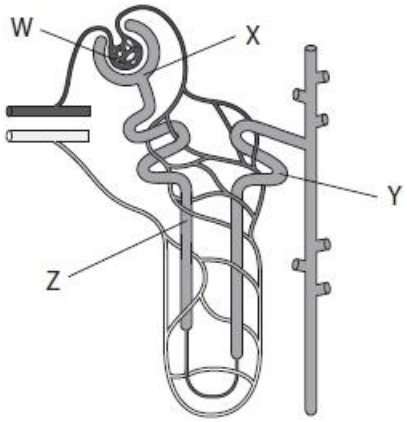
## Questions

**Q1.**

**Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

The diagram shows a nephron.




Which labelled parts of this nephron would normally contain glucose?

**(1)**

- ☒ **A** W only
- ☒ **B** W and X
- ☒ **C** W, X, and Y
- ☒ **D** W, X, Y, and Z

**(Total for question = 1 mark)**

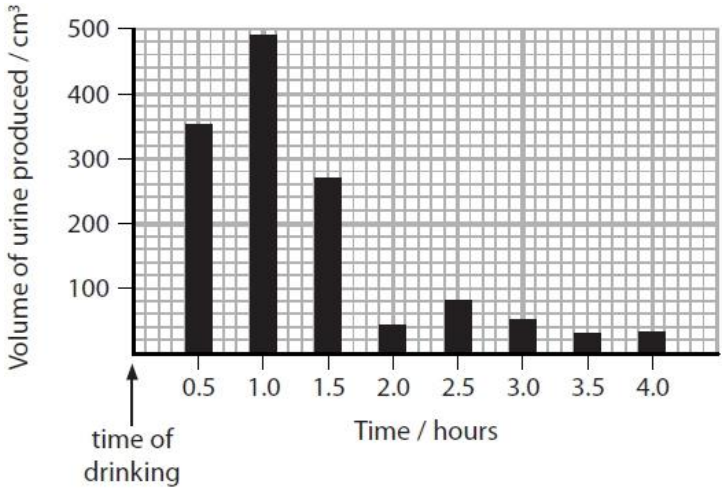
**Q2.**

Negative feedback control of blood plasma concentration is an example of homeostasis.

A student investigated the effect of drinking water on the volume of urine produced.

The student drank one $dm^3$ of water and waited for half an hour. The student then collected the urine produced every 30 minutes for four hours.

The graph shows the results of this investigation.




(i) Determine the total volume of urine produced during the first two hours.

**(1)**

Answer ..... $cm^3$

(ii) Explain the role of negative feedback in the control of blood plasma concentration during the first hour after drinking water.

**(4)**

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**(Total for question = 5 marks)**

**Q3.**

Mammals produce urea as a nitrogenous waste product.

The table shows the concentrations of molecules and ions in the blood plasma of the kidney, in the filtrate produced in Bowman's capsule and in the bladder.

| Molecule or ion | Blood plasma of kidney (%) | Filtrate produced in Bowman's capsule (%) | Urine in the bladder (%) |
|---|---|---|---|
| Water | 90 to 93 | 94 to 96 | 96 |
| Protein | 7 to 9 | 0.0 | 0.0 |
| Glucose | 0.10 | 0.10 | 0.0 |
| Urea | 0.03 | 0.03 | 2.0 |
| Sodium | 0.32 | 0.32 | 0.30 to 0.35 |
| Chloride | 0.37 | 0.37 | 0.60 |

(i) Name the process by which this filtrate is produced in Bowman's capsule.

**(1)**

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(ii) Analyse the data to explain the difference between the protein and the other molecules or ions in the filtrate in Bowman's capsule.

**(3)**

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(iii) Urea and chloride ions both become more concentrated as they pass from Bowman's capsule to the urine in the bladder.

Calculate how many more times urea becomes concentrated compared with chloride ions.

**(3)**

Answer .....

(iv) Analyse the data to explain the glucose concentration in the bladder.

**(2)**

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(v) Explain how the loop of Henlé is involved in the production of concentrated urine.

**(5)**

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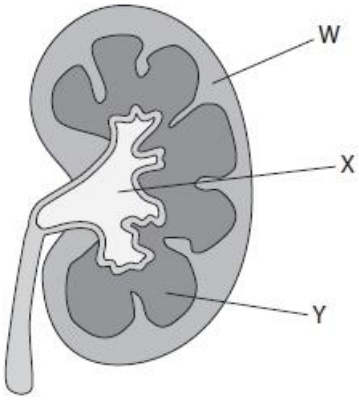
**(Total for question = 14 marks)**

