

OCR A-LEVEL BIOLOGY B • H422

BIOLOGY



EXAM QUESTION PACK

5.3.3 KIDNEY FUNCTIONS AND MALFUNCTIONS

SCORE

/199

PERCENTAGE

%

STEMUP

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1 The kidney has several functions as an endocrine organ.

Which of the options, **A** to **D**, is **not** an endocrine function of the kidney?

- A osmoregulation to control the reabsorption of water
- B secretion of erythropoietin to increase production of red blood cells
- C secretion of renin to catalyse the formation of angiotensin to increase blood pressure
- D selective reabsorption of glucose to prevent it being lost during excretion

Your answer

[1]

2 Existing treatments for kidney failure include dialysis and transplant surgery. Therapeutic cloning involves growing kidney tissue from the patient's stem cells and is another type of treatment which may be available in the future.

For which of the treatments, **A** to **D**, would the patient need to take immunosuppressant drugs?

- A donation of a kidney from a living relative
- B pphaemodialysis
- C peritoneal dialysis
- D therapeutic cloning

Your answer

[1]

3(a) Renal glucosuria is a rare condition in which glucose is excreted in the urine despite normal or low blood glucose levels.

Familial renal glucosuria (FRG) is caused by mutations in the gene coding for the sodium-glucose cotransporter SGLT2. These mutations cause a reduction in SGLT2 protein or complete loss of SGLT2 protein function.

Fig. 33.1 shows SGLT2 in the plasma membrane of a cell in the kidney nephron.

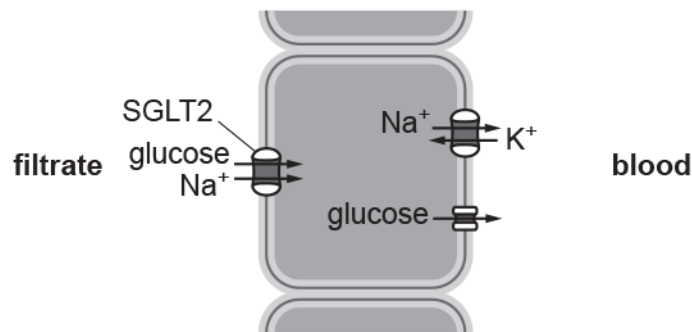


Fig. 33.1

Name the main area of the kidney, **and** the precise region of the nephron, in which the cell shown in Fig. 33.1 is located.

main area of the kidney _____

precise region of the nephron _____

[2]

(b) FRG is classified into type A, type B and type O.

Fig. 33.2 shows the relationship between blood glucose concentration and glucose reabsorption in healthy individuals and in patients with each type of FRG.

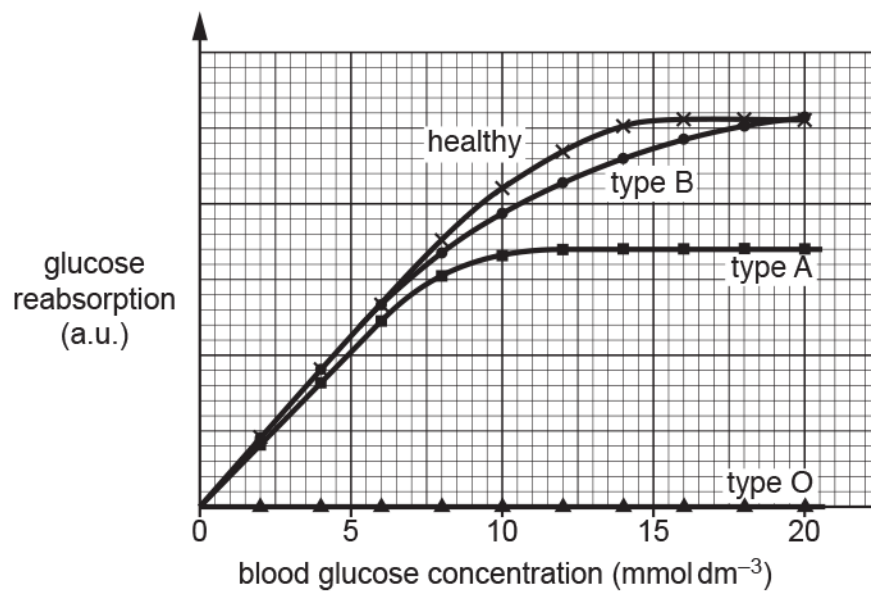


Fig. 33.2

Discuss the evidence in Fig. 33.2 to show that severity of renal dysfunction can vary among patients with FRG.

[3]

(c)

(i) Patients with FRG often produce excessive quantities of urine. Suggest why.

----- [1]

(ii) Explain how concentration of urine is regulated in healthy individuals.

----- [3]

4 Which of the following statements is/are true of haemodialysis?

- 1: Haemodialysis is often performed under medical supervision.
- 2: Molecules move from the patient's blood into the dialysis fluid by facilitated diffusion.
- 3: The water potential of the dialysis fluid is significantly greater than that of the patient's blood.

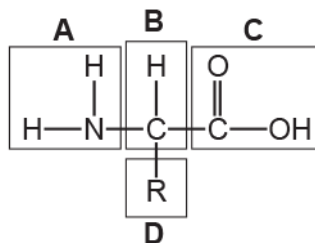
- A 1, 2 and 3 are correct
- B Only 1 and 2 are correct
- C Only 2 and 3 are correct
- D Only 1 is correct

Your answer

☐

[1]

- 5 The diagram below shows the structure of an amino acid. Four regions are labelled A to D.



Which of the regions, A to D, is removed from the amino acid to produce urea?

Your answer

[1]

- 6 Antidiuretic hormone (ADH) is required for osmoregulation.

Which of the options, A to D, is a region of the nephron that is responsive to ADH?

- A Bowman's capsule
- B collecting duct
- C loop of Henle
- D proximal convoluted tubule

Your answer

[1]

7(a) EPO can now be produced using recombinant DNA methods. The product is called rhEPO and has been used by athletes to enhance performance. This 'blood doping' has been banned since the early 1990s and anti-doping agencies have used a combination of blood and urine tests to detect the illicit use of rhEPO.

The hormone erythropoietin (EPO) is produced by the kidneys.

(i) Which cells in the body are targeted by EPO?

-----[1]

(ii) What change in conditions within the body would lead to an increase in the production of EPO?

-----[1]

(b) Patients who suffer from chronic kidney disease (CKD) often develop anaemia, the blood disorder that can occur when the body has fewer erythrocytes than normal.

(i) rhEPO can be used in the treatment of anaemia.

Explain why the normal action of EPO in the body makes it useful as a treatment for anaemia.

-----[1]

(ii) Suggest why CKD patients often develop anaemia.

-----[2]

(iii) CKD can also trigger cardiovascular disease.

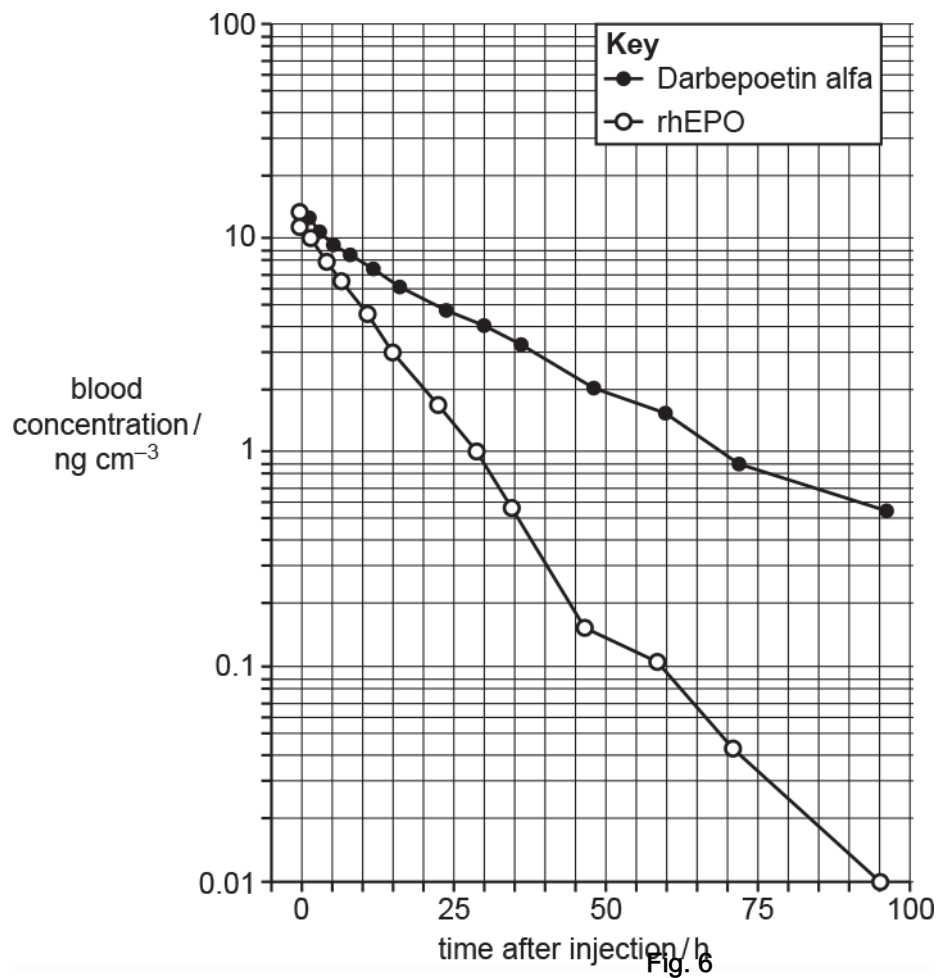
Explain how.

----- [3]

(iv) Darbepoetin alfa can also be used to treat CKD. It is a molecule with a similar structure to rhEPO.

Researchers injected a group of CKD patients with either darbepoetin alfa or rhEPO.
They measured the concentration of each drug in patients' blood for up to 96 hours after injection.

Their results are shown in Fig. 6.



A student looking at Fig. 6 stated:

After one day, there is five times more darbepoetin alfa than rhEPO remaining in the blood of patients.

Use Fig. 6 to calculate whether the student's statement is correct.

[2]

- Describe how it might be possible to overcome rejection of a transplanted kidney in the future.

[3]

8(a) (See insert for H42202, June 2018)

This question is based on the Advance Notice article **SPINAL CORD INJURIES: HOW COULD STEM CELLS HELP?**, which is an insert.

The spinal cord contains both motor and sensory neurones.

(i) State one similarity and one difference between the structure of motor and sensory neurones.

similarity -----

difference -----

[2]

(ii) Explain why a spinal cord injury (SCI) causes both paralysis **and** loss of feeling below the site of the injury.

----- [2]

(iii) Describe the role of the myelin sheath in the propagation of nerve impulses.

-----[2]

- (iv) The Advance Notice discusses oligodendrocytes, which are cells found only in the central nervous system (CNS).

State the name of the cells that perform a function equivalent to oligodendrocytes in the peripheral nervous system.

-----[1]

- (b) Treatment of injuries to the spinal cord, including with stem cell therapy, requires surgeons to determine the exact location and extent of the injury.

- (i) State the name of an imaging technique that could be used for this purpose.

-----[1]

- (ii) Describe how the technique you have given in (i) can be used to help surgeons to assess the location and extent of injury.

-----[3]

- (c) The Advance Notice article describes several types of stem cell.

Stem cells can be classified as totipotent, pluripotent, and multipotent.

