Name	Date started	Target end date

GCE A LEVEL — BIOLOGY UNIT 3 QUESTION PACK

1074 (Legacy BY4) + 1075 (Legacy BY5) · New spec Unit 3 Topic 9 · A2 unit, first sat 2017, 90 marks, 2h paper

REVISE
.wales

BIOLOGY — UNIT 3 · HOMEOSTASIS — KIDNEY & OSMOREGULATION

3.5 Homeostasis and the kidney — negative feedback, ultrafiltration, selective reabsorption and ADH

Homeostasis as negative feedback maintaining a steady internal environment, mammalian kidney structure (cortex, medulla, nephron), ultrafiltration at the Bowman's capsule, selective reabsorption in the proximal convoluted tubule, the role of the loop of Henle in producing concentrated urine, and ADH-driven control of water potential in the collecting duct.

LEGACY 2008 SPECIFICATION

Estimated time for entire question pack: ~3 h 18 min

Derived from the legacy BY4 / BY5 papers' pace of ~1.3 min/mark, padded for long-prose answers (124 marks over 10 questions).

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC BY4 (and BY5, where relevant) papers (2008 modular spec, 2011–2017) that maps onto new-spec A2 Unit 3 Topic 9 (3.5).

Questions are ordered by source paper date.

INSTRUCTIONS

Use black ink or black ball-point pen. Show all working — quality of written communication will affect marks. A calculator is allowed. Diagrams included in answers must be fully annotated.

For Examiner's use only

Q	Source	Max	Mark
1	BY4 Jun 11 Q6	15	
2	BY4 Jun 12 Q6	12	
3	BY4 Jun 13 Q7	14	
4	BY4 Jun 14 Q4	14	
5	BY4 Jun 15 Q6	14	

Q	Source	Max	Mark
6	BY4 Jun 16 Q3	5	
7	BY4 Jun 16 Q6	12	
8	BY4 Jun 17 Q1	13	
9	BY4 Jan 12 Q4	14	
10	BY4 Jan 14 Q4	11	
Total		**124**	

Homeostasis — Kidney & Osmoregulation — what the new spec asks

WJEC GCE A Level Biology (from 2015) · Unit 3: Energy, Homeostasis & the Environment · Topic 3.5.

Homeostasis & negative feedback

- Internal conditions kept within narrow limits.
- Receptor → control centre → effector returns variable to set-point.
- Examples: blood glucose, body temperature, blood water potential.

Kidney gross structure

- Cortex (Bowman's capsules, PCT, DCT) and medulla (loop of Henle, collecting ducts).
- Each kidney has ~1 million nephrons.
- Renal artery in, renal vein + ureter out.

Ultrafiltration

- Afferent > efferent arteriole diameter ⇒ high glomerular pressure.
- Basement membrane filters by size; small molecules pass into capsule.
- Blood cells & large proteins retained in blood.

Selective reabsorption

- PCT walls have microvilli + many mitochondria.
- Glucose & amino acids 100% reabsorbed via co-transport with Na^+.
- Water follows by osmosis along solute gradient.

Loop of Henle & counter-current

- Descending limb permeable to water; ascending impermeable, pumps NaCl out.
- Builds high solute concentration in medulla.
- Longer loops ⇒ more concentrated urine (desert mammals).

ADH & collecting duct

- Osmoreceptors in hypothalamus detect ↓ water potential.
- ADH released from posterior pituitary.
- Inserts aquaporins in collecting duct ⇒ water reabsorbed ⇒ concentrated urine.

Crib sheet »

Homeostasis — Kidney & Osmoregulation in one page

Quick-reference notes — revisit before each question.

Homeostasis

Maintains constant internal environment.

Negative feedback: receptor → effector → correction.

Variables: water potential, glucose, temperature.

Gross structure

Cortex (Bowman's, PCT, DCT) and medulla (loop, collecting duct).

Renal artery in, renal vein + ureter out.

~1 million nephrons per kidney.

Ultrafiltration

Afferent > efferent ⇒ high pressure in glomerulus.

Basement membrane filters by size.