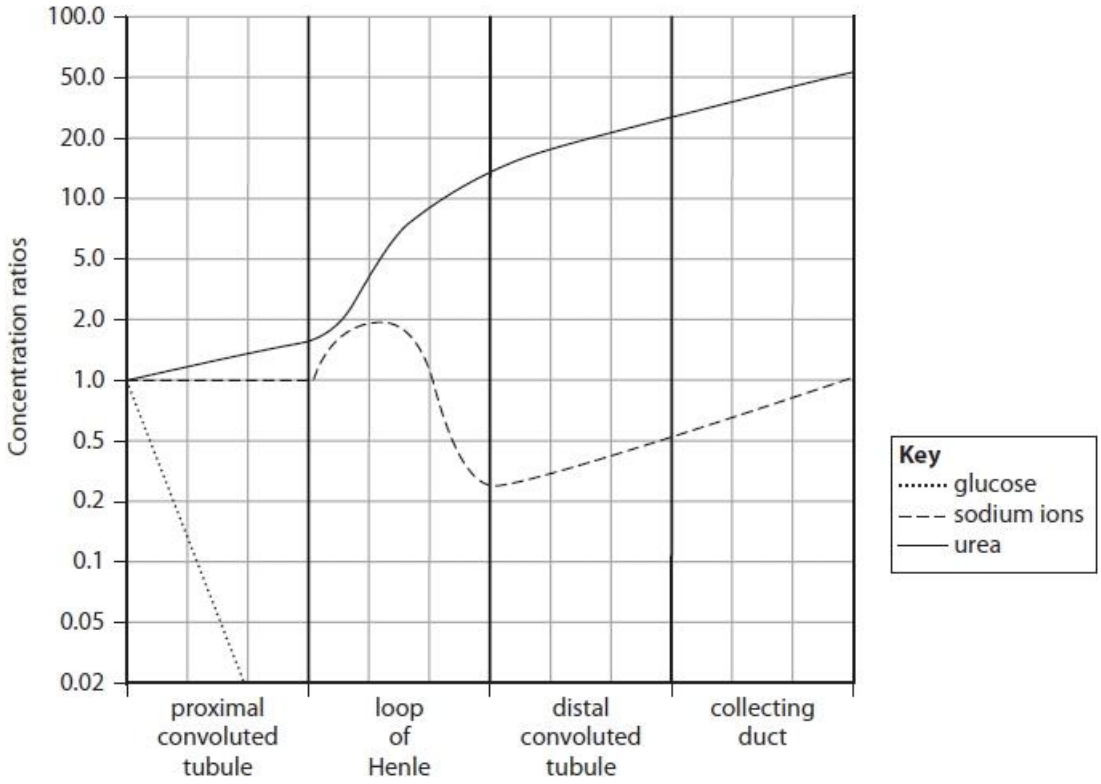
**Q4.**

The diagram shows a section through a mammalian kidney.




* The renal (Bowman's) capsule is part of each nephron found in the kidney.

The graph shows the concentration ratios of three solutes in different parts of the nephron compared with their concentrations in the renal capsule.



Explain the changes in the concentration ratios of these solutes in the different parts of the nephron.

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**(Total for question = 6 marks)**

**Q5.**

Mammals produce urea as a nitrogenous waste product.

Describe how urea is produced in mammals.

**(2)**

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**(Total for question = 2 marks)**

**Q6.**

**Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

(i) Which of the following statements about facilitated diffusion are correct?

**(1)**

1. substances move through membrane proteins
2. substances move against a concentration gradient
3. substances move down a concentration gradient
4. substances move between phospholipids

☐ **A** 1 and 2
☐ **B** 1 and 3
☐ **C** 2 and 3
☐ **D** 2 and 4

(ii) The collecting duct is also part of the nephron.

Which of the following are the effects of increased release of antidiuretic hormone (ADH)?

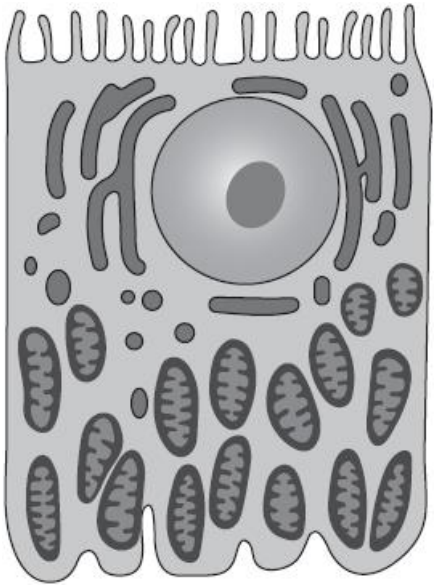
**(1)**

☐ **A** decreased permeability of the collecting duct to water, producing more concentrated urine
☐ **B** decreased permeability of the collecting duct to water, producing more dilute urine
☐ **C** increased permeability of the collecting duct to water, producing more concentrated urine
☐ **D** increased permeability of the collecting duct to water, producing more dilute urine

**(Total for question = 2 marks)**

**Q7.**

The diagram shows a cell from the proximal convoluted tubule of the nephron.



