A-Level Biology

Osmoregulation

Question Paper

Time available: 80 minutes
Marks available: 63 marks

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1. (a) Describe how ultrafiltration occurs in a glomerulus.

(3)

(b) Glucose and water are reabsorbed by the proximal convoluted tubule of a nephron.

Put a tick (✓) in the box next to the correct ways in which glucose and water are reabsorbed.

Glucose by active transport and water against a water potential gradient	☐
Glucose by diffusion and water down a water potential gradient	☐
Glucose by facilitated diffusion and active transport and water against a water potential gradient	☐
Glucose by facilitated diffusion and active transport and water down a water potential gradient	☐

(1)

(c) The equation shows the relationship between urine concentration in arbitrary units (y) and mean length of the loop of Henle in mm (x).

$$y = 0.72x + 4$$

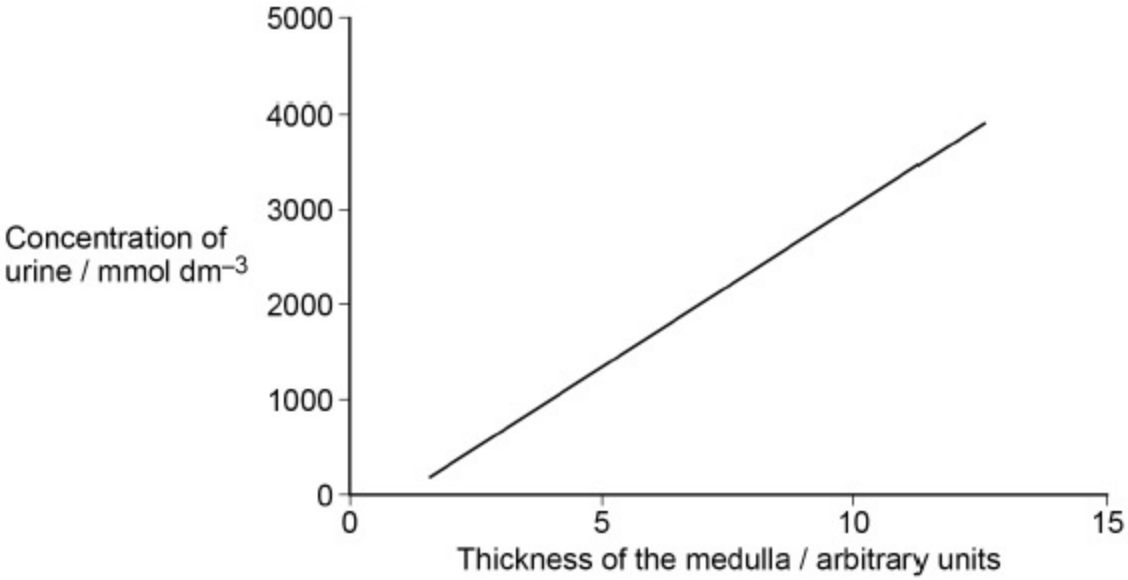
Calculate the mean length of the loop of Henle in an organism that produces urine with a concentration of 16.56 arbitrary units.

Answer = _____ mm

(1)

(d) Scientists investigated the relationship between the thickness of the kidney medulla of different species of mammals and the concentration of their urine.

The graph shows their results.

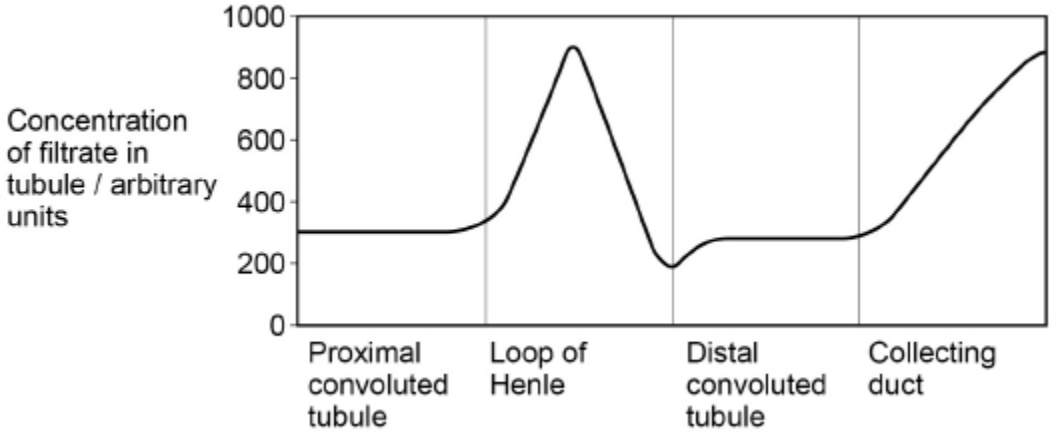


Explain the pattern shown by the results in the graph above.

(3)

(Total 8 marks)

2. 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.

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(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.

(2)

(Total 6 marks)

3. 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.

(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)

4. 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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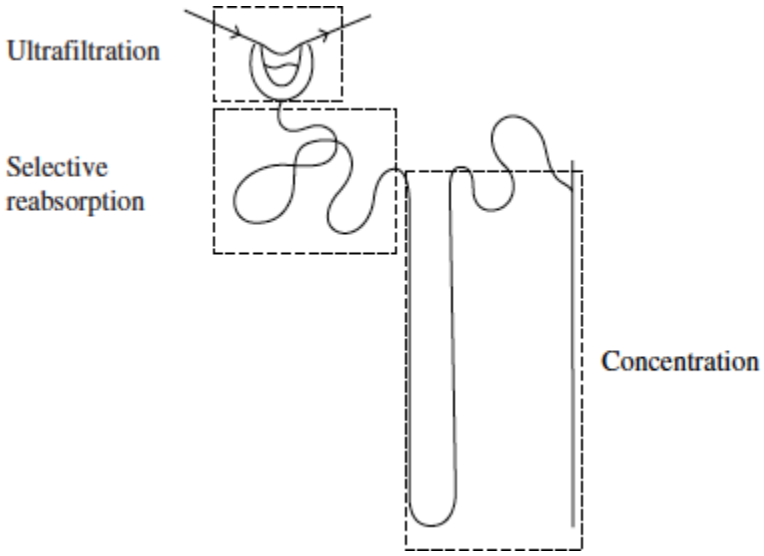
(3)

(Total 5 marks)

5. 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.

(6)

(Total 15 marks)

6. (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.

(3)

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

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(2)

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

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(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.

(3)

(Total 15 marks)

7. (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.

(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.

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(2)

(Total 5 marks)