Glucose, ions, urea, water pass; proteins & cells stay.

PCT

Microvilli + many mitochondria.

Na^+ actively pumped out ⇒ glucose / AAs co-transport with Na^+.

~85% water reabsorbed; obligatory.

Loop of Henle

Descending: permeable to H_2O, not ions.

Ascending: pumps NaCl out (thick segment).

Counter-current multiplier ⇒ high medulla solute.

ADH & collecting duct

Hypothalamic osmoreceptors → posterior pituitary releases ADH.

ADH inserts aquaporins in CD.

Water reabsorbed ⇒ concentrated urine.

Diabetes & urine

Untreated diabetes ⇒ glucose in urine.

Glucose lowers water potential ⇒ less water reabsorbed.

Polyuria — large dilute urine output.

Desert vs aquatic

Kangaroo rat: long loops, very concentrated urine.

Beaver: short loops, dilute urine.

Loop length ↔ environment.

Examiner only

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

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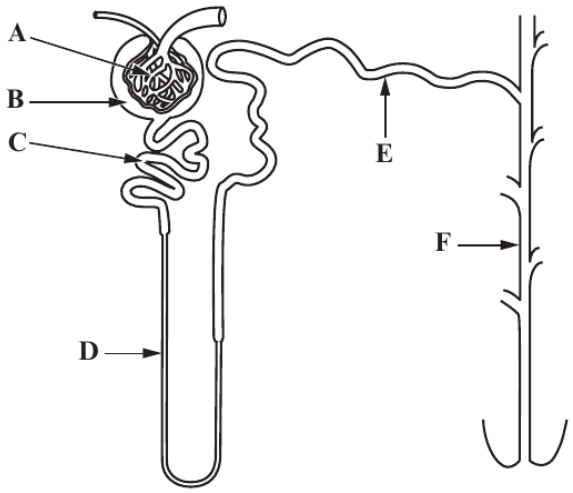

(b) (i) Name the parts labelled **A-F**. [3]

A .....

B .....

C .....

D .....

E .....

F .....

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

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

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Examiner only

(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]

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

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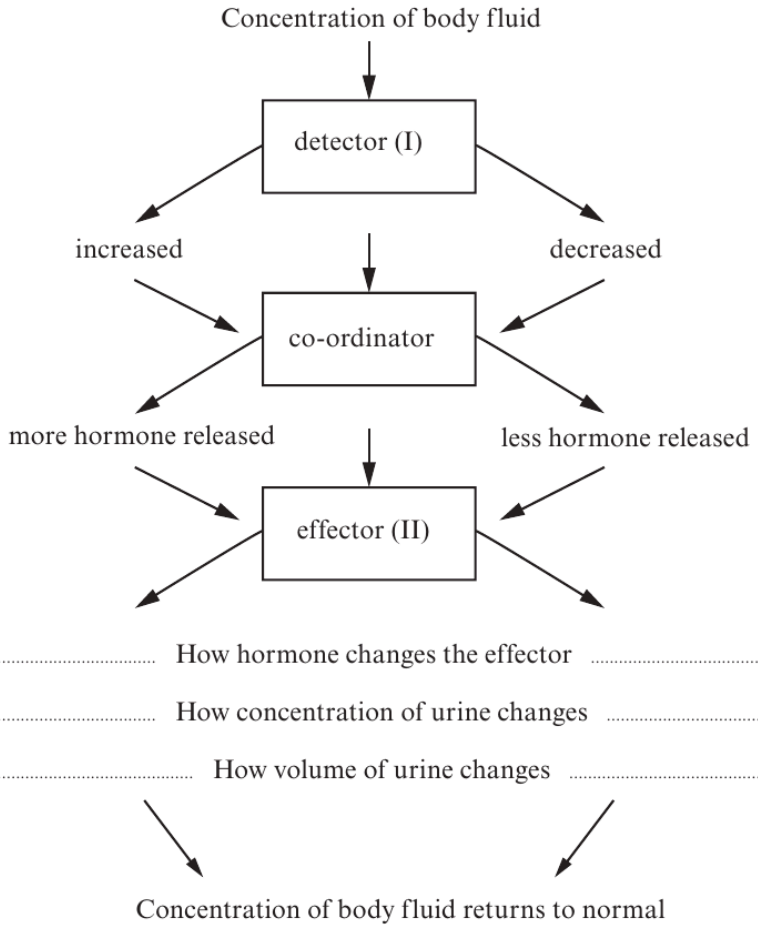
(iii) Use your answer to parts (i) and (ii) to identify, on the diagram of the Osmoregulatory Feedback Loop below [1]

