

Urinary System and Kidneys

Mark Scheme



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1. The urinary system, particularly the kidneys, plays a crucial role in maintaining homeostasis within the body. Answer the following questions. Circle the letter of the correct answer for each.

- a) Where is urea formed in the body?

B – is the only correct answer.	1 mark
	Total: 1 mark

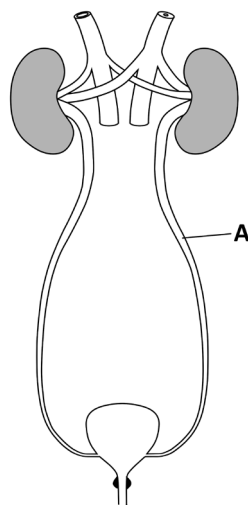
- b) In a healthy person, which of the structures below contain the least urea?

A – is the only correct answer.	1 mark
	Total: 1 mark

- c) Which of the following does **not** occur in the kidneys?

C – is the only correct answer.	1 mark
	Total: 1 mark

- d) The figure below shows the urinary system of a human.



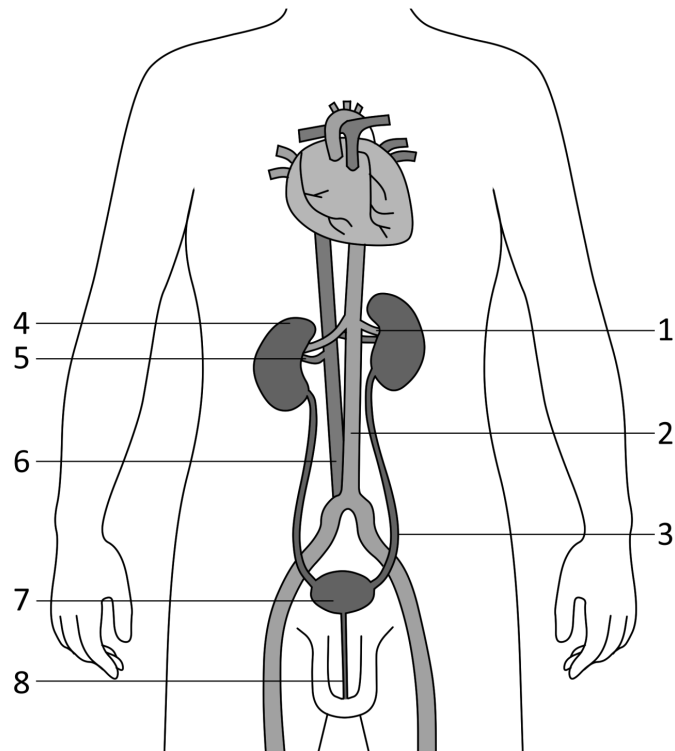
What is the part labelled A?

C – is the only correct answer.	1 mark
	Total: 1 mark

(Total for Question 1 is 5 marks)

2. The figure below shows the urinary system of a human male.

a) Identify the structures labelled 1 to 8.



1 = Renal artery	
2 = Aorta	
3 = Ureter	
4 = Kidney / Right kidney	
5 = Renal vein	
6 = Vena cava	
7 = Bladder	
8 = Urethra	
Award 1 mark for each <u>correct pair</u> of labels.	
	Total: 4 marks

b) Explain why the presence of protein in the urine of this patient indicates a problem with the glomeruli.

An explanation to include any three of the following: Allow too big.	
Normally protein molecules are large / too large. Allow: cannot be filtered out of the blood.	1 mark
So, cannot pass through the (glomerulus / Bowman's capsule) filter / membrane.	1 mark
(Presence in urine indicates) the glomerulus / filter is damaged / leaky / allowing protein through. Allow holes / pores in filter are too large	1 mark
	Total: 3 marks

- c) Suggest **two** possible reasons why glucose might be present in the urine of this patient, even if they do not have diabetes.