Explain how the features shown in the diagram enable this cell to carry out its function.

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**(Total for question = 4 marks)**

**Q8.**

The photograph shows a wood mouse, *Apodemus sylvaticus*.

(Source: © Eric Isselee/Shutterstock)

A scientist measured the population size of these mice living in a woodland habitat.

The scientist used the capture-mark-recapture method (CMR) to sample the population.

This is the CMR method used by the scientist:

- randomly place mammal traps in the woodland for one day
- put a coloured band on a leg of each captured mouse (S1)
- release these marked mice
- after one week place mammal traps in the woodland again for one day
- count the number of mice captured (S2)
- count the number of mice with leg bands in this second sample (L).

Wood mice are small mammals.

They cannot maintain their body temperature and will die if left in the trap for a long period of time.

Explain why wood mice cannot maintain their body temperature if left in the trap.

**(4)**

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**(Total for question = 4 marks)**

**Q9.**

Mammals produce urea as a nitrogenous waste product.

Bowman's capsule (renal capsule) in the kidney is involved in the excretion of urea in mammals.

Name the cluster of blood capillaries enclosed by Bowman's capsule.

**(1)**

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**(Total for question = 1 mark)**

**Q10.**

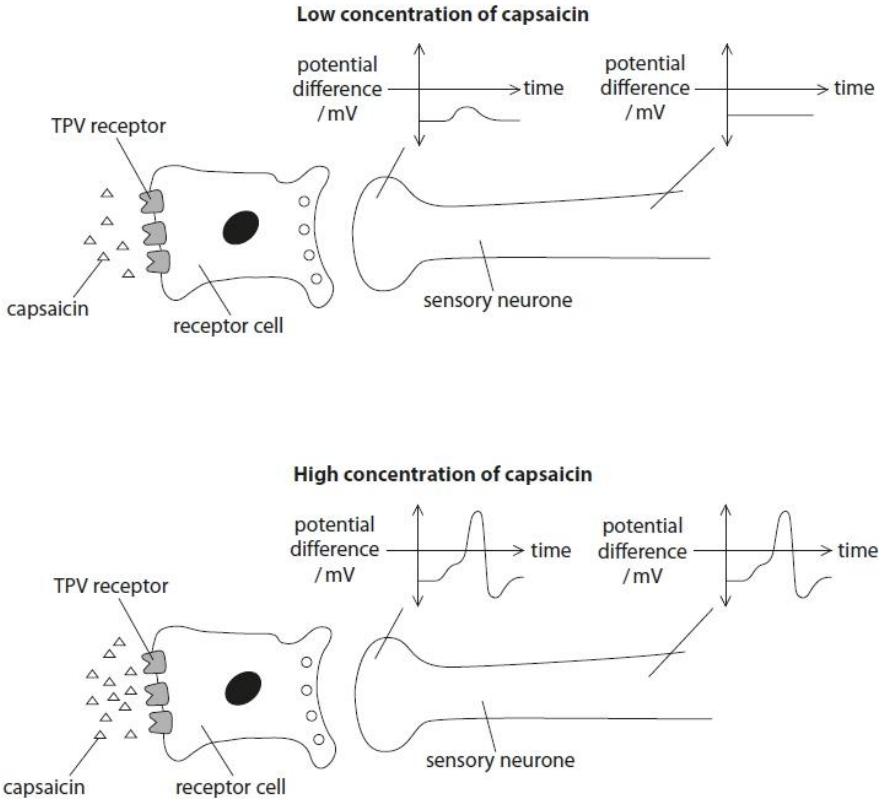
Acetylcholine is a neurotransmitter released by neurones in the autonomic nervous system.

Capsaicin is a substance found in chilli plants that makes them taste 'hot.'

Capsaicin binds to temperature receptor proteins called TPV receptors. This stimulates impulses along sensory neurones that send impulses to the brain.

The effect of capsaicin on the depolarisation of the membrane of a sensory neurone was investigated. The potential difference across the membrane was measured at two places on the sensory neurone after adding capsaicin.

The results for a high concentration and a low concentration of capsaicin are shown in the diagram.




(i) Explain the effect of capsaicin on the depolarisation of the sensory neurone.