(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]



Examiner only

6. Complete the following using appropriate scientific terms.

The general name given to glands which produce hormones are ..... glands. Hormones are involved in the maintenance of a constant internal environment, this is referred to as ..... . If there is a move away from the norm or set point a corrective procedure takes place which returns it to the norm and this is referred to as ..... .

Osmoreceptors in the ..... of the brain constantly monitor the ..... of the blood.

ADH is a hormone that is produced in specialised nerve cells and it is then stored in the ..... .

If there is a need for the body to conserve water a nerve impulse causes the release of ADH into the ..... which transports it to the target organ.

ADH acts on the cells of the ..... where it attaches to ..... on the membrane of these cells. This causes protein channels to open and water passes through these channels by ..... into the ..... of the medulla and then into the blood. A small volume of concentrated ..... is produced.

(Total 12 marks)

Examiner only

(g) The cardiac muscle fibres used to obtain the oscilloscope trace were obtained from a frog's heart. Consider the ethics of killing a frog to obtain cardiac muscle fibres by giving **one** argument in favour and **one** against. [2]

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7. *(a)* Name the vessel that brings blood to the kidney. [1]

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(b) Describe **two structural** features of glomeruli that allow ultrafiltration to occur. [2]

1. .....

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2. .....

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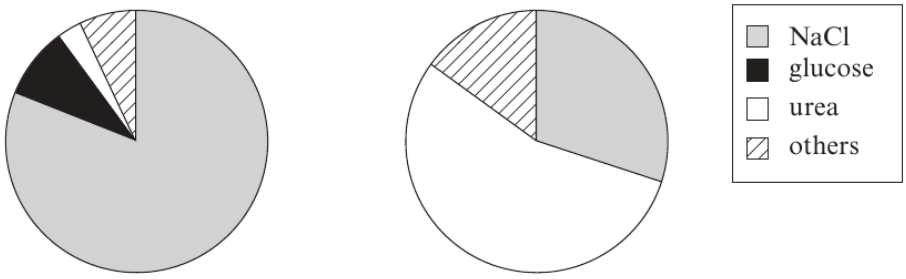
Ultrafiltration in the glomerulus results in the production of glomerular filtrate. The pie charts below show the percentage composition of solutes in human glomerular filtrate and in urine.

Glomerular filtrate **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]