A description to include any two of the following:	
Damage to the (kidney) tubules / proximal convoluted tubule (PCT). Allow: cells lining the tubules are damaged Allow general kidney damage if context implies tubules	1 mark
Meaning less / reduced / no / impaired (selective) reabsorption of glucose / active transport of glucose.	1 mark
High blood pressure causes high(er) rate of filtration / more filtrate formed (than normal). Allow: increased pressure forces more fluid/glucose out.	1 mark
Tubules cannot reabsorb all the glucose / rate of filtration exceeds maximum rate of reabsorption / transport maximum exceeded. Allow: reabsorption mechanism / active transport is overwhelmed / cannot cope Do not accept just 'too much glucose'	1 mark
	Total: 2 marks

- d) Describe a test to show that a sample of urine contains glucose.

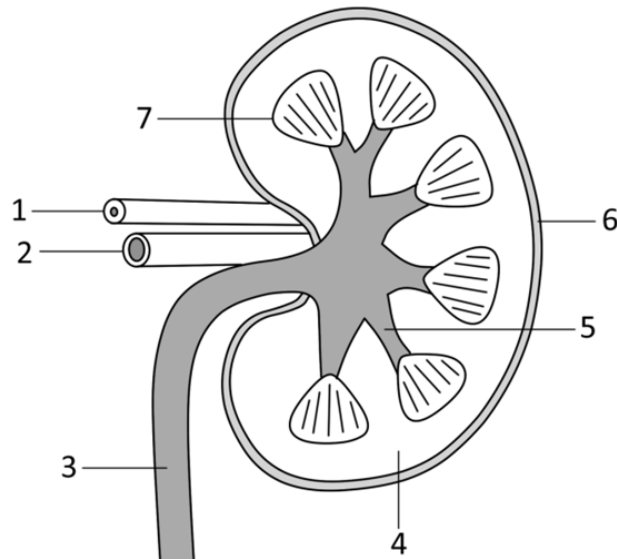
A description to include any three of the following:	
Add Benedict's solution / reagent (to the urine sample). Allow Benedict's test.	1 mark
Heat (the mixture)	1 mark
(Positive result shows) colour change from blue to green / yellow / orange / red. Allow brick red / brown ignore precipitate mention accept any correct colour sequence starting from blue.	1 mark
	Total: 3 marks

- e) Explain how glucose and amino acids are reabsorbed from the proximal convoluted tubule (PCT) to the capillaries surrounding the kidney nephrons.

An explanation to include the following:	
By active transport / active uptake.	1 mark
Requires energy / ATP.	1 mark
(Energy supplied) by respiration / from mitochondria.	1 mark
Moves substances against a concentration gradient / from low to high concentration.	1 mark
	Total: 3 marks

(Total for Question 2 is 15 marks)

3. The figure below shows a section through a kidney.



1 = Renal artery	
2 = Renal vein	
3 = Ureter	
4 = Cortex	
5 = Renal pelvis. Accept Pelvis.	
6 = Capsule.	3 marks
Marking note: 1 mark for each correct pair.	
7 = Renal medulla. Accept Medulla.	1 mark
	Total: 4 marks

Kidney failure is a serious condition where the kidneys lose their ability to filter waste products effectively from the blood.

b) Identify the substance that kidneys remove from the blood and state where this substance is produced.

Substance: <u>urea</u> .	1 mark
Produced by: <u>liver</u> .	1 mark
	Total: 2 marks

c) A patient with suspected kidney failure provides a urine sample. A test is done on the sample to determine if proteins are present in the urine.

Describe a test that could be used to identify proteins in the urine.