**(3)**

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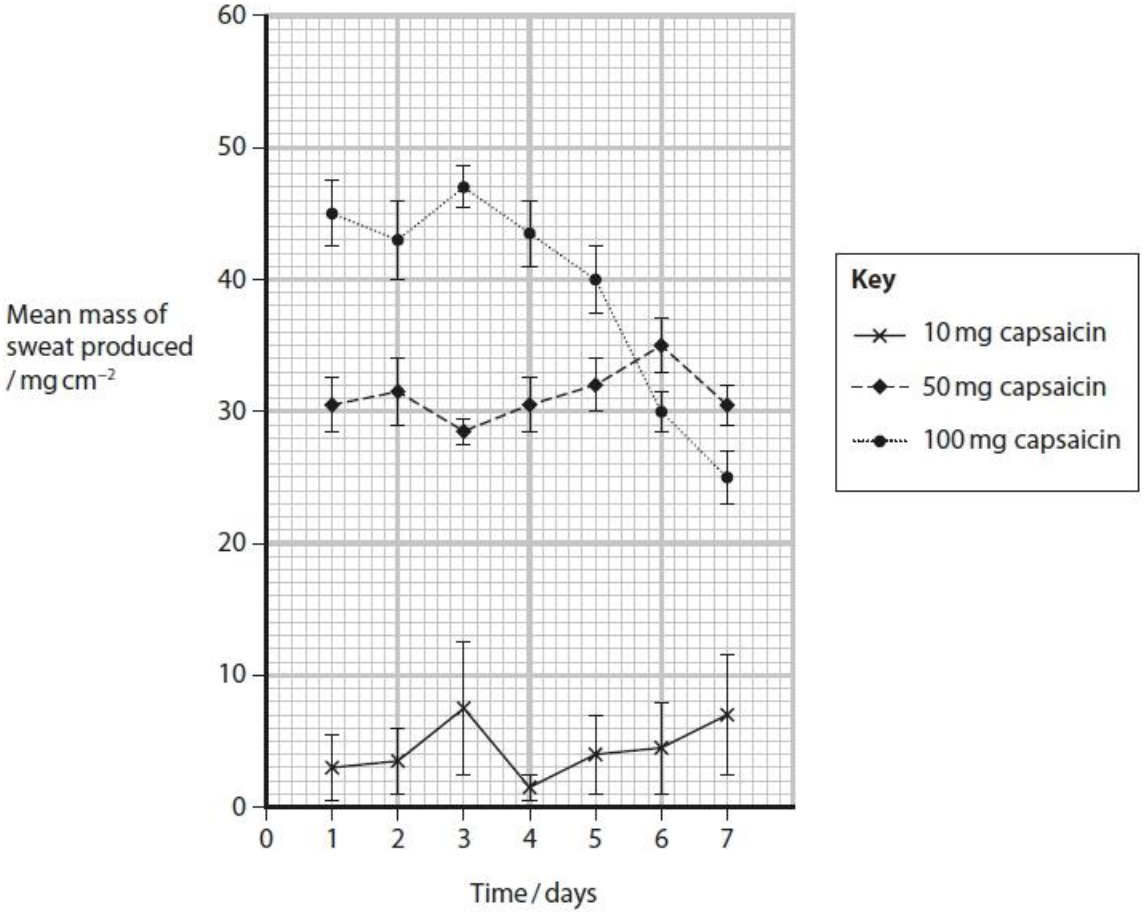
*(ii) Capsaicin affects sweat production. It has been suggested that capsaicin could be used to lower the temperature of people with fevers.

The effect of three different doses of capsaicin on sweat production was investigated.
Five students took one 10 mg tablet of capsaicin each day, for one week.
The mass of sweat produced from a 10 $cm^2$ area of skin was measured one hour after taking each tablet of capsaicin.
The mean mass of sweat per square centimetre of skin for the group of students was calculated for each day.
This was repeated with different groups of students taking 50 mg of capsaicin and taking 100 mg of capsaicin.
Most of the students who were given 100 mg of capsaicin reported a burning sensation and redness of the skin.
The results are shown in the graph.
Error bars represent standard deviations.




Analyse the data to discuss the use of capsaicin to lower the temperature of people with fevers.

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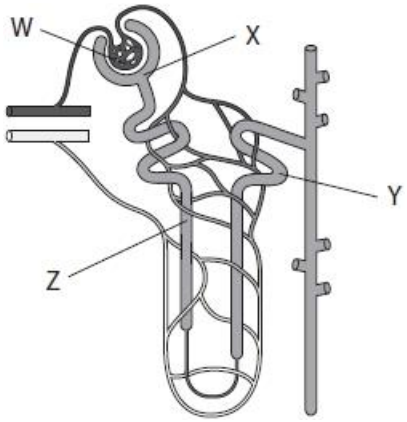
**(Total for question = 9 marks)**

**Q11.**

The diagram shows a nephron.




Oedema is an accumulation of tissue fluid. This is due to less tissue fluid being returned to the blood capillaries.

(i) Explain how tissue fluid is returned to capillaries.