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Examiner only

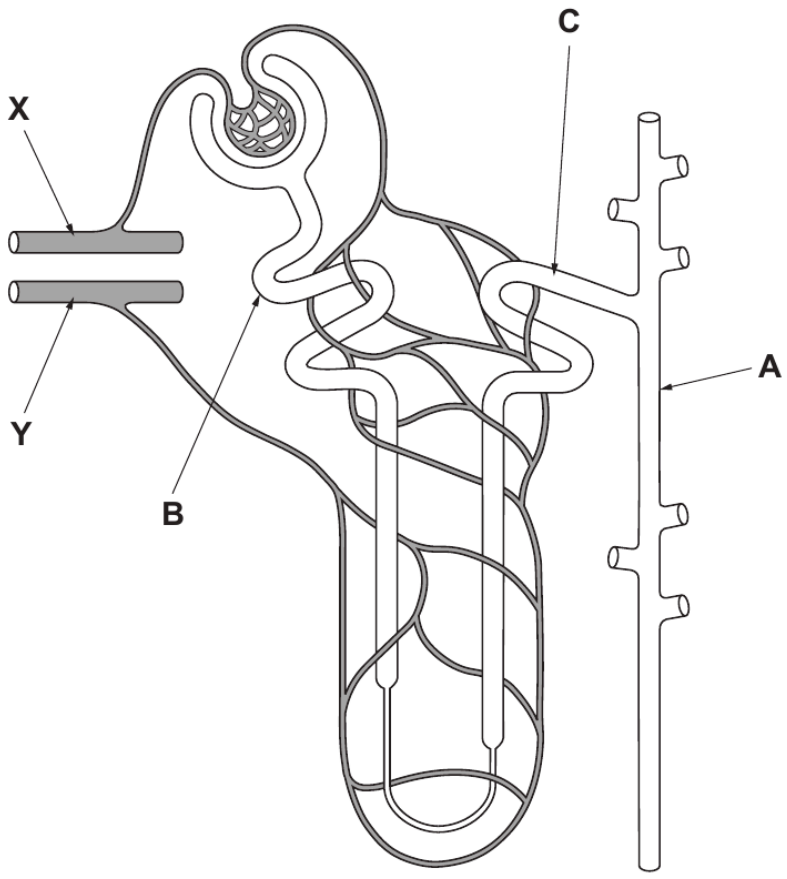
(d) (i) The urea concentration of urine is much higher than that of glomerular filtrate. Describe the role of the nephron and collecting duct in achieving this increase in concentration. [5]

(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]

Examiner only

4. 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.

Examiner only

(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]

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(d) Describe how hormonal control affects the final concentration and volume of urine produced when someone is dehydrated. [4]

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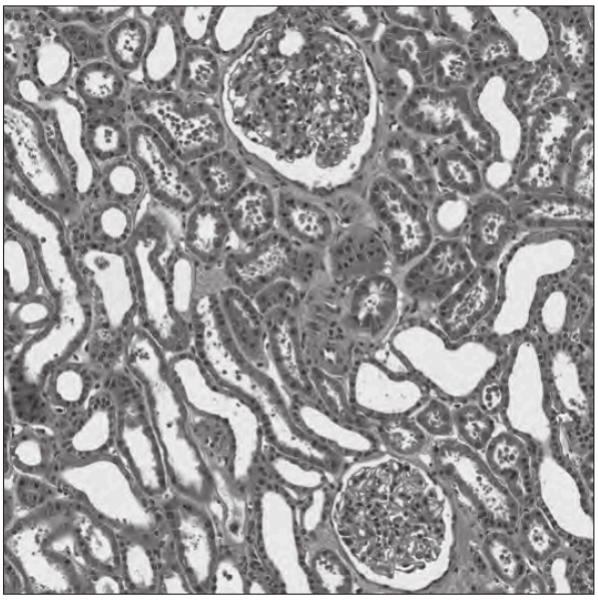
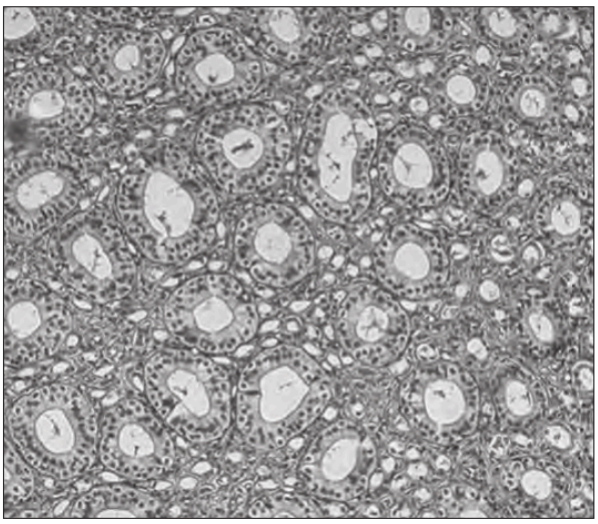
Examiner only