Suggest which of these types of stem cell have been used in the clinical trials described in the Advance Notice. Give reasons for your choice.

[3]

- (d) * Using information from the Advance Notice, evaluate the risks, benefits and ethical issues related to the use of stem cells in the treatment of spinal cord injury (SCI).

In your answer, you should demonstrate an understanding of the current and future potential of stem cell therapy.

[6]

9(a) Dialysis is a common treatment for kidney failure.

Fig. 37.1 shows a haemodialysis machine at the beginning of a dialysis session.

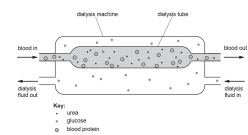


Fig. 37.1

(i) With reference to Fig. 37.1, describe how the composition of the blood changes over time.

[2]

(ii) Explain the changes described in (i).

[3]

(b) Peritoneal dialysis is another form of dialysis that is used to treat kidney failure.

State **one** advantage and **one** disadvantage of peritoneal dialysis compared with haemodialysis.

advantage_____

disadvantage_____

_____ [2]

(c) A patient with kidney failure requires treatment in the form of either haemodialysis or a kidney transplant.

Some medical notes about the patient are shown in Fig. 37.3.

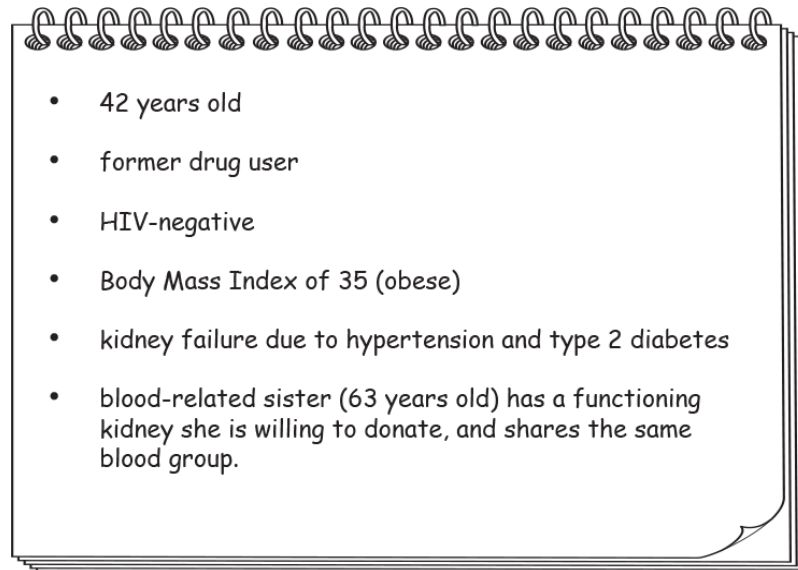


Fig. 37.3

Using the information in Fig. 37.3, discuss the suitability of each treatment option for this patient.

_____ [3]

A widely-publicised training programme claimed to improve aerobic fitness for various exercises after three months. To evaluate this claim, an investigation was conducted:

- 20 volunteers completed a series of test exercises at increasing intensities
- recovery time was recorded after each exercise
- the volunteers followed the training programme for three months
- after three months, the test exercises and measurements were repeated.

The results of the investigation are shown in Fig. 36.

The columns represent the mean recovery times before and after the training. The error bars represent the standard deviation above and below the mean.

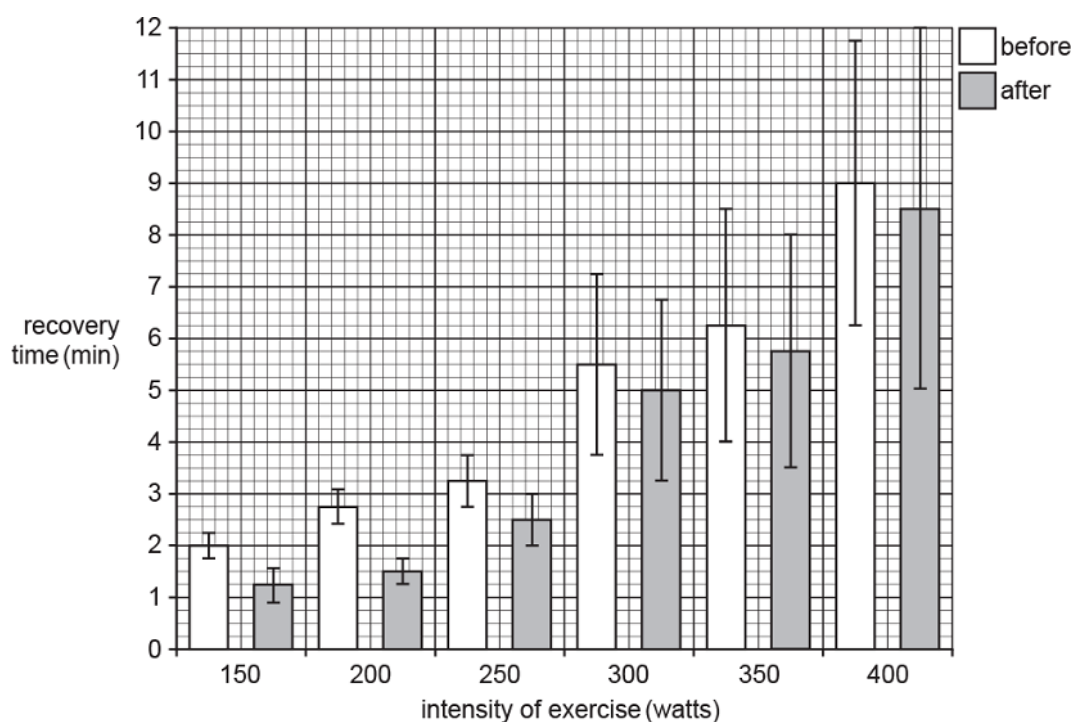


Fig. 36

(i) Name **one** statistical test that could be used to analyse the data in Fig. 36. Justify your choice.

----- [2]

(ii) Comment on how well this training programme improved fitness.

----- [2]

(iii) Promoters of the training programme claimed that it was good for training **weightlifters**. Comment on the **validity** of this statement.

----- [2]

11 Which of the options, **A** to **D**, is a direct biological effect of renin?

- A** activation of angiotensin
- B** constriction of renal blood vessels
- C** inhibition of ADH production
- D** stimulation of erythrocyte production

Your answer

[1]

12(a) Fig. 3.1 is a diagram of some of the structures found in the female excretory system.

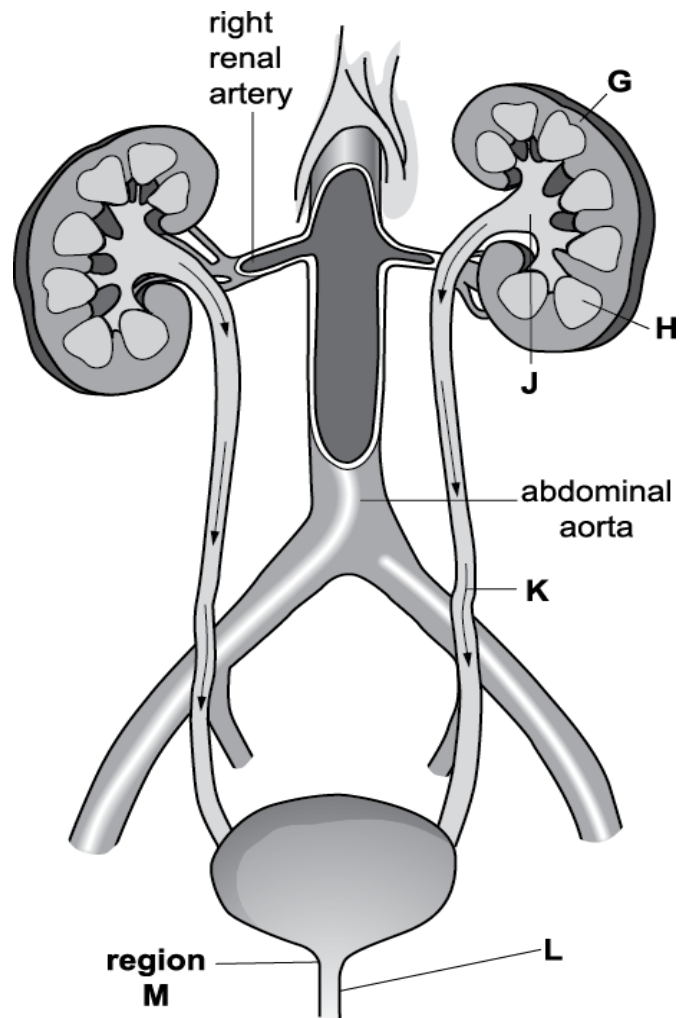


Fig. 3.1

Insert the letter or letters that correspond to each of the following:

(i) a renal pyramid _____

[1]

(ii) the ureter _____

[1]

(iii) where ultrafiltration occurs _____

(b) Name one structure that would be present at **region M** in males.

[1]

(c) A student used the enzyme urease to investigate the concentration of urea in samples of mock urine. Urease breaks down urea to produce the alkaline gas ammonia. The procedure used was as follows:

- 1 cm³ of urease solution was placed in a test tube.
- 2 drops of a pH indicator and one drop of dilute hydrochloric acid were added to the test tube. The solution turned yellow.
- 5 cm³ of a urine sample was added to the tube.
- The colour of the solution changed from yellow to red as the ammonia produced from the breakdown of urea neutralised the hydrochloric acid.
- The time taken for the solution to turn from yellow to red was recorded.

(i) Suggest how the student could minimise any uncertainty in:

measuring the volumes used in the procedure _____

measuring the time taken for a solution to change colour _____

[2]

(ii) Identify **two** ways in which the validity of the investigation could be improved.

[2]

(d) The results obtained from the investigation of two different urine samples are given in Table 3.

Replicate	Time taken for tube to change colour(s)	
	Urine sample A	Urine sample B
1	200	50
2	195	65
3	203	60
4	200	55
5	205	62
6	202	66
7	195	50
8	190	55
9	210	60
10	205	63
Mean time taken	200.5	
Standard deviation	5.9	

Table 3

(i) Calculate the mean time and standard deviation for urine sample B. The formula for calculating the standard deviation is given below. Show your working.

$$s = \sqrt{\frac{\sum (x - \bar{x})^2}{n - 1}}$$

mean = _____

standard deviation = _____

[3]

- (ii) Which of the two samples contained the highest concentration of urea? Use your knowledge of urease action to justify your conclusion.

sample _____

justification _____

[2]

- (e) Fig. 3.2 shows how the concentration of urea varies as fluid passes along the collecting duct. A value of 1.0 means that the urea concentration is the same as that in blood plasma.