**(3)**

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(ii) Furosemides are drugs that are used to reduce oedema. They are diuretics that increase urine production.

Furosemides reduce the active transport of sodium ions by the loop of Henle.

Explain how furosemides cause an increase in urine production.

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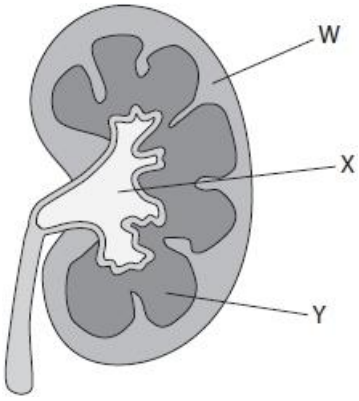
**(Total for question = 7 marks)**

**Q12.**

The diagram shows a section through a mammalian kidney.




Which row of the table names the parts of the kidney labelled in the diagram?

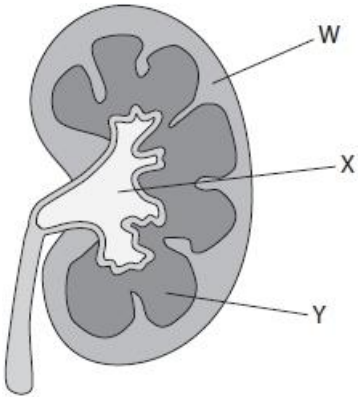
**(1)**

| | W | X | Y |
|---|---|---|---|
| ☐ **A** | cortex | medulla | pelvis |
| ☐ **B** | cortex | pelvis | medulla |
| ☐ **C** | medulla | pelvis | cortex |
| ☐ **D** | medulla | cortex | pelvis |

**(Total for question = 1 mark)**

**Q13.**

The diagram shows a section through a mammalian kidney.




The table shows information about substances found in the blood and in the filtrate in the renal (Bowman's) capsule.

| Substance | Relative molecular mass | Ratio of concentration in the filtrate in the renal (Bowman's) capsule : concentration in blood |
|---|---|---|
| sodium ions | 23 | 1.00 |
| water | 18 | 1.00 |
| urea | 60 | 1.00 |
| glucose | 180 | 1.00 |
| myoglobin | 17000 | 0.75 |
| plasma proteins | 69000 | <0.01 |

Analyse the data to explain the ratios of these substances.

**(3)**

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**(Total for question = 3 marks)**

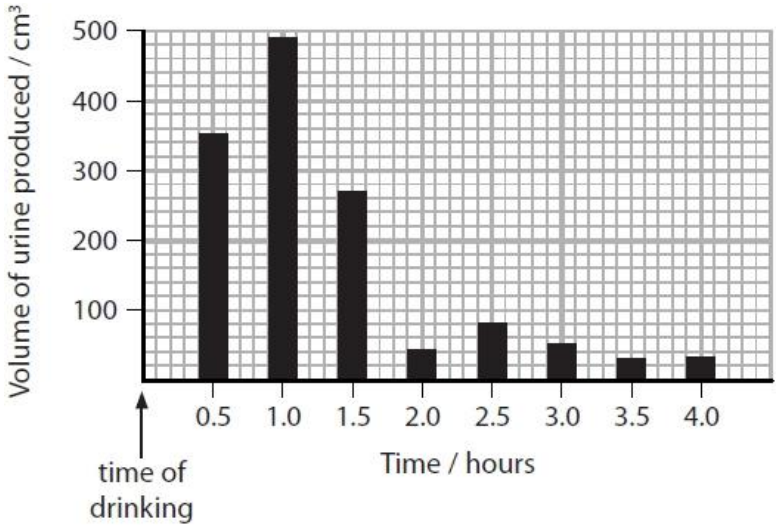
**Q14.**

Negative feedback control of blood plasma concentration is an example of homeostasis.

A student investigated the effect of drinking water on the volume of urine produced.

The student drank one $dm^3$ of water and waited for half an hour. The student then collected the urine produced every 30 minutes for four hours.

The graph shows the results of this investigation.