6. 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		

Examiner only

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

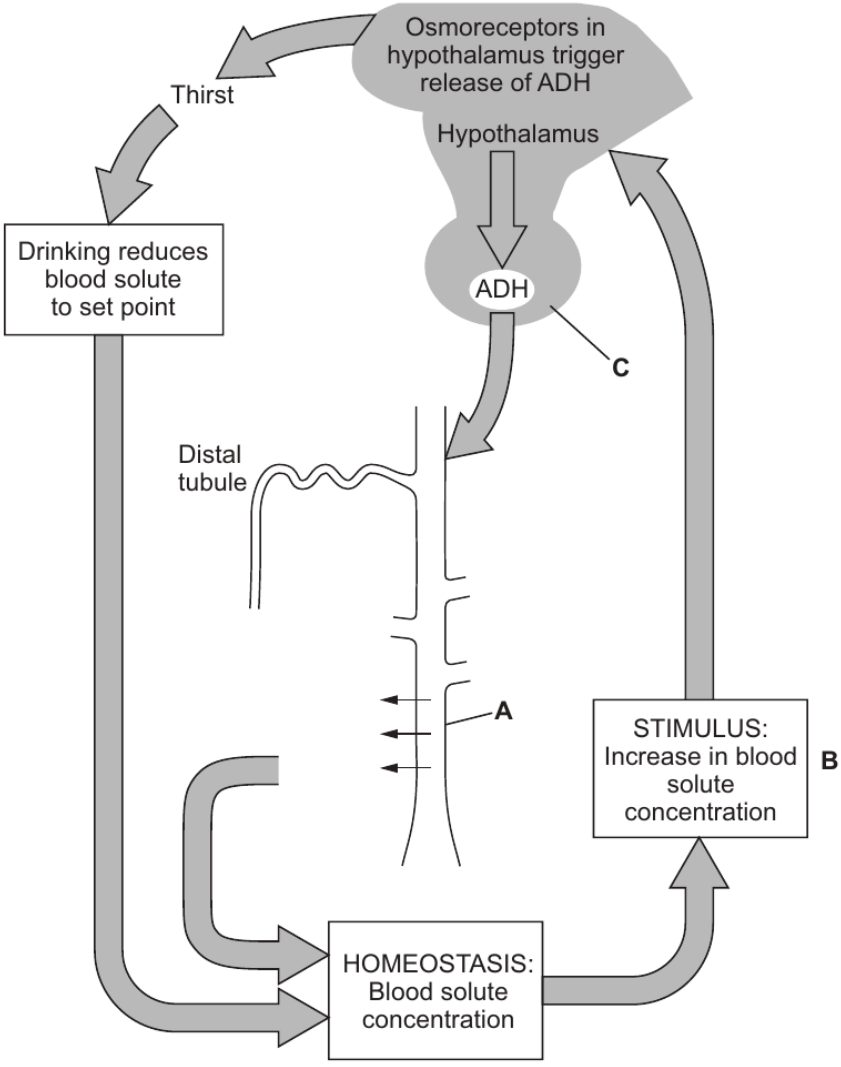
(c) Patients with severe kidney disease may be told to follow a protein controlled diet with low sodium chloride (salt) intake. Using your knowledge of the role of the kidney, suggest why this diet is recommended. [3]

Protein controlled diet

Low sodium chloride (salt) intake

Examiner only

(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 .....

Examiner only

(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]

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14

Examiner only

3. The following table compares the abilities of kidneys of various mammals to concentrate urine.

Species	Max Urine Concentration / a.u.
beaver	520
pig	1100
kangaroo rat	5500

(a) (i) Describe how the structure of the kidneys in these species would differ, which would explain the trend of data shown. [1]

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(ii) What does this data suggest about the environments in which each of these mammals live? [3]

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The maximum urine concentration for sheep is shown below.

