Answer **all** the questions.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **1.** | The kidneys of a healthy individual filter 178 dm3 day−1 of fluid from the glomeruli into the renal capsules. However, only 1.5 dm3 day−1 of urine is produced.  What percentage of the filtrate is reabsorbed back into the blood?   |  |  |  | | --- | --- | --- | |  | **A** | 176.5 | |  | **B** | 0.8 | |  | **C** | 11.8 | |  | **D** | 99.2 | | **[1]** | | | | | |
| |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **2(a).** | The kidney is one of the organs of excretion in vertebrate animals.  Fig. 2.1 shows a light micrograph of a section through a kidney cortex.  p5_01_150   1. Name the parts of the kidney labelled **A** and **B**. 2. Calculate the length of the line labelled **X** to **Y**.  Give your answer in micrometres (µm) to **two** significant figures.      |  | | --- | | Answer = ...........................................................µm **[2]** | | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **(b).** | The measurement of kidney filtration rate provides an indication of the health of the kidneys.  A filtration rate of below 60 cm3 min−1 for three consecutive months or more is a sign of chronic kidney disease.  A patient was found to have the following kidney filtration rates:  Month 1: 54.00 cm3 min−1 Month 2: 4.85 × 10−5 m3 min−1 Month 3: 1.12 cm3 s−1 Month 4: 9.70 × 10−7 m3 s−1  Do these results suggest the patient has chronic kidney disease?  Explain your conclusion using the information given.  **[2]** | | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **3.** | Most excess amino acids are metabolised in the liver, resulting in products that are relatively harmless to the body.  The figure outlines the first step in the metabolism of amino acids in the liver.  p17_01a_150   1. State the name given to this reaction.   **[1]**   1. Identify the toxic product of the reaction.   **[1]** | | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **4.** | Fig. 6.1 is a diagram that represents the nephron in a mammalian kidney.  p18-01a_150  **Fig. 6.1**  Use the letter or letters from Fig. 6.1 to identify:   1. the region or regions where glucose is selectively reabsorbed into the blood capillaries   **[1]**   1. the region or regions present in the cortex   **[1]**   1. the region or regions where podocytes are located.   **[1]** | | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **5.** | The main forms of renal replacement therapy (RRT) use dialysis. Most patients receiving dialysis have haemodialysis using a dialysis machine. However, the number of people receiving another form of dialysis, peritoneal dialysis, is increasing.  Fig. 4.2 represents the procedure of peritoneal dialysis. Some of the key points of this procedure are listed below.  p14_01_150   * The peritoneum is a membrane that lines the abdominal cavity and is well supplied with blood capillaries. * The peritoneum acts as a surface across which waste can be removed. * The dialysis fluid, containing the sugar dextrose, fills the abdominal cavity. * The fluid remains in the abdominal cavity for 4 to 6 hours. * The fluid is then drained from the abdominal cavity and thrown away. * The procedure usually needs to be done four times each day.  1. How might the peritoneum differ in its **function** from the artificial membrane in a dialysis machine used in haemodialysis?   **[1]**   1. Why does the dialysis fluid used in peritoneal dialysis contain dextrose solution rather than water alone?   **[2]**   1. Suggest why patients receiving peritoneal dialysis usually need to have the peritoneal dialysis fluid replaced four times a day, but those receiving haemodialysis only need treatment three times a week.   **[2]** | | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **6(a).** | A scientist investigated the effect of different types of food on the rate of urine production in adults.   * The subjects were given one food type for a period of three hours. * After this, their rate of urine production was measured for the following three hours. * Over the 6 hours of the procedure they consumed a controlled volume of water.   Fig. 19.2 is a graph of the results.  p20-01a_150    **Fig. 19.2**  Explain, with reference to Fig. 19.2, why some foods affect urine production.  **[4]** | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **(b).