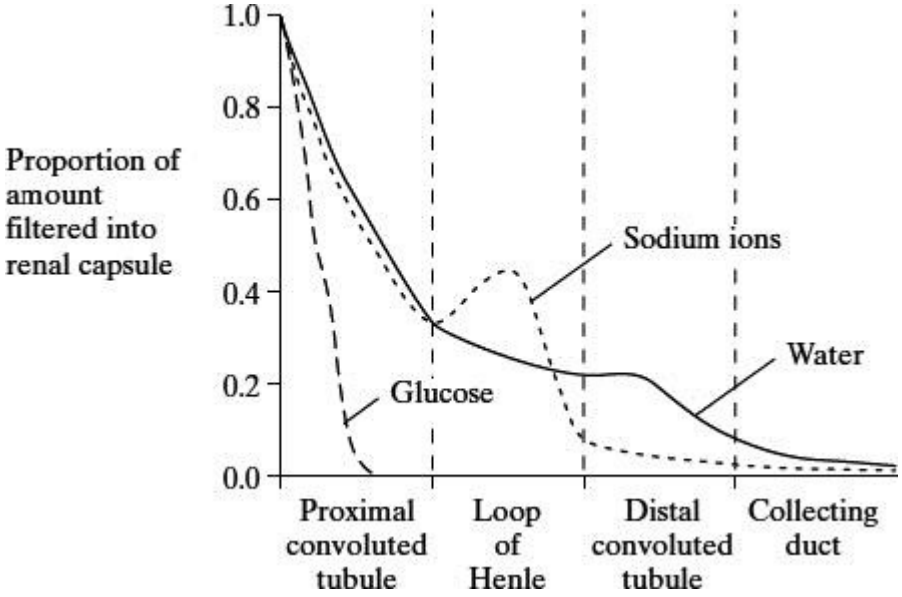
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(1)

(Total 8 marks)

Q17.

The graph shows changes in the amounts of water, glucose and sodium ions as fluid passes along a kidney tubule from the renal capsule to the collecting duct



(a) Which hormone causes the decrease in the water content in the distal convoluted tubule?

_____

(1)

(b) Explain the change in the amount of glucose.

_____

_____

_____

_____

(2)

(c) Explain the shape of the curve for sodium ions in the loop of Henle.

_____

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(3)

(Total 6 marks)

Q18.

Answers should be written in continuous prose, where appropriate.
Quality of Written Communication will be assessed in these answers.

The kidney plays an important part in the regulation of blood water potential. This involves control of the amount of water reabsorbed from the filtrate produced in the kidney tubules. The amount of water reabsorbed affects the volume of urine produced, the rate at which the bladder fills and how often it has to be emptied.

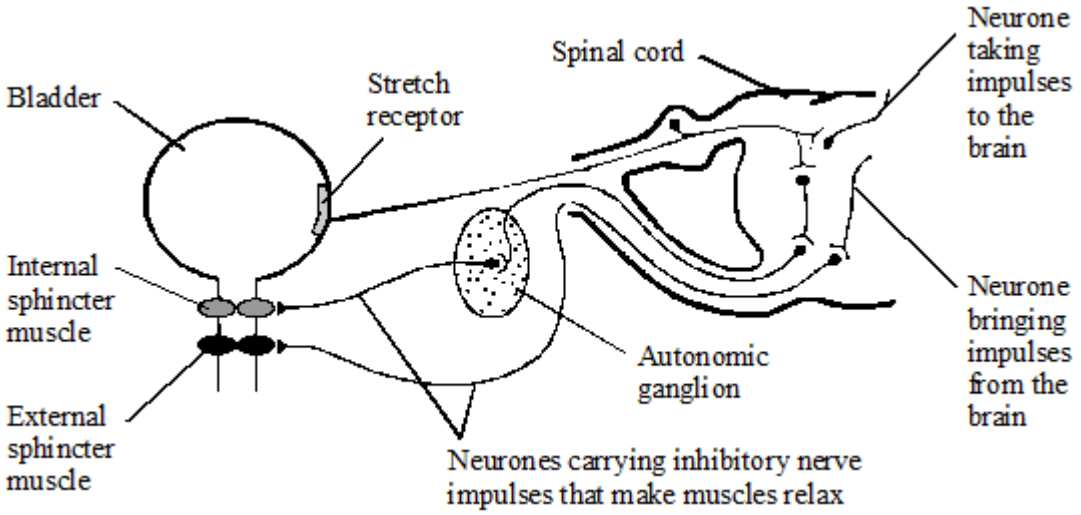
(a) Explain how the loop of Henle maintains the gradient of ions which allows water to be reabsorbed from filtrate in the collecting duct.

(5)

(b) Explain how ADH is involved in the control of the volume of urine produced.

(4)

(c) The diagram shows the systems involved in controlling the emptying of the bladder. In babies, emptying of the bladder is controlled by an autonomic reflex involving the internal sphincter muscle. Conscious control is learnt between the ages of two and three and involves the external sphincter as well.



Using information in the diagram, explain how the autonomic reflex arc is different from a simple reflex arc involving voluntary muscle;

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_____

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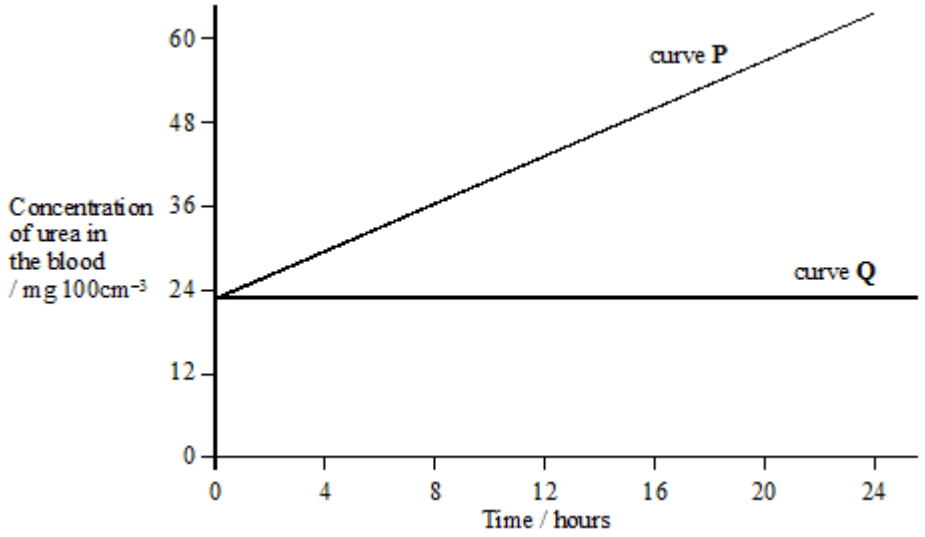
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(2)

(Total 11 marks)

Q19.

The graph shows the concentration of urea in the blood of a mammal after the kidneys stopped working (**P**) and after both the kidneys and the liver stopped working (**Q**).



(a) Explain how the evidence from the graph shows **one** function of

(i) the kidneys;

Function _____

Evidence from graph _____

_____

(1)

(ii) the liver.

Function _____

Evidence from graph _____

_____

(1)

(b) On the graph, draw the curve you would expect if the liver stopped working at time 0, and the kidneys stopped working 12 hours later.

(2)

(Total 4 marks)