Species	Max Urine Concentration / a.u.
sheep	3500

(b) What does this suggest about the environment in which sheep have evolved? Explain your answer. [1]

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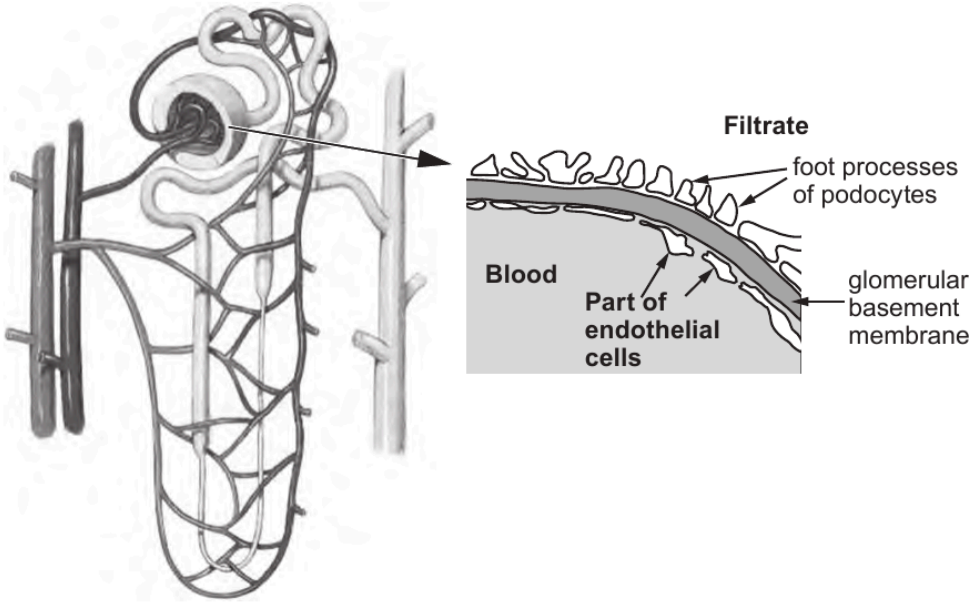
Examiner only

6. *(a)* Glucose is not present in normal urine. A person with untreated diabetes produces large volumes of urine containing glucose. The diagram below shows a nephron with a section enlarged to show the site of ultrafiltration of the blood.



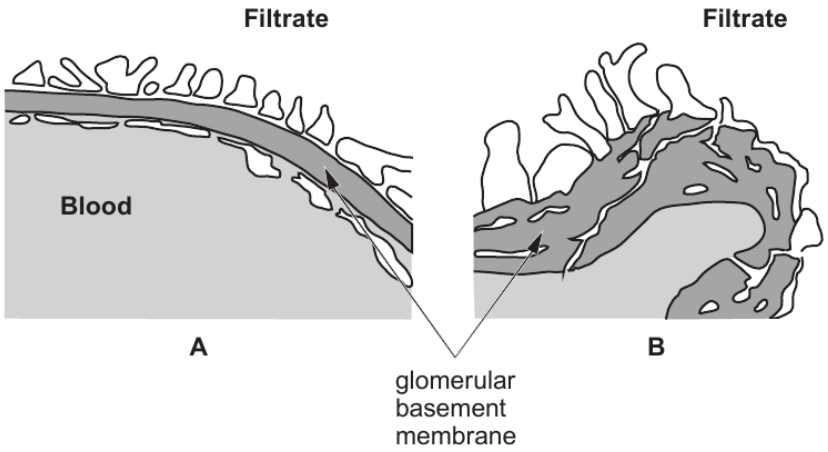
(i) Explain why large proteins are not usually found in the glomerular filtrate. [2]

(ii) Glucose is filtered out of the blood, but is not found in urine. Explain why glucose is not present in urine. [2]

(iii) If the blood glucose level is high, as may occur in a person with diabetes prior to diagnosis and treatment, glucose is present in the urine. Normally, water is reabsorbed from the collecting duct. Explain why a person with diabetes produces a larger volume of urine than a person that does not have diabetes. [3]

Examiner only

(b) In Alport syndrome, the glomerular basement membrane is abnormal because it lacks a particular type of collagen. Picture **B** below shows a diagrammatic representation of the condition. Picture **A** shows a normal glomerular basement membrane.
Most people with Alport syndrome develop kidney failure in early adult life. In the early stages of the syndrome, symptoms may include blood and protein in the urine.