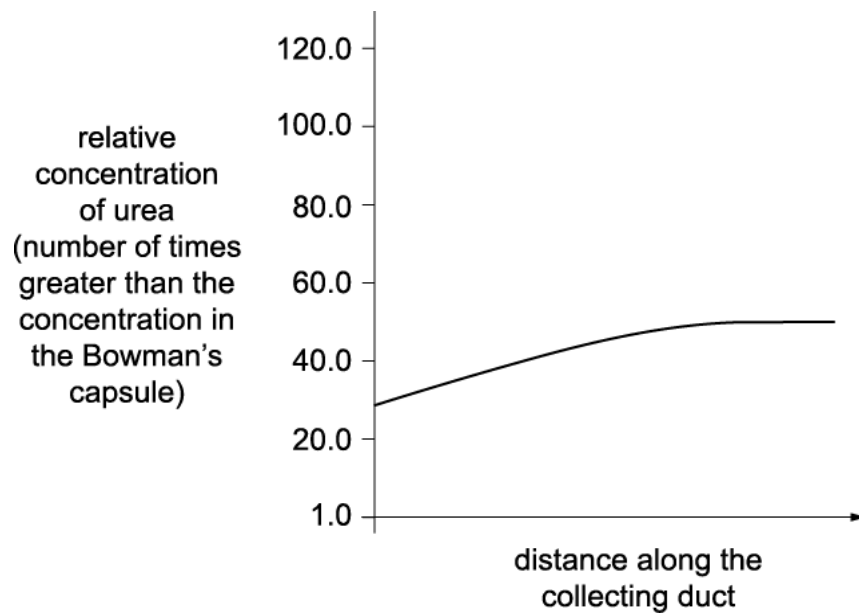


Fig. 3.2

- (i) Draw a line on Fig. 3.2 to show what would happen to the concentration of urea in the collecting duct if ADH concentration in the blood is increased.

Justify your answer.

----- the answer to part of this question should be drawn on Fig. 3.2 -----

justification -----

----- [2]

- (ii) Explain how the action of ADH on the cells of the collecting duct brings about changes in the concentration of urine.

----- [4]

(b) Some forms of **HUS** are not associated with *E. coli* O157 infections. These are known as atypical **HUS** or **AHUS**.

Some cases of **AHUS** are known to be due to an inherited gene mutation.

Carefully read and then complete the following passage about the inheritance of **AHUS** and the role of the genetic counsellor.

Some inherited forms of **AHUS** are due to a _____ mutant allele.

Parents show no symptoms of the disease so, if they have a child who develops **AHUS**, the child must be _____ for this allele. Since neither parent shows symptoms, yet both carry the mutant allele, the allele does not show _____ linkage.

A genetic counsellor would use a _____ diagram to explain the risk of any further children either developing **AHUS** or being a carrier. Where unaffected parents have one child with **AHUS**, there would be a _____ percent chance of having a child who is a carrier.

[5]

14(a) The control of blood glucose is essential because changes in blood glucose concentration will change the water potential of blood.

Water potential changes are detected by the osmoregulatory centre and adjustments are then made to the secretion of ADH.

- (i) State **one** reason, other than the effect that it has on water potential, why blood glucose concentrations must be controlled.

----- [1]

- (ii) State the location in the brain of the osmoregulatory centre and the source of ADH secretion.

osmoregulatory centre

source of ADH secretion

[1]

- (b) If people with type 1 diabetes do not administer the appropriate medication, the concentration of glucose in the blood can remain higher than the normal range for relatively long periods of time.

- (i) Name the medication that is required to treat type 1 diabetes.

Describe how and when this medication is administered **and** how it acts to reduce the blood glucose concentration.

[5]

- (ii) **Predict** the effect of high blood glucose concentration on ADH release and urine volume. You should assume that no glucose is lost from the blood and that glucose levels remain high. Justify your prediction.

effect on ADH release

effect on urine volume

justification

[3]

(c) Fig. 5.1 represents the structure of part of a kidney nephron and its surrounding blood vessels.

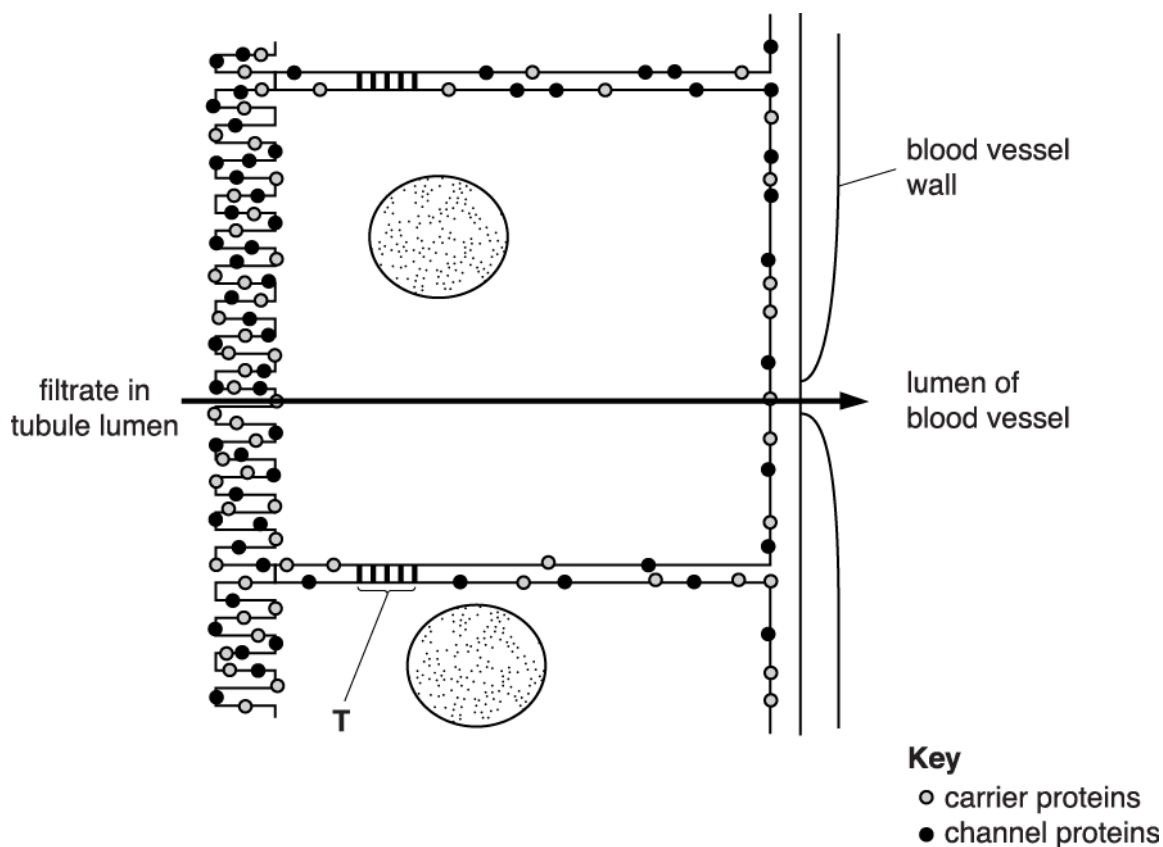


Fig. 5.1

(i) Using Fig. 5.1, identify, with a reason, the following:

the region of the nephron shown

reason

the type of blood vessel shown

reason

[2]

- (ii) Structure T is a 'tight junction' between two adjacent cells. Tight junctions prevent proteins located at the surface of cells from changing their positions.

Suggest why, if there were no tight junctions, proteins in cell surface membranes would be able to change positions.

[2]

- (iii) The region of the nephron shown in Fig. 5.1 is the region where glucose is reabsorbed.

Using the information in Fig. 5.1, name a mechanism used for selective reabsorption of glucose and explain why glucose appears in urine when blood glucose concentrations are high.

[3]

(d) Some people with diabetes will develop a condition called diabetic kidney disease. One of the symptoms of this condition is the appearance of the protein albumin in the urine.

(i) Suggest where albumin is normally found in the body.

-----[1]

(ii) Suggest, with reasons, which region of the kidney is damaged due to diabetic kidney disease.

-----[2]

15(a) In humans, the kidneys are a key organ in the excretory system. They are also essential for the maintenance of blood volume and electrolyte balance.

Changes in the functioning of the kidneys can be detected by monitoring the composition of urine.

Explain why the kidneys can be considered as **excretory organs**.

----- [2]

(b) The functional unit of the kidney is the nephron. Fig. 5.1 shows a simplified diagram of a nephron.

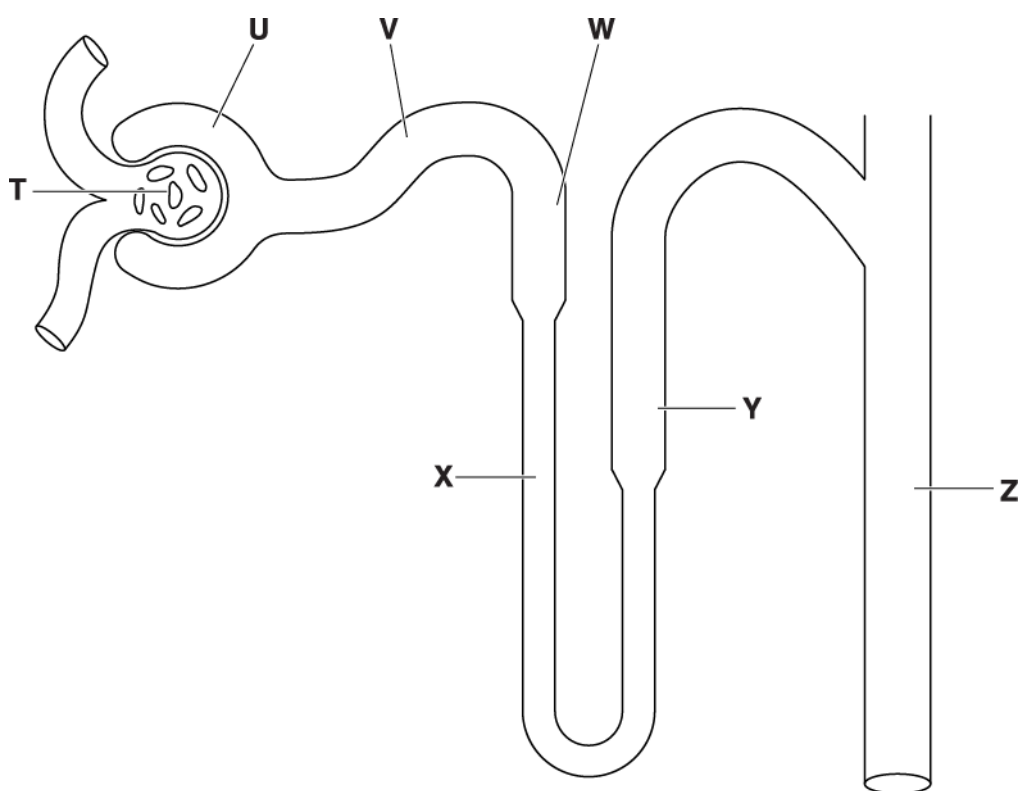


Fig. 5.1

(i) Identify the structures **T** and **U** and state the region of the kidney where these structures are found.

T

U

Region of kidney -----

[3]

- (ii) Complete the following paragraphs about the passage of filtrate through the loop of Henle by inserting the most appropriate word.

Electrolytes such as sodium ----- are actively reabsorbed from the filtrate
at region Y, which is the ----- limb of the loop of Henle. This reabsorption
reduces the ----- of the
surrounding tissues in the ----- of the kidney.

The walls of the tubule in region X are ----- to water. The result is that
water is reabsorbed from the filtrate by the process of -----.

[6]

- In a condition known as familial glycosuria, the glucose transport proteins in region **W** are not functioning. This results in glucose being present in the urine.

- [3]

- [1]

16(a) One form of AMD, known as **neovascular** AMD or wet AMD, is caused by the growth of blood vessels into the macula.

- A growth factor is normally released by cells in response to low oxygen concentrations.
- The growth factor stimulates the growth of blood vessels.
- Blood vessels may leak causing very rapid loss of vision.

(i) Suggest **one** factor, other than ageing, which may increase the risk of developing wet AMD.

Explain your suggestion.

[2]

(ii) The growth of blood vessels is stimulated by a growth factor called **VEGF**.

VEGF binds to receptors on the cell surface membrane of endothelial cells.