A description to include any two of the following:	
Add Biuret solution / reagent (to the urine sample).	1 mark
Allow add sodium hydroxide (solution) then add copper sulfate (solution) do not accept just copper sulfate.	
Positive result shows colour change from blue to purple / lilac / mauve.	1 mark
	Total: 2 marks

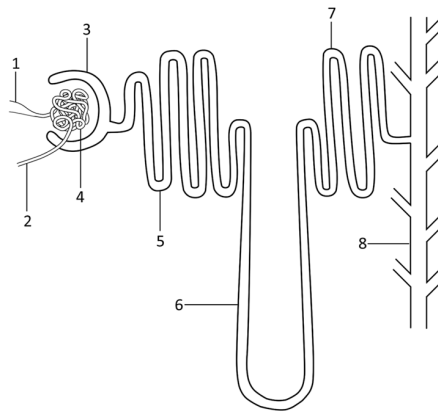
- d) When kidney failure reaches a severe stage, patients often require kidney dialysis.
The figure below shows how kidney dialysis can be done.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Basic statements describing one or both treatments. Information may be limited or lack detail regarding advantages/disadvantages.
Level 2	3 - 4	A clear description of both kidney dialysis and kidney transplant or a detailed discussion of one treatment including advantages and disadvantages. There may be some attempt at comparison.
Level 3	5 - 6	A detailed and coherent discussion of both kidney dialysis and kidney transplant. Includes relevant advantages and disadvantages of each treatment, allowing for a clear comparison.

Indicative content:	
Kidney Dialysis: • Blood removed from patient and passed through a dialysis machine / dialyser. • Uses a partially permeable membrane to separate blood from dialysis fluid. • Waste products (e.g., urea) diffuse from blood into dialysis fluid (down concentration gradient). • Excess ions / salts diffuse from blood into dialysis fluid. • Dialysis fluid contains normal / ideal concentrations of glucose / useful substances (so they don't diffuse out of blood). • Dialysis fluid contains no urea. • Water potential of dialysis fluid controlled to remove excess water. • Requires multiple sessions per week, each lasting several hours. • Restricts diet / fluid intake between sessions. • Can cause side effects / discomfort (e.g., cramps, drop in blood pressure). • Risk of infection / blood clots. • Keeps patient alive while waiting for a transplant. Kidney Transplant: • Diseased kidney(s) replaced with a healthy kidney from a donor. • Donor can be living or deceased. • Needs a close tissue match to reduce risk of rejection. • Allows patient to lead a more normal life / no need for regular dialysis / less restrictive diet. • Cheaper for the NHS in the long term (compared to dialysis). • Involves major surgery with associated risks (e.g., infection, bleeding). • Risk of rejection (immune system attacks the donor kidney). • Requires lifelong immunosuppressant drugs. • Immunosuppressants increase susceptibility to other infections / diseases. • Shortage of donor kidneys / long waiting lists. • Transplanted kidney may not last indefinitely. Comparison points examples: • Transplant offers a potential 'cure' / long-term solution, whereas dialysis is ongoing treatment. • Dialysis is more immediately available, transplants depend on donor availability. • Lifestyle is less restricted with a successful transplant compared to dialysis. • Both treatments have risks and potential complication.	
	Total: 6 marks

(Total for Question 3 is 14 marks)

4. The figure below shows the structure of a kidney nephron.



a) Identify the structures labelled 1 to 8.

1 = Afferent arteriole	
2 = Efferent arteriole	
3 = Bowman's capsule	
4 = Glomerulus	
5 = Proximal convoluted tubule	
6 = Loop of Henle	
7 = Distal convoluted tubule	
8 = Collecting duct	
Award 1 mark for each <u>correct pair</u> of labels.	
	Total: 4 marks

b) Name the blood vessel that carries blood into this structure.

Afferent arteriole.	1 mark
	Total: 1 mark

c) Describe **two** features of this structure that allow the efficient movement of small molecules from the blood into the surrounding capsule.

A description to include:	
Feature 1: Pressure related. - High blood pressure (in the glomerulus) - Generated because afferent arteriole is wider than efferent arteriole. - High pressure forces fluid / small molecules out of the blood.	1 mark
Feature 2: Surface area / Distance / Permeability related. - Large surface area (of glomerular capillaries). - Allows for higher rate / more filtration / movement of substances. - Thin walls / barrier is thin / walls are one cell thick capillary wall +/- capsule wall. - Provides short pathway / distance for filtration / diffusion.	1 mark
	Total: 2 marks