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(i) Briefly describe the biochemical structure of collagen. [2]

(ii) Using your knowledge of ultrafiltration and the diagrams above, suggest how the symptoms of Alport syndrome are caused. [3]

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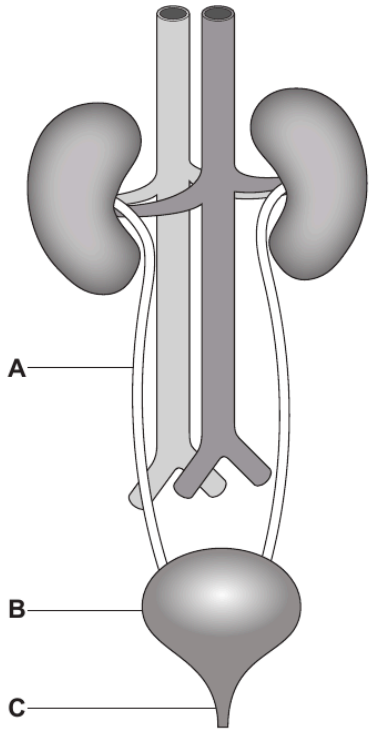
Examiner only

Answer **all** *questions.*

1. The diagram below shows the urinary system of a mammal.



(a) Identify the structures labelled **A**-**C**. [2]

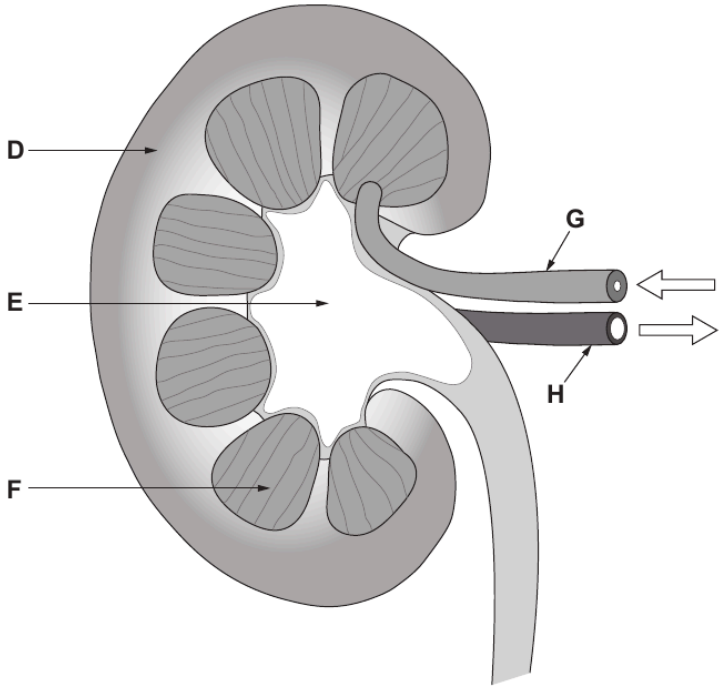
A .....

B .....

C .....

Examiner only

A diagram showing the main regions of the kidney is shown below.



(b) Identify **D-H** shown on the diagram above. [3]

D .....

E .....

F .....

G .....

H .....

Examiner only

The total filtrate formed by the kidneys per minute is called the glomerular filtration rate (GFR). In healthy kidneys the GFR is approximately 125 cm^3 per minute.
There are five stages of kidney disease shown in the table below. The stage of kidney disease is based on the presence of kidney damage and GFR.

Stages of kidney disease		
Stage	**Description**	**Glomerular Filtration Rate (GFR)**
1	Kidney damage (e.g., protein in the urine)	90 and above
2	Kidney damage with mild decrease in GFR	60 to 89
3	Moderate decrease in GFR	30 to 59
4	Severe reduction in GFR	16 to 29
5	Kidney failure	15

(c) Calculate the percentage decrease in GFR between healthy kidney function and someone with kidney failure. Show your working. [2]

Percentage decrease in GFR = ... %

(d) Explain how stage **1** kidney disease causes protein to appear in the urine. [2]

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Examiner only

(e) Explain how the collecting duct carries out osmoregulation and how it is adapted to carry out this process. [4]