One treatment available for wet AMD involves blocking the action of **VEGF** using a modified antibody.

Suggest how the modified antibody prevents the action of **VEGF**.

[2]

(b) Fig. 4.3 shows the results from one clinical trial of the modified antibody treatment.

At 3-monthly intervals, each patient’s visual acuity was measured and compared to their visual acuity at the beginning of the trial. A positive value indicates an improvement and a negative value indicates a decline.

- (i) State what may be concluded about the effectiveness of the modified antibody treatment based on the results of this clinical trial.

[2]

- (ii) Suggest **one** further piece of information that would be required in order for your conclusion to be valid.

[1]

- 17 Different healthcare professionals are involved in the diagnosis and treatment of medical conditions and diseases.

Complete the table by inserting appropriate examples of the following in each row:

- the named medical condition or disease
- the healthcare professional
- a diagnostic test
- a treatment.

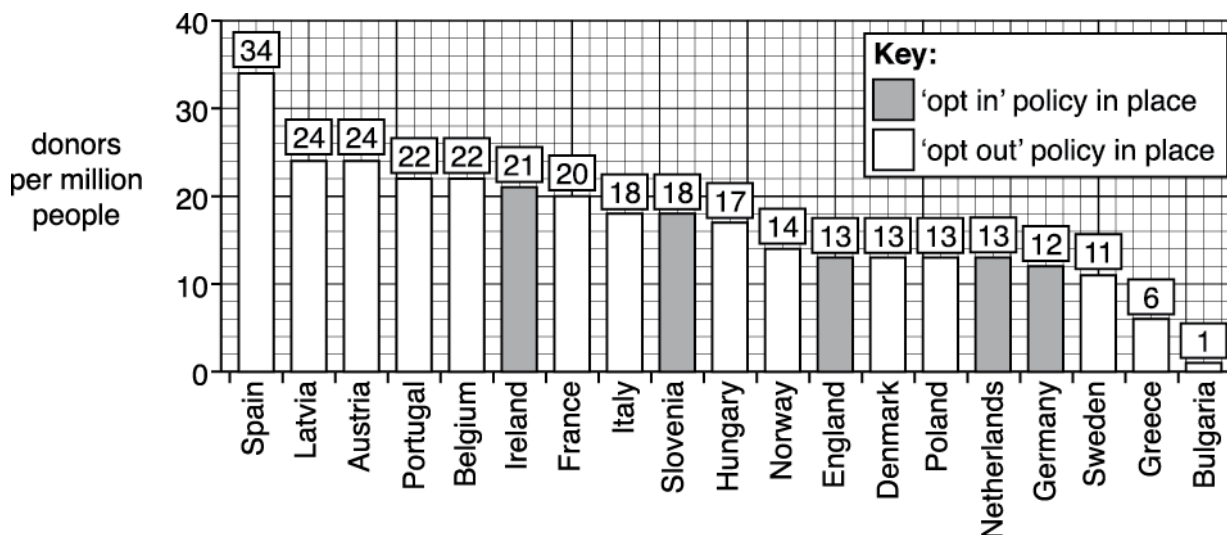
Medical condition or disease	Healthcare professional	Diagnostic test	Treatment
	radiographer	DEXA scan	calcium supplements
anaemia	nurse specialising in chronic kidney disease		
		pedigree analysis	
	paramedic	take core body temperature	application of ice packs

[6]

- 18 The current policy for organ donation in England is an 'opt in' approach. People choose to become registered as an organ donor and specify that they consent to their organs being used in transplant surgery.

Some European countries have an 'opt out' policy where people are **presumed** to be willing to donate their organs unless they specify that they do **not** wish to.

The figure is a bar chart showing the number of people donating organs in different countries, some of which have 'opt in' policies, such as England, and some of which have 'opt out' policies.



- (i) Using the information in the figure, evaluate the evidence for concluding that 'opt out' policies result in more organ donors.



In your answer, you should use data to support the evidence both for and against the conclusion.

----- [5]

(ii) State **one** advantage of using a kidney transplant as an alternative to haemodialysis for treating kidney failure.

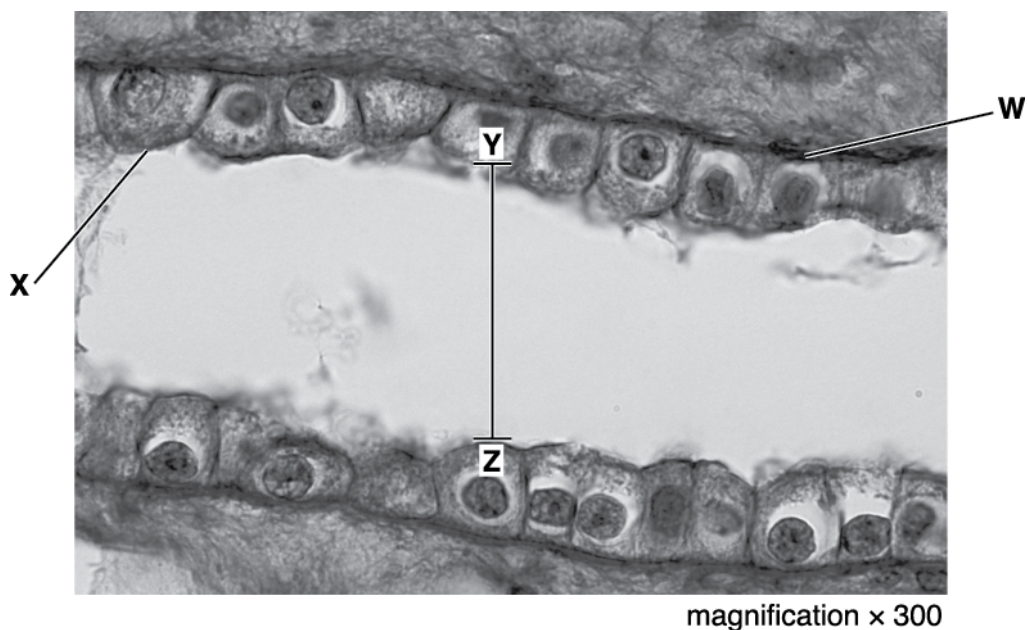
----- [1]

19(a) Excretion is the removal of metabolic waste products from the body. The kidney is one of the organs involved in excretion. One of the functions of the kidney is to remove nitrogenous waste.

Name **one** nitrogenous waste product that is removed by the kidney.

-----[1]

- (b) The following figure is a photomicrograph of a longitudinal section through the cortex of a kidney, showing the epithelial tissue lining a collecting duct.



- (i) Using the information in the figure, calculate the diameter of the lumen of the collecting duct between positions Y and Z.

Show your working. Give your answer to the nearest whole number.

Answer = ... [2]

- (ii) Suggest why the diameters of collecting ducts in the medulla of the kidney can be much wider than the diameters of collecting ducts in the cortex.

.....
.....
..... [1]

(c)

- (i) Name the hormone that binds to receptors at location **W** in the figure, **and** name the endocrine gland from which this hormone is released.

Hormone _____

Endocrine gland _____

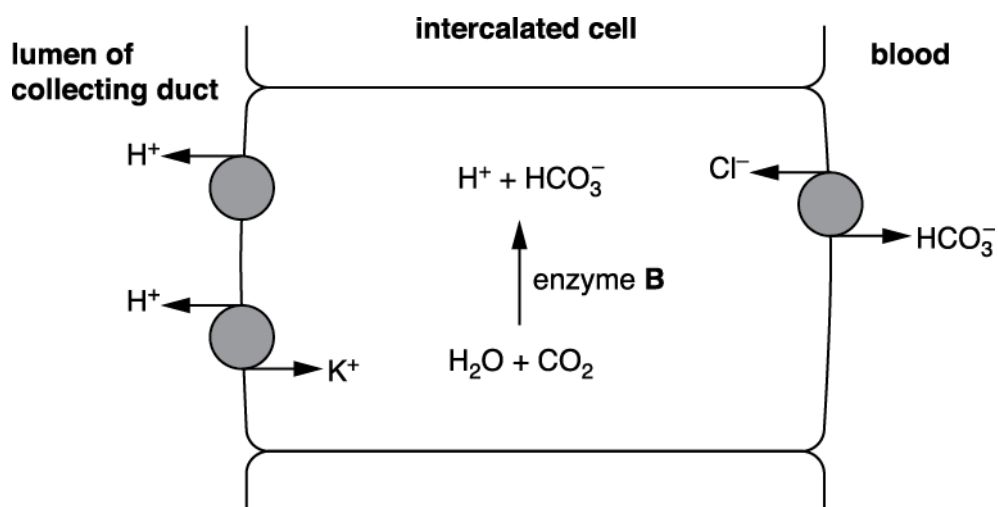
[1]

- (ii) Describe how the **appearance** of membrane **X** in the figure would differ from that of a cell lining the wall of a **proximal convoluted tubule**.

_____ [1]

- (d) Intercalated cells are specialised cells located in the walls of the collecting ducts. One function of intercalated cells is the regulation of the pH of blood plasma.

This figure is a diagram of an intercalated cell showing some of the mechanisms involved in the regulation of pH by the kidney.



- (i) Name the enzyme labelled **B** in the figure that catalyses the reaction shown.

-----[1]

- (ii) Using the information in the figure, suggest why intercalated cells contain large numbers of mitochondria.

-----[1]

- (iii) Identify **one other** organ system in the body that is responsible for controlling the pH of blood.

-----[1]

(e) The solute concentration of the fluid in the lumen of collecting duct can vary.

If a health professional suspects that a patient may have diabetes insipidus, a water deprivation test may be carried out.

Part of the procedure for carrying out a water deprivation test is given below:

- the patient does not drink for the duration of the test
- the patient is weighed at the beginning of the test and after collecting each urine sample
- urine samples are collected at regular intervals over a period of up to 9 hours
- the solute concentration of each urine sample is measured.

(i) State **one** way in which the composition of urine of a person with diabetes insipidus will be different from that of a person with diabetes mellitus.

-----[1]

(ii) Suggest why it is important to monitor the weight of the patient during the test.