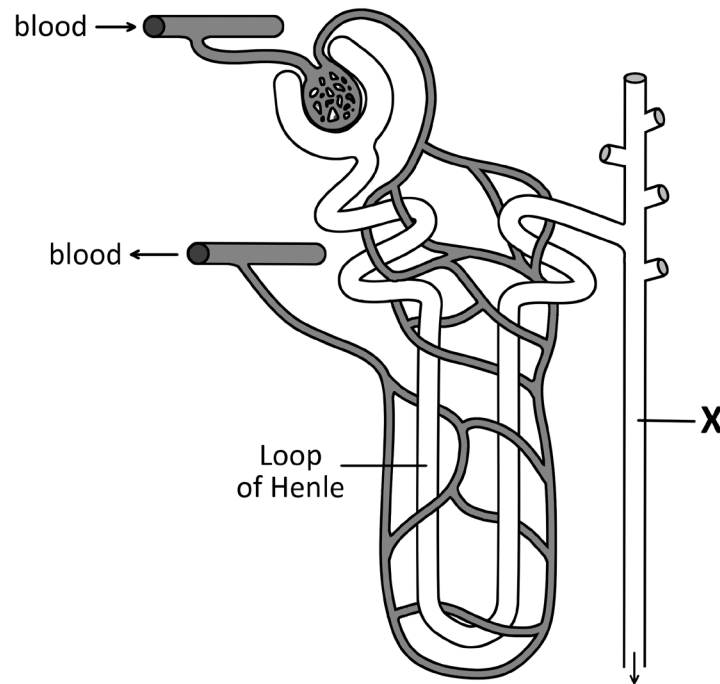
- d) Describe how dialysis removes unwanted substances from the blood. Include examples of unwanted substances in your answer.

Marking guidance		
Level	Marks	Descriptor
Level 1	1 - 2	Basic statements about dialysis. May mention blood being cleaned or waste removal. Mentions diffusion or the membrane but explanation is limited or absent.
Level 2	3 - 4	A clear description of the main principles. Explains diffusion across a membrane driven by concentration gradients. Mentions removal of waste products (may give examples) and may mention the composition of dialysis fluid.
Level 3	5 - 6	A detailed and coherent description of the process. Explains the roles of the partially permeable membrane, diffusion, and concentration gradients accurately. Clearly links the composition of the dialysis fluid to the removal of specific unwanted substances (e.g., urea, excess ions) and the retention of useful substances.

Indicative content:	
• Patient's blood passed through a dialysis machine / dialyser. • Blood flows on one side of a partially permeable membrane. • Dialysis fluid / dialysate flows on the other side of the membrane. • Unwanted substances / waste products are removed by diffusion. • Example: Urea (is an unwanted substance). • Example: Excess ions / salts (are unwanted substances). • Unwanted substances are in high concentration in the blood (compared to dialysis fluid). • Fresh dialysis fluid has low / no concentration of urea / waste products. • (Creates) a steep concentration gradient (for unwanted substances). • Unwanted substances diffuse down the concentration gradient. • From the blood into the dialysis fluid. • Partially permeable membrane allows small molecules (like urea, ions, water, glucose) to pass through. • Large molecules (like proteins, blood cells) cannot pass through / remain in the blood. • Dialysis fluid contains normal / ideal concentrations of useful substances (e.g., glucose, some ions). • This prevents the net diffusion / loss of these useful substances from the blood. • Dialysis fluid is continuously replaced / flows (often counter-current) to maintain the concentration gradients. • Excess water moves from blood to dialysis fluid by osmosis / due to water potential gradient. • Cleaned blood returned to the patient.	
	Total: 6 marks

(Total for Question 4 is 13 marks)

5. The figure below shows the structure of a kidney nephron of a human.



a) Identify the process that takes place in the glomerulus of the nephron.

Ultrafiltration.	1 mark
	Total: 1 mark

b) Describe the process of how substances move from the blood in the glomerulus into Bowman's capsule. In your answer, you should refer to the relevant structures and the forces involved.