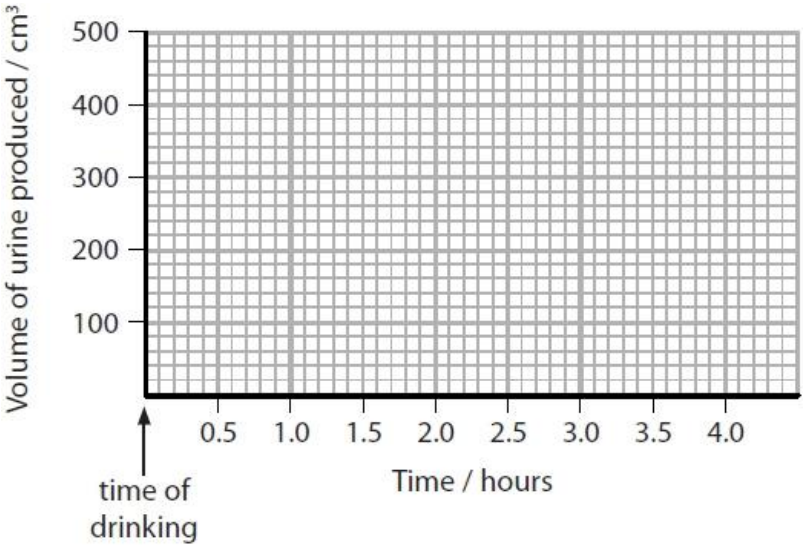



The next day the student drank one $dm^3$ of dilute salt solution with the same water potential as blood plasma.

The student waited half an hour and collected the urine produced every 30 minutes for four hours.

Sketch a graph to predict the results.

**(1)**




**(Total for question = 1 mark)**

**Q15.**

A student investigated the effect of the concentration of sodium chloride solution on blood.

The student set up six test tubes, each with a different concentration of sodium chloride solution.

Five drops of blood were added to each test tube.

The appearance of the solutions was then recorded.

Samples of each solution were observed using a light microscope.

The table shows the results of this investigation.

| Concentration of sodium chloride (%) | Appearance of solution after blood was added | Observation with light microscope |
|---|---|---|
| 3.0 | very cloudy | cells seen with shrunken edges |
| 1.0 | very cloudy | cells seen |
| 0.9 | very cloudy | cells seen |
| 0.7 | slightly cloudy | cells seen |
| 0.5 | cloudy at first, then went clear | no cells seen |
| 0.3 | clear | no cells seen |

(i) State the part of the brain responsible for osmoregulation.

**(1)**

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(ii) Explain how, on a very hot day, the brain ensures that the water potential of the blood remains constant.

**(4)**

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**(Total for question = 5 marks)**

## Mark Scheme

Q1.

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | The only correct answer is B<br>W and X<br><br>A is incorrect because glucose passes out of the glomerulus<br>C is incorrect because glucose is absorbed in the PCT<br>D is incorrect because glucose is absorbed in the PCT | | 1 comp |

**Q2.**

| Question Number | Answer | Mark |
|---|---|---|
| (i) | (350 + 490 + 270 + 40 =) 1146 to 1150 | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (ii) | An explanation that makes reference to four of the following:<br>• {blood / plasma} concentration {low / decreased / dilute / high(er) water potential / hypotonic} (1)<br>• detected by {osmoreceptors / hypothalamus} (1)<br>• therefore {no/less} ADH released by pituitary (1)<br>• collecting duct is less permeable / impermeable (1)<br>• therefore less/no {reabsorption} of water (1) | **DO NOT ACCEPT** higher concentration of water<br>**ACCEPT** baroreceptors<br>**ACCEPT** fewer aquaporins | (4) |

**Q3.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (i) | • ultrafiltration | | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (ii) | An explanation that makes reference to the following:<br>• proteins are too big to pass through (1)<br>• concentrations of the other molecules or ions are the same in both filtrate and plasma (1)<br>• because they are small enough to pass through (1) | | (3) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (iii) | An answer that makes reference to the following:<br>• calculation of increase in concentration of urea (1)<br>• calculation of increase in concentration of chloride (1)<br>• calculation of how many more times concentrated urea is compared to chloride (1) | Example of calculation<br>2.0 ÷ 0.03 = 66.7 / 66.67<br>0.6 ÷ 0.37 = 1.6 / 1.62<br>66.67 ÷ 1.62 = 41.2 / 41.15 times more<br>66.7 ÷ 1.6 = 41.7 / 41.69 times more<br>Correct answer with no working gains full marks<br>**ecf** allowed for Mp3 if number in Mp 1 or Mp2 inappropriate rounding | (3) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (iv) | An explanation that makes reference to two of the following:<br>• glucose has been (selectively) reabsorbed (1)<br>• by {active transport / against a concentration gradient} (1)<br>• in the proximal tubule (1) | **Do not accept** absorbed | (2) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (v) | An explanation that makes reference to five of the following:<br>• {sodium / chloride} ions are moved out of the ascending limb by active transport (1)<br>• ascending limb is impermeable to water (1)<br>• this results in a {high(er) concentration / low(er) water potential} in medulla (1)<br>• (loop of Henlé) acts as a counter-current multiplier (1)<br>• the collecting ducts are permeable to water (1)<br>• therefore water moves out (of the collecting ducts) by osmosis (1) | | (5) |