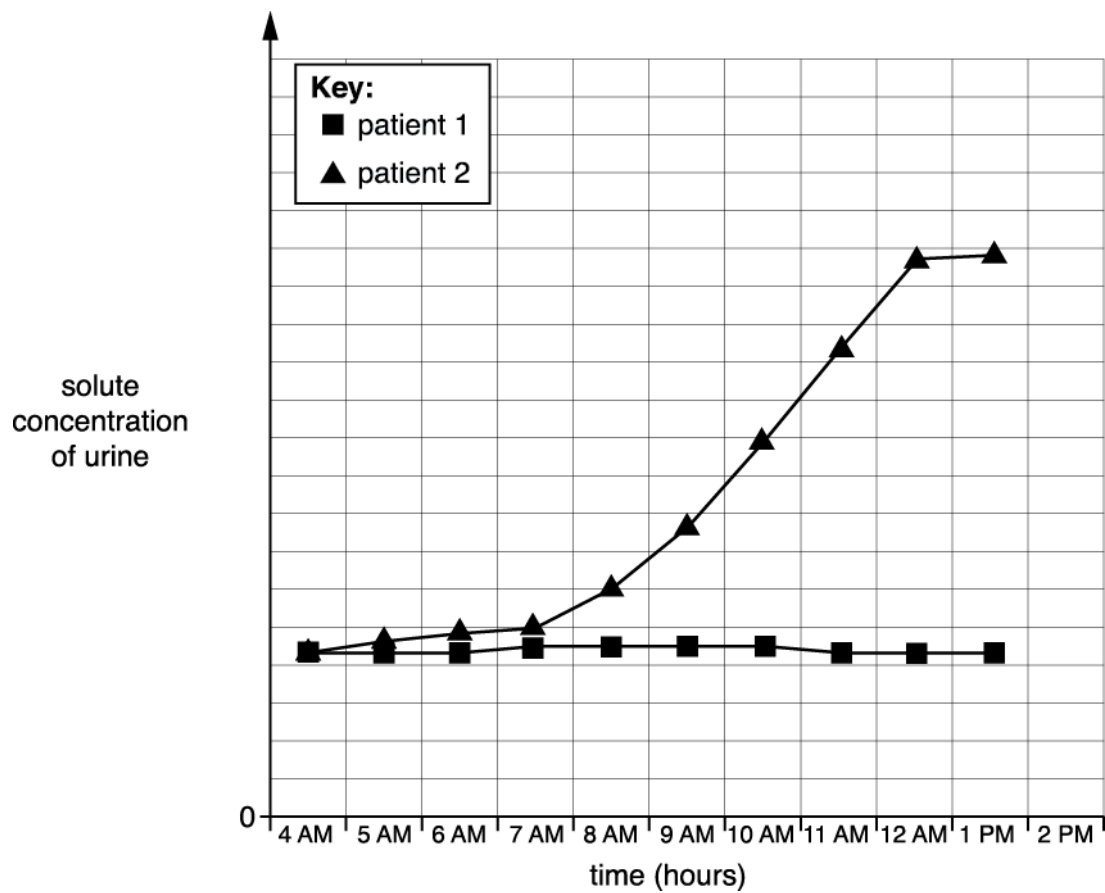
-----[1]

(iii) The solute concentration of each urine sample is measured.

Suggest **one** further measurement that should be carried out on the urine samples.

-----[1]

(iv) The following graph shows the results of a water deprivation test carried out on two different patients.



Which of the two patients would be diagnosed with diabetes insipidus?

Use the information in the graph and your biological knowledge to explain your answer.

[3]

20 * Aspirin (2-*O*-acetylsalicylic acid) is a drug commonly used in medicine.

Ingestion of more than 500 mg kg⁻¹ of aspirin causes severe and possibly fatal toxicity.

Once in the body aspirin is gradually broken down in the liver into salicylic acid.

Salicylic acid is excreted through the kidney and leaves the body in the urine.

Estimates of the amount of aspirin remaining in the body can be made by determining the amount of salicylic acid in the urine. Salicylic acid reacts with a solution of iron(III) chloride to give a purple-coloured substance.

Write a method to determine the concentration of salicylic acid in a sample of urine.

Your method must be based on the assumption that you are provided with the following:

- a solution of 100 mg dm⁻³ salicylic acid
- a 1% solution of iron(III) chloride
- a colorimeter
- school or college laboratory resources.

[9]

21(a) Dietary reference values (DRVs) are estimated requirements for groups of people. They are based on the normal distribution of the daily requirement for a nutrient within a population.

For energy, the DRV used is the Estimated Average Requirement (EAR).

DRV values for energy and calcium for both pregnant and non-pregnant adult females are given in Table 7.1.

	Energy (kJ)	Calcium (mg)
Adult females	8100	700
Pregnant females	8900	700

Table 7.1

Fig. 7.1 shows the normal distribution curve for energy requirement within a population.

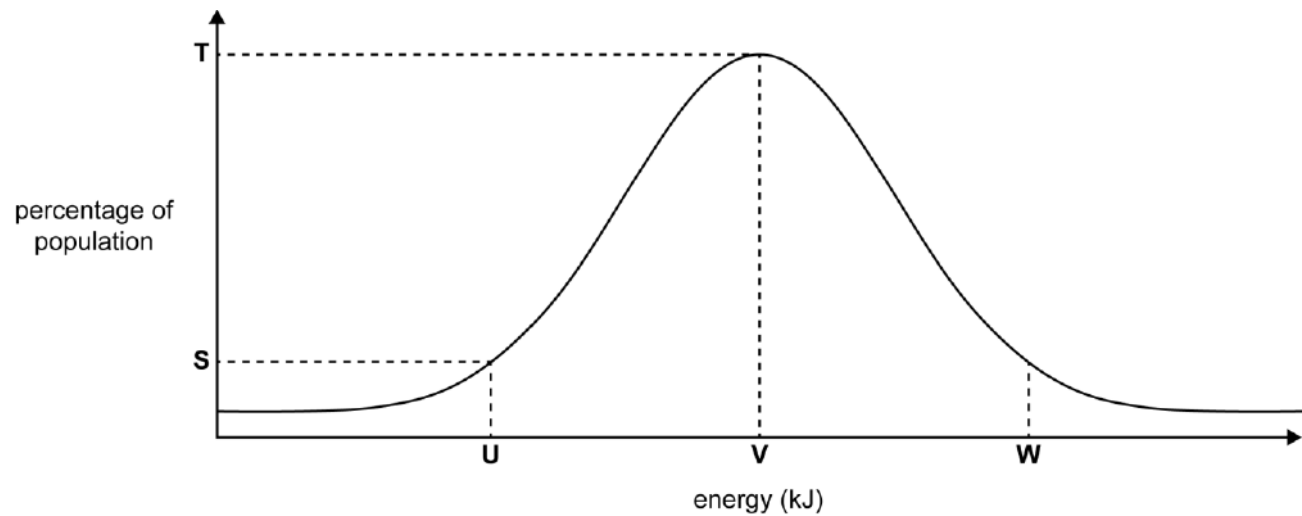


Fig. 7.1

Using the information in Table 7.1 and Fig. 7.1, identify the **value(s)** or **letter(s)** that corresponds to the following:

- (i) A percentage of the population with an energy requirement below average.

-----[1]
- (ii) The modal value for energy requirement for a population of pregnant women.

-----[1]

- (b) The same dietary intake of calcium in pregnant and non-pregnant women results in different concentrations of calcium ions in their blood plasma.

A student wrote the following statement:

I think plasma calcium ion concentration will be higher in pregnant women because there is no change in the DRV value in Table 7.1.

- (i) Explain why the student's statement is correct.

----- [2]

- (ii) Suggest how changes in the proximal convoluted tubule in the kidney might result in an increase in the concentration of calcium ions in blood plasma.

----- [2]

Methyl groups are added to the cytosine in cytosine-guanine dinucleotides (CpGs) by the enzyme DNMT.

Fig.1.2 shows the structure of a section of DNA that has been methylated.

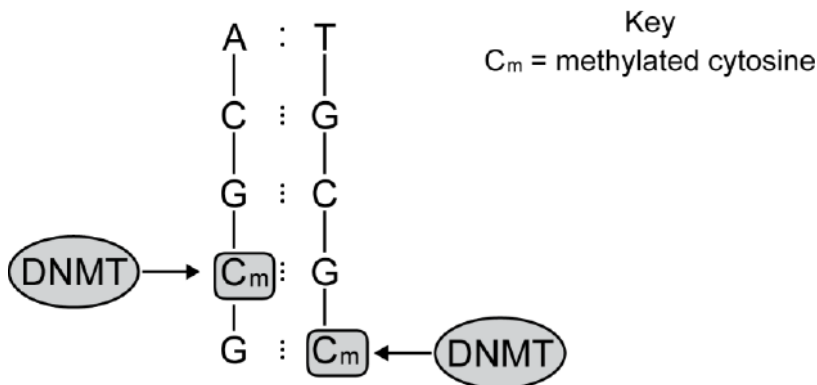


Fig. 1.2

- (i) A nucleotide containing cytosine and a nucleotide containing guanine can be bonded together in two ways:
- in a dinucleotide
 - in a base pair.

How are these bonds different?

[2]

- (ii) Fig. 1.3 shows a sugar bonded to a molecule of cytosine which has been methylated by DNMT.

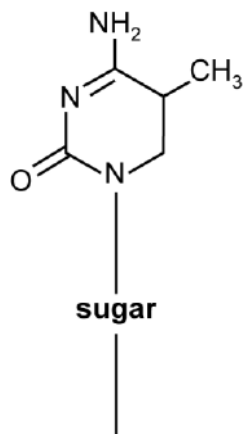


Fig. 1.3

Name the sugar to which the methylated cytosine is attached.

-----[1]

- (iii) The addition of a methyl group to cytosine increases the chances of the molecule being **deaminated** and converted to thymine.

On Fig.1.3, circle the part of the molecule that would be removed by deamination.

[1]

23(a) Fig. 33.1 shows the structure of a kidney nephron in a mammal.

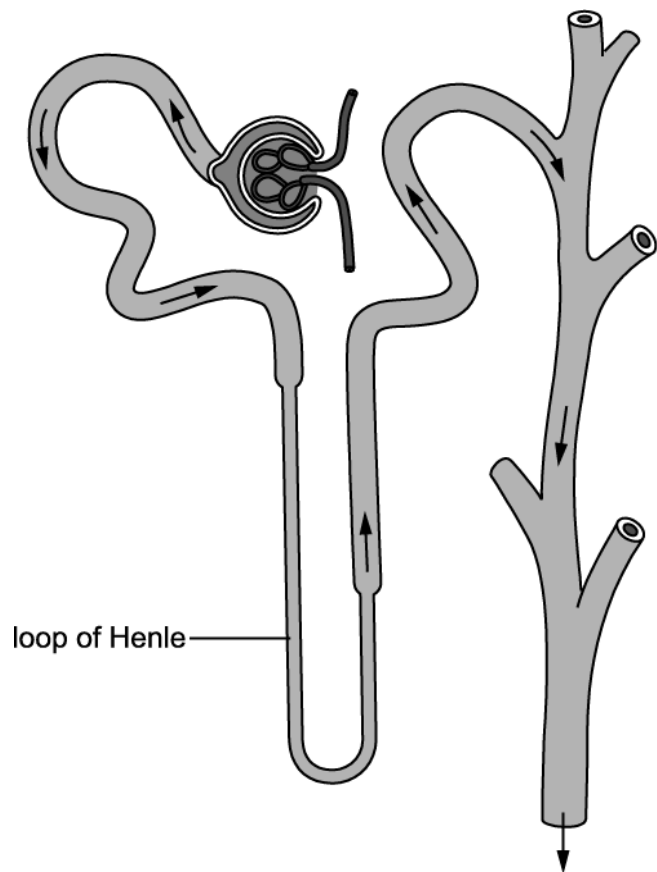


Fig. 33.1

Explain how the loop of Henle performs its role in the production of urine.

[3]

(b) Glomerular filtrate rate (GFR) is a measure of renal function.

High urinary protein levels and reduced GFR have independently been associated with an increased risk of death among patients with CKD.

A study was conducted to determine the combined influence of urinary protein level and GFR on the risk of death.

Data were drawn from 331 hospital admissions of patients with CKD. Death risk was recorded as the percentage of patients who died within a year of their CKD evaluation on admission to hospital.

The results are shown in Fig. 33.3.