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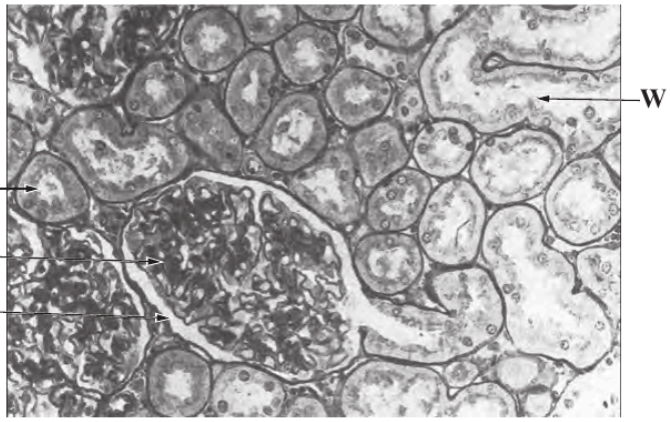
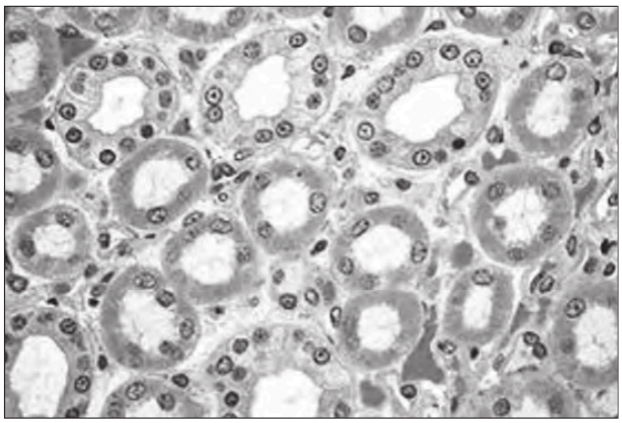
Examiner only

4. The micrographs are of kidney as seen using a light microscope.

Micrograph **A**



Micrograph **B**



(a) (i) Name the area of the kidney from which micrograph **A** is taken. [1]

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(ii) In micrograph **A** identify structures **X**, **Y** and **Z**. [3]

X .....

Y .....

Z .....

(iii) **X** and **W** are the same structure. How do you account for their different appearance under the microscope? [1]

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Examiner only

(iv) Micrograph **B** shows structures in the medulla. Which parts of the nephron can be seen? [3]

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(b) Describe the process of ultrafiltration. [6]

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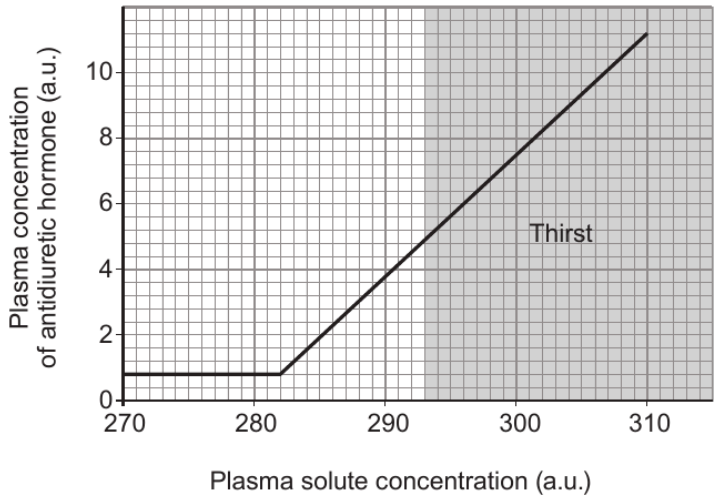
(Total 14 marks)

Examiner only

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. [6]

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



Examiner only

(i) Describe the relationship shown in the graph opposite. [2]

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(ii) Suggest why a person only begins to feel thirsty at a plasma solute concentration of 293 AU. [2]

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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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END OF QUESTION PACK

10 questions · 124 marks · ~3 h 18 min
Source: WJEC BY4 + BY5 (2008 modular spec, 2011–2017)
Curated for WJEC Biology 2015 spec A2 Unit 3 — Topic 9 (3.5)