**Q4.**

| Question Number | Indicative content |
|---|---|
| * | Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.<br><br>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.<br><br>Indicative content:<br><br>Proximal convoluted tubule: **(P)**<br>• glucose is all reabsorbed<br>• by active transport / use of energy / use of ATP<br>• urea concentration rises as water is reabsorbed<br>• sodium ions absorbed because concentration does not increase (despite less water)<br><br>Loop of Henle: **(L)**<br>• urea concentration rises<br>• sodium ion concentration rises in descending limb<br>• water reabsorbed from descending limb<br>• by osmosis<br>• sodium ion concentration falls in ascending limb<br>• sodium ions actively pumped out of ascending limb<br>• reference to countercurrent multiplier<br><br>Distal tubule and collecting duct: **(C)**<br>• urea and sodium ion concentration rise<br>• water is reabsorbed<br>• by osmosis<br>• ADH affects permeability |

| Level | Marks | |
|---|---|---|
| 0 | 0 | No awardable content |
| 1 | 1-2 | Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.<br><br>The explanation will contain basic information with some attempt made to link knowledge and understanding to the given context.<br><br>**Any number of descriptions from graph = 1 point**<br>**Answer with description only and no explanation max 1**<br>**1 REGION and at least one explanation = 2** |
| 2 | 3-4 | Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts to provide the explanation being presented.<br><br>Lines of argument occasionally supported through the application of relevant evidence (scientific ideas, processes, techniques and procedures).<br><br>The explanation shows some linkages and lines of reasoning with some structure.<br><br>**2 REGIONS and 3 to 4 points** |
| 3 | 5-6 | Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts to provide the explanation being presented.<br><br>Line(s) of argument supported throughout by sustained application of relevant evidence (scientific ideas, processes, techniques and procedures).<br><br>The explanation shows a well-developed and sustained line of reasoning which is clear, coherent and logically structured.<br><br>**3 REGIONS and 5 plus points with no MAJOR errors e.g. urea moving into nephron, sodium ions moving into the nephron** |

**Q5.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | A description that makes reference to two of the following:<br>• removal of amino group from amino acids / deamination (1)<br>• ammonia combines with carbon dioxide (1)<br>• the ornithine cycle produces urea (1) | | (2) |

**Q6.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (i) | B ☒ **B** 1 and 3<br>*A is incorrect because facilitated diffusion does not move substances against a gradient*<br>*C is incorrect because facilitated diffusion does not move substances between phospholipids*<br>*D is incorrect because facilitated diffusion does not move substances against a gradient* | | 1 |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (ii) | C increased permeability of the collecting duct to water, producing more concentrated urine<br>*A is incorrect because ADH increases the permeability of the collecting duct*<br>*B is incorrect because ADH increases the permeability of the collecting duct*<br>*D is incorrect because ADH results in more concentrated urine* | | 1 |

**Q7.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | An explanation that makes reference to the following:<br>• large numbers of mitochondria (1)<br>• to provide ATP for active uptake of {glucose / salts / amino acids} (1)<br>• microvilli providing large surface area (1)<br>• for many carrier proteins for {glucose / salts / amino acids} (1) | **Accept** correct named minerals | 4 |

**Q8.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | An explanation that makes reference to four of the following:<br>• mice have large surface area to volume ratio (1)<br>• (therefore) {lose a lot of heat / lose heat quickly} (1)<br>• heat generated by {metabolism / respiration} (1)<br>• insufficient food to {maintain (high) metabolic rate / release enough energy} (1)<br>• no bedding {for insulation / to prevent heat loss} (1) | | (4) |

**Q9.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | • glomerulus | **Do not accept** incorrect spelling | (1) |

**Q10.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (i) | An explanation that makes reference to three from:<br>• capsaicin binds to (TPV) receptors in membrane of receptors cells (1)<br>• this causes neurotransmitter (from receptors) to bereleased onto sensory neurone {generating an epsp / opening sodium channels / causing sodium ions to flow in} (1)<br>• high concentrations of capsaicin generate an epsp that) overcomes threshold to form an {action potential} (1)<br>• action potential moves along the neurone by (opening sodium channels) (1) | **Allow** low concentrations does notovercome threshold<br>**Allow** high concentrations opens voltage gated sodium channels | **3** |