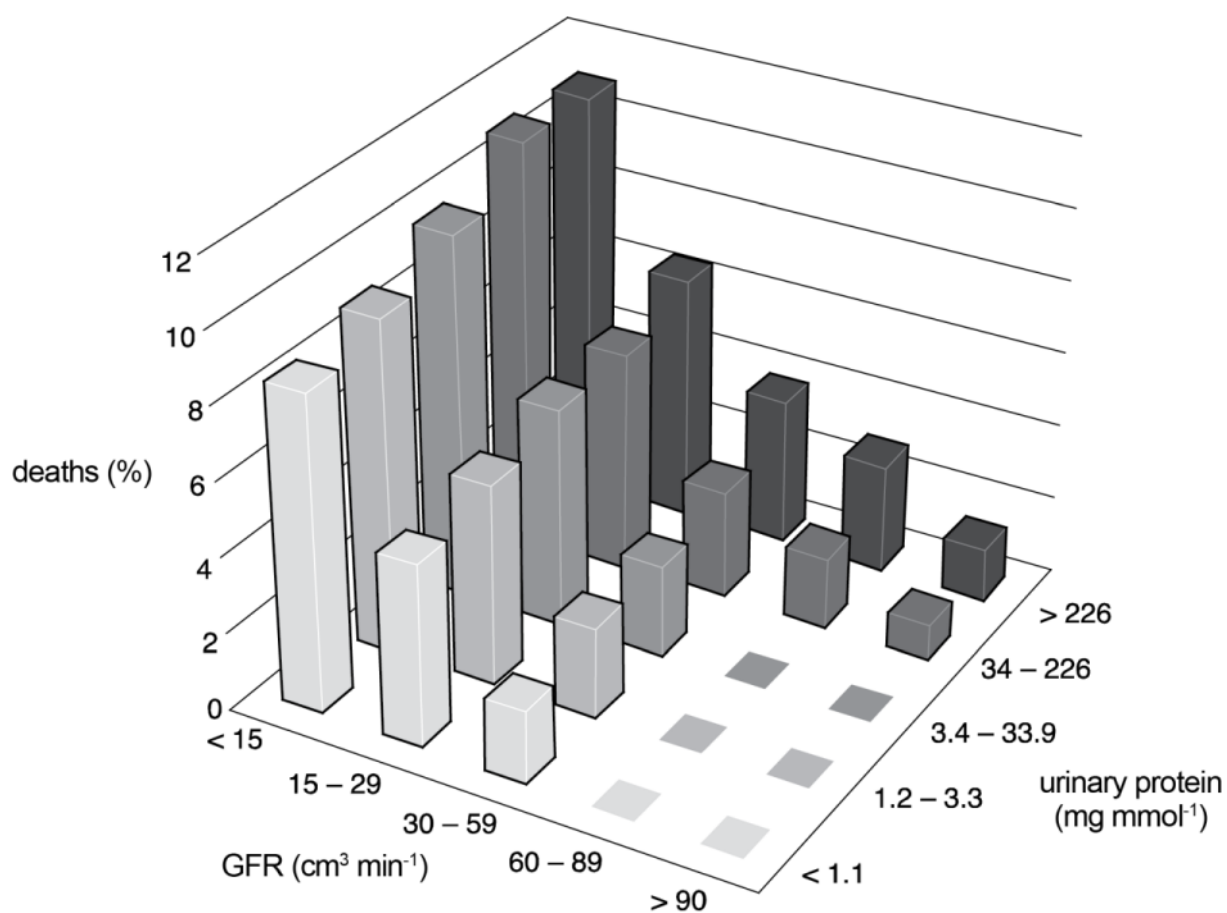


Fig. 33.3

(i) Using the data in Fig. 33.3, comment on the apparent influence of urinary protein level and GFR on the risk of death in patients with CKD.

[3]

(ii) Discuss the **validity** of the conclusions that could be drawn from the study described.

[3]

(iii) Suggest **one** way in which the study could be improved.

[1]

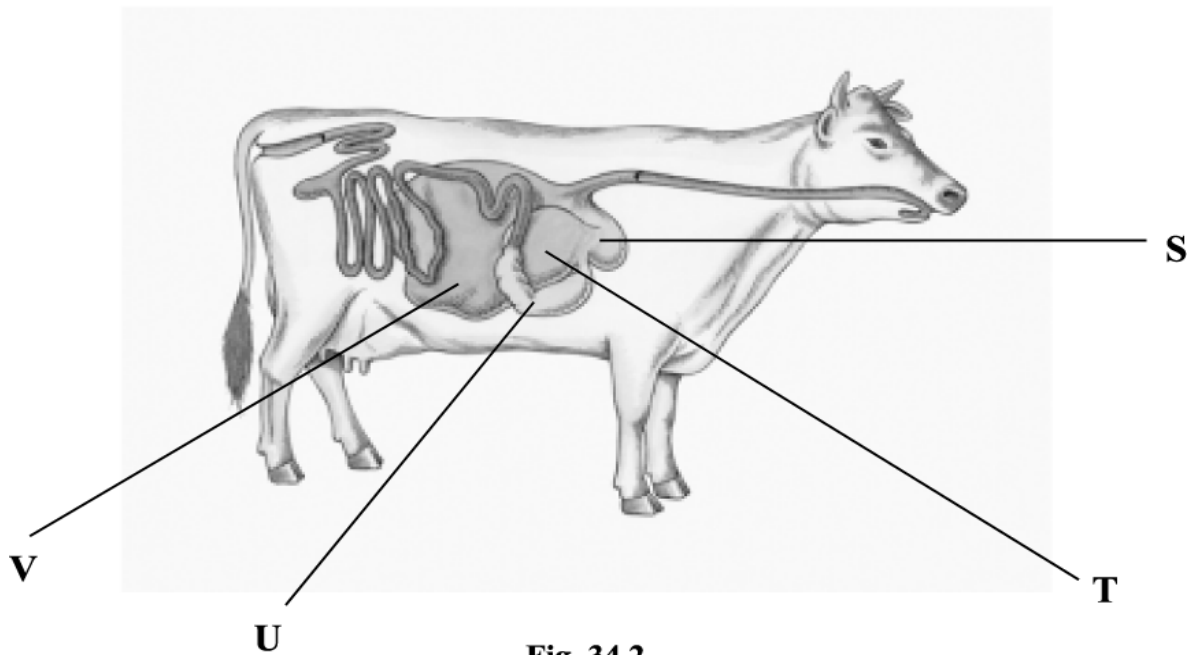


Fig. 34.2

(i) Complete the following table about the parts of the cow's digestive system labelled in Fig. 34.2.

Description	Name	Letter
Secretes hydrochloric acid and protease enzymes.		
Allows the cow to regurgitate material back up to the mouth for further chewing.		

[2]

- (ii) Both cows and humans need a range of amino acids to make their own proteins.
- Amino acids which have to be present in the diet are called essential amino acids.
 - Unlike humans, essential amino acids do **not** need to be present in the diet of cows.

Explain how cows obtain their essential amino acids.

[2]

- (iii) Amino acids which have been absorbed but which are **not** required for protein synthesis cannot be stored.

State what happens in liver cells to the amino acids which are not required for protein synthesis.

END OF QUESTION PAPER

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
1			D	1(AO1.1)	
			Total	1	
2			A	1(AO1.2)	
			Total	1	
3	a		<i>main area:</i> (renal) cortex ✓ <i>precise region:</i> <u>proximal</u> convoluted tubule ✓	2 AO2.1	
	b		no glucose reabsorption at any blood glucose concentration in patients with type 0 FRG ✓ no more glucose reabsorption at blood glucose concentrations greater than 10 mmol dm ⁻³ in type A patients ✓ glucose reabsorption in type B patients similar to healthy state ✓	3 AO3.2	
	c	i	diffusion of water (from blood into filtrate), by osmosis / down water potential gradient ✓	1 AO2.5	ALLOW water potential of filtrate is very low so water remains in the filtrate
		ii	any 3 from: (osmoreceptors in) <u>hypothalamus</u> detect water potential (ψ) of blood ✓ If low : ADH / antidiuretic hormone / vasopressin, released from <u>pituitary</u> (gland) ✓ insertion of aquaporins into collecting duct cells ✓ more water reabsorbed from collecting duct (by osmosis) ✓ solute concentration of urine increases ✓ water potential of blood increases ✓	max 3 AO1.2	ORA for any m.p.
			Total	9	
4			D	1 AO1.2	
			Total	1	
5			A	1 AO2.1	
			Total	1	
6			B	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
7	a	i	bone marrow ✓	1	ALLOW haemocytoblasts <u>Examiner's Comments</u> Well answered for both. Some candidates stated red blood cells for (i) and gave a range of unusual conditions for (ii), including water potential and red blood cell count.
		ii	decrease in (partial pressure of) oxygen ✓	1	ALLOW O₂ for 'oxygen' <u>Examiner's Comments</u> Well answered for both. Some candidates stated red blood cells for (i) and gave a range of unusual conditions for (ii), including water potential and red blood cell count.
	b	i	EPO stimulates production of red blood cells ✓	1	ALLOW RBCs / erythrocytes <u>Examiner's Comments</u> This was well answered with only a few candidates answering solely in terms of anaemia as an iron deficiency.
		ii	(damaged) kidney no longer produces (sufficient) EPO ✓ (so) fewer red blood cells are produced ✓ blood loss in haemodialysis ✓ red blood cells (maybe) filtered into the urine ✓	3	ALLOW RBCs / erythrocytes ALLOW RBCs / erythrocytes <u>Examiner's Comments</u> Candidates that connected CKD with EPO production scored mark points 1 and 2. Those who did not answer in the context of EPO did appreciate the possible dysfunctional filtration of the kidney leading to red blood cells in the urine. A few candidates discussed the release of toxins into the blood that would damage red blood cells e.g. urea.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	(kidney disease causes) increased production of renin ✓ renin catalyses conversion of angiotensinogen to angiotensin ✓ increases blood pressure /causes hypertension ✓ (increased blood pressure) damages endothelium in arteries / causes atherosclerosis ✓	3max	<u>Examiner's Comments</u> Most candidates appreciated this would lead to hypertension. Some candidates did recall the increased production of renin but rarely followed through with discussion of the reaction it catalyses. Few candidates were able to describe a damaged endothelium or artery wall, merely stating that hypertension would lead to a heart attack.
		iv	<i>Selection of correct data</i> 4.8-5.2 for darbepoetin alfa AND 1.5-1.8 for rhEPO ✓ <i>Incorrect because</i> (only) 2.6-3.4 (x more darbepoetin alfa than rhEPO) ✓	2	IGNORE % values ALLOW calculated figure (lower than 5) AND stated as less than '5x more' <u>Examiner's Comments</u> Many candidates struggled with interpreting the log scale to obtain the correct data for darbepoetin alfa and rhEPO, although most candidates were able to correctly compare their answers (correct or incorrect) in terms of a times increase or decrease.  There are quizzes and tutorials to help with interpreting log scales: http://www.ocr.org.uk/qualifications/by-subject/biology-related/maths-for-biology/m1-handling-data/

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		(have more accurate) match to, antigens on red blood cells / MHC ✓ use patients' own stem cells ✓ (which will) differentiate into kidney cells ✓ (not rejected because) genetically identical / seen as 'self' ✓ (could use) induced pluripotent stem cells / iPSCs ✓ (these are examples of) therapeutic cloning ✓	3 max	ALLOW more accurate blood grouping IGNORE growing kidneys <u>Examiner's Comments</u> This was well answered for at least 1 mark with most candidates suggesting using patients own stem cells. Many candidates discussed growing whole kidneys without appreciating the need to differentiate into cells then tissues first. Many candidates just discussed immunosuppression without relating it to a future advance.
			Total	13	