** | Fig. 19.3 is a light microscope image of kidney tubule cells.  p21-01a_150  **Fig. 19.3**   1. State **three** structures within the tubule cells that are **not** visible in this image.   **[3]**   1. Draw **one** of the cells from Fig. 19.3 in the space below.  Label your diagram to show any visible features.   p21_01_150  **[4]** | | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **7.** | One very popular indoor bonsai tree is the Sago palm, Cycas cirinalis. It is common for domestic pets to chew and accidentally ingest poisonous leaves from C. cirinalis.  C. cirinalis leaves contain the toxin cycasin, which causes liver damage in dogs.  Fig. 22 shows slides of normal liver tissue from a dog and liver tissue damaged by cycasin.  p28-01a_150    **Fig. 22**  Describe **two** ways in which the liver tissue damaged by cycasin is different from normal liver tissue.  1  2  **[2]** | | |
| |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **8(a).** | Studies of the cell surface membranes of the **distal** convoluted tubule have provided the following evidence:   * Sodium-potassium pumps: – move potassium ions from the blood to the tubule fluid – move sodium ions from the tubule fluid to the blood – use ATP in these processes. * Sodium-calcium co-transport proteins: – move calcium ions from the tubule fluid to the blood – move sodium ions into the tubule fluid – use the electrochemical gradient of sodium ions to drive this process.  1. Using this information and your own knowledge, compare the processes occurring in the **proximal** and **distal** convoluted tubules.   **[3]**   1. Nephrogenic diabetes insipidus is a disease of the kidney that affects the regulation of water potential in the blood. One cause is lithium poisoning. Lithium ions enter the kidney tubules through sodium channels.  This prevents the cells of the collecting duct from responding to ADH in the blood.  State and explain **one** symptom you would expect to observe as a result of nephrogenic diabetes insipidus.   **[2]** | |  |  |  |  |  |  | | --- | --- | --- | --- | --- | | |  |  | | --- | --- | |  |  | | **(b).** | Fig. 22.2 shows a podocyte from the kidney. The many gaps between the microscopic processes form fenestrations in the Bowman’s capsule.  pg37_001_150 **Fig. 22.2**   1. Explain why podocytes are usually unable to undergo mitosis.   **[3]**   1. Studies show that after damage by infection or injury, it is possible for nephron tissues to be regenerated. Adult stem cells are involved in this process. What features of adult stem cells make them suitable for regeneration of tissues in the kidney?   **[2]** | | |

**END OF QUESTION paper**

# Mark scheme

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Question** | | | **Answer/Indicative content** | **Marks** | **Guidance** |
| 1 |  |  | D | 1 |  |
|  |  |  | **Total** | **1** |  |
| 2 | a | i | A = Glomerulus (1) B = Bowman's capsule (1) | 2 | **ALLOW** capillary (network) |
|  |  | ii | 190 (1)(1) | 2 | **AWARD ONE MARK** for: 0.03 or 3 / 160 |
|  | b |  | Conclusion: No because month 3 is above 60 cm3 min-1 (1) | 2 |  |
|  |  |  | Month 2: 48.5 cm3 min-1 Month 3: 67.2 cm3 min-1 Month 4: 58.2 cm3 min-1 (1) |  | The second mark is for 3 correct calculations |
|  |  |  | **Total** | **6** |  |
| 3 |  | i | deamination; | 1 | **Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**   **DO NOT CREDIT** deanimation |
|  |  | ii | ammonia / NH3; | 1 | **Mark the first answer.** If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**  **DO NOT CREDIT** ammonium / NH4+  **Examiner's Comments**  Most candidates answered both parts of the question correctly. |
|  |  |  | **Total** | **2** |  |
| 4 |  | i | **Q**; | 1 | **Mark the first answer**. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**  **IGNORE** named region as question requires candidates to identify the relevant regions from the diagram.   **Examiner's Comments**  Most candidates accessed 2/3 marks here. The most common error was to reverse the positions of the cortex and medulla. Almost all answers correctly followed the instruction to use letters rather than the names of the relevant parts of the nephron. |