A description to include:	
High blood pressure in the glomerulus.	1 mark
This high pressure is caused by the afferent arteriole being wider/ allowing more blood into the glomerulus than can leave.	1 mark
Forces fluid / water and small molecules out of the blood / glomerulus	1 mark
Through the walls of the capillaries / glomerulus and into the Bowman's capsule.	1 mark
Small molecules (e.g. urea, water, glucose, ions) pass through, but large molecules (e.g. proteins, blood cells) do not / remain in the blood	1 mark
	Total: 4 marks

c) Water is reabsorbed by the loop of Henle. How is water reabsorbed?

Osmosis.	1 mark
	Total: 1 mark

d) Describe the process by which water is reabsorbed in the loop of Henle.

A description to include:	
(By) osmosis.	1 mark
From an area of high water concentration to an area of lower water concentration.	1 mark
Through a partially permeable membrane.	1 mark
	Total: 3 marks

e) Identify structure X of the nephron labelled above.

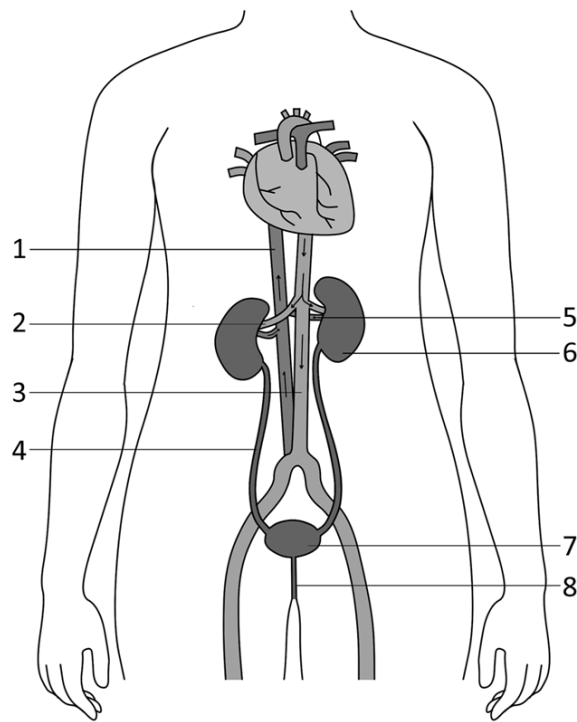
Collecting duct.	1 mark
	Total: 1 mark

f) Explain how this structure in the kidney plays a crucial role in osmoregulation, making reference to the hormone(s) involved in this process.

An explanation to include:	
(Osmoregulation controlled by) ADH / Antidiuretic Hormone.	1 mark
ADH affects the permeability / makes the walls of the collecting duct / (distal) tubule more permeable (to water).	1 mark
(If blood water potential low / blood too concentrated / dehydrated) more ADH is released.	1 mark
(So more permeability means) more water is reabsorbed (from collecting duct / tubule back into blood) by osmosis.	1 mark
OR (if blood water potential high / blood too dilute / hydrated) less ADH released.	1 mark
(So less permeability means) less water is reabsorbed / more water remains in filtrate.	1 mark
	Total: 4 marks

(Total for Question 5 is 14 marks)

6. The figure below shows the urinary system of a human female.



a) Identify the structures labelled 1 to 8.

1 = Vena Cava	
2 = Renal artery	
3 = Aorta	
4 = Ureter	
5 = Renal vein	
6 = Left Kidney	
7 = Bladder	
8 = Urethra	
Award 1 mark for each correct pair of labels.	
	Total: 4 marks

b) Explain how glucose and amino acids are reabsorbed from the proximal convoluted tubule (PCT) to the capillaries surrounding the kidney nephrons.

An explanation to include:	
(Reabsorption occurs) by active transport / active uptake.	1 mark
Allow: uses carrier proteins / pumps.	
Requires energy / uses ATP	1 mark
To move substances against a concentration gradient / from low to high concentration.	1 mark
Allow: ensures all / most glucose / amino acids are reabsorbed.	
Energy supplied by respiration / (PCT cells) have many mitochondria.	1 mark
	Total: 4 marks

(Total for Question 6 is 8 marks)