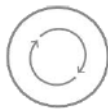
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
8	a	i	<i>Similarity (presence of)</i> axon / cell bodies / dendrites / synaptic knobs / myelin (sheath) / Schwann cells / nodes of Ranvier ✓ <i>difference</i> cell body at end of motor neurone AND cell body in middle of sensory neurone OR sensory neurone has a dendron / sensory neurone has short axon AND motor neurone has long axon ✓	2	IGNORE ref to function or direction of impulse. ALLOW suitably labelled diagrams DO NOT ALLOW both have long axons <u>Examiner's Comments</u> Similarities were well answered with a good spread of answers. Candidates who did not gain the difference mark had difficulty explaining the position of the cell body. Many candidates described the direction of the impulse and so did not appreciate the key word 'structure' in the question.  Few candidates attempted diagrams to answer this but appropriately labelled diagrams would be an excellent way of illustrating both differences and similarities and avoid the difficulties some candidates encountered when trying to describe the position of the cell body for the two types of neurones. Candidates should not be restricted to text just because lines are provided.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	both sensory and motor neurones are damaged ✓ impulse cannot, reach muscles / pass through motor neurone ✓ prevents impulse transmission, through sensory neurone / from receptors ✓	2 max	IGNORE signals/messages/information for 'impulses' ALLOW from stimulus for 'from receptors'. <u>Examiner's Comments</u> This was well answered with many candidates appreciating the relevance of the two consequences of damage to the two types of neurone. More candidates recognised the significance of the (damaged) motor neurone to paralysis than the (damaged) sensory neurone to loss of feeling.
		iii	insulates (the axon) / prevents passage of ions ✓ saltatory conduction ✓ (this) increases / speeds up , (rate of) transmission of impulses ✓	2 max	IGNORE signals/messages/information for 'impulses' ALLOW action potential jumps from node to node for 'saltatory conduction'. <u>Examiner's Comments</u> Most candidates recognised myelin as an insulator and could either state saltatory conduction or describe it.  Myelin was often referred to as protecting the axon which suggests an analogy with adipose tissue in various parts of the body. This is not correct and myelin should be described purely in terms of its role in increasing the axon's membrane resistance and decreasing the membrane capacitance. Relating the role of myelin to symptoms of multiple sclerosis often helps to emphasise the importance of its function in a contextual sense. Succinct

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					descriptions can be found at: https://www.sciencedirect.com/topics/neuroscience/myelin (1aii & 1aiii)  Too many candidates use terms like signals, messages and information to describe an action potential. When describing the propagation of an action potential, avoid using signalling or messaging as transitive verbs referring to the direction of impulse, e.g. avoid 'an impulse signals to the CNS'. This will help to remove these words in any context (verb or noun). Concentrate on using words e.g. transmitted, propagated. This should help candidates to disconnect the use of signals and messages when describing any aspect of nerve transmission. Key Misconception 
		iv	Schwann cells	1	<u>Examiner's Comments</u> Generally, well answered although many candidates stated glial cells. There were a few NR for this question part.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	b	i	MRI / fMRI (functional MRI) / CT ✓	1	ALLOW lower case letters <u>Examiner's Comments</u> Most candidates described MRI and recalled the use of a magnetic field and radio-waves to produce an image. Those who described a CT scan successfully recalled the use of X-rays and producing a 3D image.  Candidates described the resultant images as showing damaged areas, as if the whole image would focus only on areas of injury. It should be demonstrated that images would show damaged areas compared to surrounding healthy tissue. Many images can be found that illustrate small areas of damage compared to surrounding tissue. Videos can also be shown that can be in any context e.g. herniated disc, as it serves to illustrate the relevance and limitations of these techniques. https://www.bing.com/videos/search?q=herniated+disc+mri&view=detail&mid=26378AD9C02AB6505D1B26378AD9C02AB6505D1B&FORM=VIRE

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	1 (both) show difference, between healthy and damaged areas ✓ <i>MRI / fMRI</i> M2 uses magnet(s) / magnetic field ✓ M3 detects, increase in water (content) / swelling / inflammation / (changes in) blood flow ✓ M4 (can be used to) detect areas of demyelination ✓ OR <i>CT</i> C2 uses X-rays (and computer) ✓ C3 builds up 3-D image (of the spinal cord) ✓ C4 shows areas with, poor blood supply / bleeding / blood clot ✓	3 max	IGNORE ref to tumours or other conditions not related to SCI IGNORE ref to technique other than <i>1bi</i> answer ALLOW 3DMRI gives a 3D image <u>Examiner's Comments</u> Most candidates described MRI and recalled the use of a magnetic field and radio-waves to produce an image. Those who described a CT scan successfully recalled the use of X-rays and producing a 3D image.  Candidates described the resultant images as showing damaged areas, as if the whole image would focus only on areas of injury. It should be demonstrated that images would show damaged areas compared to surrounding healthy tissue. Many images can be found that illustrate small areas of damage compared to surrounding tissue. Videos can also be shown that can be in any context e.g. herniated disc, as it serves to illustrate the relevance and limitations of these techniques. https://www.bing.com/videos/search?q=herniated+disc+mri&view=detail&mid=26378AD9C02AB6505D1B26378AD9C02AB6505D1B&FORM=VIRE

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		1 neural stem cells / human brain tissue stem cells / MSCs, are <u>multipotent</u> ✓ 2 (as) derived from adult (stem cells) / able to differentiate into a limited range of cell types ✓ 3 embryonic stem cells are <u>pluripotent</u> ✓ 4 (as) they can differentiate into any type of cell ✓	3 max	ALLOW ref to trial names (e.g. Balgrist / Neuralstem) for 'neural stem cells/MSCs' ALLOW pluripotent in the context of iPSCs ALLOW ref to Asterias trial for 'embryonic stem cells' ALLOW embryonic stem cells are <u>toti</u> potent as <u>early</u> embryo used <u>Examiner's Comments</u> Well answered with most candidates clearly extracting relevant information from the Advance Notice article. Marks were lost for confusing pluripotent with totipotent stem cells.  As both pluripotent and totipotent stem cells derive from embryos and can differentiate into any type of cell, candidates confuse the terms and focus on totipotent stem cells. It should be emphasised that the medical use of stem cells use pluripotent stem cells that are also called embryonic stem cells or ESC's.
	d		<i>Summary of instructions to markers:</i> <i>Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)</i> <i>Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in <i>italics</i>):</i> award the higher mark where the Communication Statement has		

Mark Scheme

Question	Answer/Indicative content	Marks	Guidance
	been met. - award the lower mark where aspects of the Communication Statement have been missed. - The science content determines the level. - The Communication Statement determines the mark within a level. Level 3 (5–6 marks) An evaluation of the risks and benefits and the ethical issue of using stem cells. There is clear reference to the future potential of stem cell therapy. <i>There is a well-developed line of reasoning which is clear and logically structured and uses scientific terminology at an appropriate level. There are clear links to the information in the article. All the information presented is relevant and forms a continuous narrative.</i> Level 2 (3–4 marks) An evaluation of the benefits and risk or risks and benefit of using stem cells including any ethical issue surrounding this use. There is reference to the future potential of stem cell therapy. <i>There is a line of reasoning presented with some structure and use of appropriate scientific language. There is a link to the information in the article The information presented is mostly relevant.</i> Level 1 (1–2 marks) An evaluation of the risk or benefit and any ethical issue related to the use of stem cells. However, there is no reference to future potential. <i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i> 0 marks No response or no response worthy of	6	Indicative scientific points may include Risks Risk of rejection Risk of infection with many injections or collection of MSCs Risk of further injury with many injections Need for immunosuppression Unknown long-term effect May not work Risk of teratogenesis / oncogenesis (with iPSCs) Too much emphasis on data with small sample size Benefits Reduces symptoms of SCI/ treats SCI Replace damaged cells Patients could walk/move, again Prevents further damage due to SCI Still under research/ not known Lack of other treatments Gives hope to patients No rejection if from own bone marrow Data used to help future sufferers Ethical Destroying embryos Use of iPSCs Use of human brain tissue Gives false hope Future potential Stem cell therapies will be approved Use of iPSCs Data gathered can be used in future <u>Examiner's Comments</u>