|  |  | ii | **Q and J and K and L;** | 1 | **All 4 letters required for the mark. If additional letters given, = 0 marks**  **IGNORE** named region as question requires candidates to identify the relevant regions from the diagram.   **Examiner's Comments**  Most candidates accessed 2/3 marks here. The most common error was to reverse the positions of the cortex and medulla. Almost all answers correctly followed the instruction to use letters rather than the names of the relevant parts of the nephron. |
|  |  | iii | **J**; | 1 | **Mark the first answer**. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = **0 marks**  **IGNORE** named region as question requires candidates to identify the relevant regions from the diagram.   **Examiner's Comments**  Most candidates accessed 2/3 marks here. The most common error was to reverse the positions of the cortex and medulla. Almost all answers correctly followed the instruction to use letters rather than the names of the relevant parts of the nephron. |
|  |  |  | **Total** | **3** |  |
| 5 |  | i | it can perform, active transport / facilitated diffusion; | 1 | **IGNORE** ref to structural features e.g. channel proteins   **Examiner's Comments**  Very few candidates gained a mark here although the majority did give the question careful thought. The word ‘function’ was emboldened in the question but some still went on to answer in terms of structure e.g. with references to channel proteins. Others discussed blood supply, counter-current mechanisms, differences in permeability and the different procedures of dialysis. |
|  |  | ii | 1. idea that (dialysis is replicating function of kidney and) part of kidney's function is to remove (excess) water from blood; 2. (dextrose / sugar) reduces, water potential / p15_01_150(of dialysis fluid) **or** (dextrose / sugar, solution) has a lower, water potential / p15_01_150(than water); 3. water moves from blood (into dialysis fluid) by osmosis **or** prevents water moving into the blood (from dialysis fluid) by osmosis; 4. (if it was water alone) cells would, swell / burst; | 2 max | **IGNORE** ref to the use of dextrose rather than glucose **IGNORE** ref to ions   **Examiner's Comments**  This challenging question was hard to access for many candidates. Most who scored marks realised that dextrose would affect water potential, but then did little with this information such as relating this to removal of water from the blood or cell damage. Candidates need to use the term ‘osmosis’ when describing the movement of water. Incorrect answers referred to the presence of dextrose to feed the cells in the abdomen or to ensure there was not too much sugar lost due to kidney failure. |
|  |  | iii | 1. peritoneal dialysis can remove less (named) waste (than haemodialysis); 2. idea that in haemodialysis dialysis fluid is constantly, refreshed / changed (but not in peritoneal dialysis); 3. haemodialysis uses counter-current flow; 4. idea that haemodialysis maintains concentration gradient **or** in peritoneal dialysis the concentration gradient, reduces / is lower; 5. (in peritoneal dialysis) the fluid reaches equilibrium with the blood; | 2 max | **IGNORE** ref to ‘cleaning’ blood   1. **ora** e.g. haemodialysis is more, efficient / effective, at removing (named) waste   **Examiner's Comments**  There were some excellent answers that showed good appreciation of how haemodialysis is able to maintain optimal concentration gradients. Many candidates, however, found this even more challenging. Many referred to the differences in convenience or volume of fluid but failed to expand on the idea. Some were distracted by the abdomen and referred to removing waste from only part of the body. |
|  |  |  | **Total** | **5** |  |
| 6 | a |  | salted crisps **AND** boiled sweets reduce water potential of blood (because of high sugar / salt content) ✓  osmoreceptors in hypothalamus, detect change in water potential in blood / cause increased release of ADH ✓  ADH causes production of aquaporins in collecting duct so more water is reabsorbed (into capillaries) ✓  bread / milk / chocolate, increase water potential of blood ✓  causes reduced ADH release ✓ | 4 max | **IGNORE** descriptions of graph |
|  | b | i | ribosomes ✓  mitochondria ✓  (rough / smooth) endoplasmic reticulum ✓ Golgi apparatus ✓  vesicle ✓  centriole ✓ | 3 max | **IGNORE** organelles not present in this cell, e.g. flagellum / chloroplast |