| Question Number | Indicative content | |
|---|---|---|
| (ii) | Answers will be credited according to candidate's deployment of knowledge and understanding ofmaterial in relation to the qualities and skills outlined in the generic mark scheme.<br><br>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientificand relevant.<br><br>**Descriptions**<br>• 100 mg / 50 mg / higher doses / of capsaicin increase mass of sweat produced D<br>• sweat production from 100 mg decreases after 5 days D<br>• 10 mg has less effect D<br>• 10 mg / 50mg have same effect for all seven days D<br>• 100 mg effect decreases after 3/4/5 days D<br>• 100 mg generates less sweat than 50 mg after 5/6 days D<br><br>**Explanation / Optimal Dose**<br>• increased sweating and evaporation of water E<br>• evaporation of water requires heat energy E<br>• latent heat of vaporisation is high for water so sweating removes a lot of heat energy E<br>• 50 mg is optimal dose E<br>• because there 100 mg begins to lose effect after 3/4/5 days E<br>• and 100 mg produces more side effects / burning sensations / red rash E<br><br>**Validity of data**<br><br>• 50 mg dose has consistent sweat production as error bars all overlap V<br>• 100 mg and 50 mg are significantly higher than 10 mg as error bars do not overlap V<br>• 10 mg has a high variation between responses of volunteers V | **6** |

| | | | |
|---|---|---|---|
| | | • no control experiment has been carried out V<br>• sample size is small V<br>• capsaicin may interfere with other medicines / may make illness worse / no tests done on illpeople V | |
| **Level** | **Marks** | | |
| **Level 0** | Marks | No awardable content | |
| **Level 1** | 1-2 | Limited scientific judgement made with a focus on mainly just one method, with a fewstrengths/weaknesses identified.<br><br>A conclusion may be attempted, demonstrating isolated elements of biological knowledgeand understanding but with limited evidence to support the judgement being made.<br><br>**Basic description of the effects of each dose**<br>**one mark: any one from D, E, V**<br>**two marks: 3D, 2D + 1E, 2D + 1V** | |
| **Level 2** | 3-4 | A scientific judgement is made through the application of relevant evidence, with strengthsand weaknesses of each method identified.<br><br>A conclusion is made, demonstrating linkages to elements of biological knowledge andunderstanding, with occasional evidence to support the judgement being made.<br><br>**Detailed description and either E or V**<br>**three marks: at least four points from D + E or D + V**<br>**four marks: at least five points from D + E or D + V** | |
| **Level 3** | 5-6 | A scientific judgement is made which is supported throughout by sustained application ofrelevant evidence from the analysis and interpretation of the scientific information.<br><br>A conclusion is made, demonstrating sustained linkages to biological knowledge andunderstanding with evidence to support the judgement being made.<br><br>**Must have elements of D, E and V.**<br>**five marks: at least six points from D, E and V**<br>**six marks: at least seven points from D, E and V AND must refer to standard deviations** | |

**Q11.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (i) | An explanation that makes reference to three of the following points:<br>• there is more protein in plasma than tissue fluid (1)<br>• because plasma proteins are too large to pass out of the capillary (1)<br>• and **oncotic** pressure generated by (plasma) proteins (1)<br>• (so fluid moves in) as {oncotic / osmotic} pressure is greater than hydrostatic pressure (1) | **Accept** converse<br>**Accept** converse | 3 exp |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (ii) | An explanation that makes reference to four of the following points:<br>• sodium ions are not removed from the **ascending** limb (1)<br>• so the water potential of medullary fluid is higher (1)<br>• therefore less water is removed from the **descending** limb (1)<br>• and less water is removed from the {collecting duct / distal tubule} (1)<br>• (a higher volume of) {dilute / low concentration} urine is produced (1) | **Accept** less negative water potential **Accept** water potential gradient is lower **Accept** osmotic gradient is lower | 4 exp |

**Q12.**

| Question Number | Answer | Mark |
|---|---|---|
| | **The only correct answer is B**<br>***A*** *is not correct because X is the pelvis*<br>***C*** *is not correct because W is the cortex*<br>***D*** *is not correct because W is the cortex* | **(1)** |

**Q13.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | An explanation that makes reference to the following:<br>• (substances) with higher (relative molecular) mass have a {lower ratio / ratio less than 1.00} (1)<br>• small(er) substances pass through / large substances do not pass through (1)<br>• because of the size of the pores in the {glomerulus / capillary / renal capsule / (basement) membrane} (1) | **ACCEPT** a ratio of 1.00 means substance passes through / a ratio less than 1.00 means not all substance passes through<br>**ACCEPT** substances with a mass lower than 180 pass through | **(3)** |

**Q14.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| | line or bars at 100 $cm^3$ or below for total duration | | **(1)** |

**Q15.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (i) | An answer that makes reference to the following:<br><br>• hypothalamus | | (1) |
| (ii) | An explanation that makes reference to four of thefollowing:<br><br>• sweating occurs causing loss of water from the blood (1)<br><br>• therefore the water potential of the blood falls (1)<br><br>• osmoreceptors are stimulated (1)<br><br>• causing the pituitary gland to secrete {antidiuretic hormone /ADH} (into the blood) (1)<br><br>• causing the {collecting ducts / kidney tubules} in the kidneyto reabsorb more water (into the blood) (1) | | (4) |