|  |  | ii | one cell drawn **AND** clear continuous lines ✓  correct proportions ✓  uses ≥50% of area provided ✓    labels:  label lines drawn with a ruler to correct feature ✓  cell membrane **AND** nucleus **AND** cytoplasm ✓ | 4 max | **DO NOT ALLOW** more than one cell  **DO NOT ALLOW** ragged lines / any shading  **ALLOW** if it is clear which cell the candidate has attempted to draw     **IGNORE** any annotations not mentioned here  **DO NOT ALLOW** arrow heads |
|  |  |  | **Total** | **11** |  |
| 7 |  |  | (large) gaps / holes, in tissue / between cells ✓  cell death ✓  *idea that* usual structure of liver tissue is not present ✓ | 2 max | e.g. sinusoids not present, etc. |
|  |  |  | **Total** | **2** |  |
| 8 | a | i | similarities **S1** both use active transport ✔  **S2** both involve, co-transport / described ✔  **S3** both involve selective reabsorption ✔  **S4** both involve use of, sodium ions / Na+ ✔    differences **D1** DCT involves use of, calcium ions / Ca2+ ✔  **D2** (co-transport in) DCT involves ions only ✔  **D3** PCT involves ions and (named) molecules ✔ | **3 max** | maximum two marks for similarities or differences        **IGNORE** sodium / Na      **IGNORE** calcium / Ca      **e.g.** glucose / amino acid(s)  **Examiner’s Comments** **Q22 (b)(i)** required a comparison of similarities and differences between the convoluted tubules and some candidates struggled to structure their responses appropriately. Weaker candidates were inclined to repeat the information given without processing and in some cases it was unclear whether the comment related to the distal convoluted tubule (DCT), the proximal convoluted tubule (PCT), or both. Good responses were seen where candidates had drawn a table to show similarities and differences thereby clarifying the comparative aspects. Candidates should be encouraged to practise questions involving the command word ‘compare’ to develop techniques for expressing similarities and differences within a response. |
|  |  | ii | symptom high volume of / excess, urine **OR** always thirsty / AW ✔  explanation fewer / AW, aquaporins in the (plasma) membrane (of collecting duct cells) ✔ | **2** | **ALLOW** large amount / lots, of urine **IGNORE** reference to, dilute urine / water potential / frequency of urination   **ALLOW** protein water channels for aquaporins  **Examiner’s Comments** In **Q22(b)(ii)** many candidates recognised that there would be large quantities of urine produced but there were also responses that referred to dilute urine or increased frequency of urination which did not gain credit. Few candidates mentioned aquaporins for mark point two and of those that did mention it some had the idea that there would be more aquaporins inserted in the cell surface membrane or failed to mention membrane at all in their response. |
|  | b | i | |  |  | | --- | --- | | **1** | have already / are, differentiated / specialized (so cannot divide) ✔ | | **2** | are in, G0 (phase of cell cycle) / resting phase ✔ | | **3** | idea that shape is (too), irregular / asymmetrical (so cannot divide) ✔ | | **4** | cytoskeleton cannot function / spindle (fibres) cannot form✔ | | **5** | (if mitosis occurred) it would alter, number / size, of the, gaps / fenestrations ✔ | | **6** | idea that it would alter an aspect of ultrafiltration ✔ | | **3 max** | **ALLOW** cannot pass G1 checkpoint / cannot go into S phase / remains in G1  e.g. (podocyte) has projections (so cannot divide)          **ALLOW** for aspect of ultrafiltration e.g. different sized molecules can pass through e.g. no / less, ultrafiltration e.g. changes rate of ultrafiltration e.g. changes composition of filtrate  **Examiner’s Comments** In **Q22(c)(i)** there were some excellent responses where candidates recognised that podocytes must already be differentiated and so in the G0 stage. A surprisingly high number of candidates incorrectly stated that podocytes do not have a nucleus and that this is the reason why they could not undergo mitosis. |
|  |  | ii | (adult stem cells) are multipotent ✔   (differentiate to) become any cell type within, kidney / nephron (tissue) ✔ | **2** | **DO NOT ALLOW** totipotent / pluripotent **ALLOW** (adult stem cells) can, differentiate / specialise  **Examiner’s Comments** Many candidates knew that adult stem cells had the ability to differentiate to achieve mark point one in **Q22(c)(ii)**, but some contradicted their response by using the incorrect term, i.e. totipotent or pluripotent. |
|  |  |  | **Total** | **10** |  |