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			credit.		Well answered with most candidates covering all aspects of ethical risks, benefits and potential future benefit. Many candidates had learned about the use and potential of induced pluripotent stem cells (iPSCs). Some candidates used up too much space (and time) discussing ethical issues in terms of playing god, embryos can't give consent, etc. without mentioning the obvious fact that producing embryonic stem cells usually means destroying an embryo. Candidates often lost marks for failing to appreciate the future potential of stem cell therapy. Exemplar 1 The benefits of using stem cells in the treatment of spinal cord injuries are that they may be able to treat the spinal cord injury, restoring function and feeling to affected areas, by restoring neurons, replace lost myelin, and protect the cord from spreading the damage after injury. Then the financial, social, for physical and psychological problems on the patients with the injury will be resolved and hopefully removed. These financial, social and psychological burdens also affect the patients' family, thereby making stem cells a great idea for the patient's spinal cord injury. You are also helping their family and support system. The risks associated with stem cell use created the stem cells may induce tumours in the patients, the tumours are known as teratomas. Another risk is with the use of stem cells on the patient the patient may have to take low levels of immunosuppression medication which may leave them vulnerable to opportunistic infections, etc. tuberculosis. The ethical issues associated with the use of stem cells for spinal cord injuries are that if the stem cells used are from human embryos some people believe this is wrong, as you are destroying a potential human life, while others believe the embryo is simply a ball of undifferentiated cells lacking human qualities. Also some people worry that using stem cells in medicine may lead to the cloning of humans or that people may receive human enhancement technology. Also stem cells in the future can be used to test drugs which could help treat diseases such as spinal cord injuries in vitro rather than in the patient. Good use of all available space on page. Clearly moves through ethical benefits, risks and potential for future benefit. There was good discussion of each, with no focus on any particular component and always related to SCI.
			Total	20	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
9	a	i	any 2 from: decrease in urea concentration (in blood) ✓ glucose concentration (of blood) remains unchanged ✓ protein, composition / concentration, (of blood) remains unchanged ✓	max 2	IGNORE reference to glucose increasing or decreasing Examiner's Comments (a)(i) and (ii) both referred to Fig and serve to emphasise how important it is for candidates to read command words. The question was not asking about what happens in the kidney so any references to glucose diffusing out to the tubule and being selectively reabsorbed or proteins being too large to pass through the basement membrane did not gain credit. This was a question about movement of molecules across a partially permeable membrane in the context of dialysis and successful candidates studied the figure and used it to describe and explain the movement of molecules. Those candidates who suggested that glucose would diffuse into the tubing probably made the error based on number of molecules rather than concentration.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	passage of molecules through partially permeable membrane via (passive) <u>diffusion</u> ✓ urea (diffuses) from a high concentration to a low concentration / down concentration gradient ✓ glucose (stays the same) because of, equilibration of molecules either side of membrane / no net diffusion ✓ protein too large to pass through membrane / tubing ✓	max 3	ALLOW 'semi-permeable membrane' DO NOT ALLOW ECF from 37 (a)(i) Examiner's Comments (a)(i) and (ii) both referred to Fig and serve to emphasise how important it is for candidates to read command words. The question was not asking about what happens in the kidney so any references to glucose diffusing out to the tubule and being selectively reabsorbed or proteins being too large to pass through the basement membrane did not gain credit. This was a question about movement of molecules across a partially permeable membrane in the context of dialysis and successful candidates studied the figure and used it to describe and explain the movement of molecules. Those candidates who suggested that glucose would diffuse into the tubing probably made the error based on number of molecules rather than concentration.
	b		<i>Advantage:</i> 1 from: no need for specialist equipment ✓ can be done, at home / by patient ✓ patient can be mobile during treatment ✓ <i>Disadvantage:</i> 1 from: risk of infection ✓ required more frequently than haemodialysis ✓	2	AW Examiner's Comments (b) was accessible to, and well answered by, most candidates.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c		surgery would carry risk due to, high BMI / weight / obesity ✓ hypertension / type 2 diabetes would damage transplanted kidney ✓ patient does not pose risk to other dialysis patients (due to HIV status) ✓ sister ageing, so risks from surgery ✓ <i>idea of</i> blood vessels not being suitable for haemodialysis due to drug use ✓	max 3	ACCEPT ref to 'existing conditions' IGNORE unqualified statements relating to the best treatment option Examiner's Comments In (d) candidates were asked to use the information from a figure to discuss the suitability of treatment options. Candidates were not asked to give advice to the patient, so those that recommended that the patient lose weight before surgery were not credited unlike candidates who stated that the surgery would carry risks. In questions such as this it is advisable to use as much of the given information as possible. Candidates often failed to realise that a patient who is HIV negative would not be a risk to others when undergoing dialysis. The candidates who scored highly for this question referred to several of the bullet points in the figure.
			Total	10	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
10		i	(Student's) t-test ✓ paired / measurements from same people (before and after) ✓	2	Examiner's Comments It was encouraging to see that over 60% of candidates were awarded at least one mark when asked about the type of statistical test that could be used to analyse the data in (b)(i). A significant number of candidates justified their choice, clearly explaining how measurements were taken from the same people before and after exercise.
		ii	improvement in recovery time (at all intensities / wattages of exercise) ✓ improvement falls as intensity / wattage rises ✓ uncertainty in making conclusion because standard deviations / error bars (for before-and-after) overlap ✓	2	ORA Examiner's Comments (b)(ii) was another example where candidates showed that they could describe data clearly. They were also able to identify that large error bars illustrated the data was variable but often failed to develop the idea of lack of significance when error bars overlapped.
		iii	higher intensity / wattage exercises such as weightlifting show less improvement in recovery time ✓ weightlifting is not an aerobic exercise ✓ weightlifting occurs over a short duration / in short bursts ✓	2	ORA ALLOW if not awarded in (b)(ii) uncertainty in making conclusion (about weightlifting) because standard deviations / error bars (for before-and-after) overlap Examiner's Comments (b)(iii) required candidates to understand that weightlifting is not an aerobic exercise and occurs in short bursts so this training programme, which candidates were told focused on aerobic fitness, would not be appropriate.
			Total	6	
11			B ✓	1	
			Total	1	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
12	a	i	H ✓	1	
		ii	K ✓	1	
		iii	G ✓	1	
	b		prostate (gland) ✓	1	
	c	i	<i>volumes</i> <i>idea of</i> using the appropriate measuring instrument (e.g. 1 cm ³ syringe for urease / 5 cm ³ for urine / microsyringe instead of 'drops' for indicator) ✓ <i>times</i> <i>idea of</i> a stop watch / timer and a comparison to determine final colour ✓	2	ALLOW alternative relevant answers ALLOW suggestion that reaction is monitored in a colorimeter and the same absorbance value used each time for the end point
		ii	use same concentration of urease (throughout) ✓ place tubes in a water bath ✓	2	ALLOW alternative relevant answers DO NOT ALLOW 'add a buffer' or 'control pH' as a change in pH is the dependent variable
	d	i	mean = 58.6 ✓ standard deviation = 5.8 ✓✓	3	ALLOW ECF for incorrect calculation of mean 2 max if either answer is given to more than 3 significant figures
		ii	Sample B (no mark) <i>justification</i> <i>idea of</i> more substrate molecules available ✓ more enzyme-substrate complexes form in a given time ✓ rate of the reaction increases ✓	max 2	ALLOW ammonia produced at a faster rate

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	e	i	<i>Line on graph</i> line steeper than current line ✓ <i>Justification</i> <i>idea that</i> water would leave the collecting duct at a faster rate (were ADH concentration to rise) ✓	2	ALLOW a straight line IGNORE starting position and end position of the line (line may start and finish above or below the line on the diagram) DO NOT ALLOW a line that drops downwards at any point
		ii	(ADH) binds to receptors on cell surface membrane ✓ (leading to) increase in concentration of cAMP ✓ <i>idea that</i> (cAMP) causes vesicles containing aquaporins to move ✓ <i>idea that</i> aquaporins / AW, increase in cell surface membrane lining the lumen ✓ (more) water is reabsorbed and concentration (of urine) increases ✓ detail of action of cAMP ✓	max 4	ALLOW a description of an aquaporin for this mark point e.g. activates protein kinase(s), increased transcription of aquaporin genes
			Total	19	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
13	a	i	<i>Named treatment for short term:</i> Haemodialysis; peritoneal dialysis; <i>long term treatment</i> kidney transplant; <i>organ / donor detail</i> matched MHC antigens / blood groups between donor and recipient OR use of close relative to obtain tissue match OR ref to cadaver / xenotransplants; <i>recipient detail</i> use of immunosuppressant to prevent rejection; <i>idea of control of diet / low salt;</i> <i>operation detail</i> connection of renal artery and vein / connection to alternative artery (iliac) / old kidney left in place; <i>detail of alternative long term treatment</i> <i>peritoneal dialysis</i> dialysis fluid introduced into abdominal cavity OR peritoneum acts as the partially permeable membrane OR reference to CCPD / described	5	DO NOT CREDIT 'kidney or renal' dialysis DO NOT CREDIT haemodialysis as a long term treatment ACCEPT 'alternative treatment' as 'long term' ACCEPT alternative correct details CREDIT description of CCPD such as attached overnight to a dialysis exchanger Examiner's Comments In part (i) many candidates misread the question which was about treating kidney failure not treating an E.coli infection. The error was frequently compounded as description was only required for the long term treatment. Many candidates did score maximum marks but many failed to take into account the context of the question.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	(injections of) erythropoietin / EPO; <i>explanation:</i> (EPO) stimulates, RBC synthesis; as (damaged) kidneys not making EPO; OR (packed red blood cell, whole blood) transfusion; as {damaged} kidneys not making EPO; (so) RBC synthesis not stimulated (by EPO);	3	Examiner's Comments There were some good answers on EPO treatment and on blood transfusions in (ii) but many candidates again had lost the context of the question which was kidney damage and answered in terms of iron supplements.
	b		recessive; homozygous / double, recessive; sex; pedigree; fifty / 50;	5	Examiner's Comments Answers were good with the majority of candidates scoring at least 3 marks. The commonest mistakes were autosomal rather than sex linkage and mistake on the probability at the end suggesting this was a guess rather than using a Punnett square. Many scripts did show evidence that this is what good candidates did.
			Total	13	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
14	a	i	<i>idea that</i> glucose is a respiratory substrate OR (plasma) glucose is the only respiratory substrate for neurones OR if blood glucose too low neurones lose function / AW;	1	IGNORE ref to preventing hyper or hypo glycaemia without further qualification CREDIT idea of preventing a coma Examiner's Comments In (i) the question required applying knowledge of the role of blood glucose other than its effect on water potential. High blood pressure and damage to cells are due to the osmotic effect of glucose. A number of candidates also think that high blood glucose causes diabetes rather than being a symptom of it. Many candidates did answer in terms of the role of glucose as a respiratory substrate.
		ii	hypothalamus AND (posterior) pituitary;	1	Mark the first answer on each line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer then = 0 marks BOTH answers required for 1 mark DO NOT CREDIT anterior pituitary Examiner's Comments In (ii) many candidates lost marks by stating the anterior pituitary gland as the source of ADH secretion.
	b	i	insulin; injections / pump / insulin pen; <i>idea that</i> injected prior to a meal OR blood glucose measured to determine how much insulin is needed; binds to receptors on,(cell surface membrane(s) of,) liver / fat / muscle (cells);	5	IGNORE epipen ACCEPT 3 or 4 times a day

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
			<i>idea that it, <u>promotes</u> / <u>increases</u> uptake of glucose;</i> <i>idea that it promotes / triggers, the conversion of glucose to glycogen / <u>glycogenesis</u>;</i> idea that use of glucose in respiration, is increased OR glucose is respired preferentially to, fats/fatty acids;		CREDIT '<u>more</u> glucose is taken up' DO NOT CREDIT a description if an incorrect term or incorrectly spelled term is then used as this is a contradiction e.g. 'stimulates glycogenolysis which is the conversion of glucose to glycogen' = 0 MARK DO NOT CREDIT 'insulin converts glucose to glycogen' DO NOT CREDIT 'increase in respiration of glucose' Examiner's Comments Part (i) was answered well although one common misconception was that insulin is administered after meals. Some candidates lost marks by describing the conversion of glucose to glycogen but then using an incorrect term. This was treated as a 'contradiction'. Most candidates expressed themselves well but some phrase their answer in terms of insulin converting glucose to glycogen or insulin opening glucose channels in the membrane rather than insulin being the cell signalling molecule which triggers these events.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	more / AW, (ADH) AND decrease (in urine volume); <i>justification</i> (high blood glucose) lowers water potential, (stimulating /AW, release of ADH); (ADH triggers) more water reabsorption (so a lower urine volume);	3	Examiner's Comments Many candidates gained full marks on (ii) although some candidates linked the presence of ADH to glucose uptake.
	c	i	(region) proximal convoluted tubule AND (blood vessel) capillary; (PCT) has microvilli / has carrier / channel proteins (for uptake); (capillary has) wall one cell thick / AW OR (capillary has) fenestrations / gaps / pores;	2	IGNORE 'because this is the region where glucose is reabsorbed' as a reason as this does not use the diagram. Examiner's Comments Many candidates correctly identified the PCT and capillary in (i). The presence of microvilli and transport proteins as evidence for the region being the PCT was the commonest way of gaining the second mark. Where candidates had identified the capillary, vague answers such as 'thin wall' or 'one cell thick' did not gain credit. Part (ii) was a stretch and challenge question. Relatively few candidates linked the movement of proteins to the fluid mosaic structure of the membrane.
		ii	<i>idea that</i> (membrane has) fluid (mosaic) structure; <i>Idea that</i> proteins 'float' in (phospho)lipid bilayer;	2	Examiner's Comments Part (ii) was a stretch and challenge question. Relatively few candidates linked the movement of proteins to the fluid mosaic structure of the membrane.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	<i>mechanism</i> facilitated diffusion / active transport / co-transport; <i>idea that</i> number of (channel / carrier) proteins is limiting / AW; <i>idea that</i> glucose is filtered out but not all reabsorbed; no glucose, transport proteins / uptake, in other regions of nephron;	3	IGNORE ref to incorrect part of nephron ACCEPT descriptions e.g. 'there are too many glucose molecules for channels to cope with' ACCEPT 'glucose in filtrate is not reabsorbed' Examiner's Comments Part (iii) also had elements of stretch and challenge. Most candidates were able to identify a transport mechanism which required a protein but only the most able could describe the number of available protein channels as a limiting factor in glucose uptake. Weaker candidates are clearly very confused by the terminology of kidney function and use 'ultrafiltration' and 'selective reabsorption' as interchangeable terms.
	d	i	blood/ plasma;	1	ACCEPT liver Examiner's Comments In part (i) a lot of 'guessing' had taken place. 'Liver' was allowed as one role of the liver is the synthesis of plasma proteins such as albumin.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	(region) cortex / AW; (reason) <i>idea that</i> proteins normally too large to cross (basement membrane);	2	ACCEPT ref to glomerulus / glomeruli / basement membrane IGNORE renal capsule ACCEPT idea of proteins being too large to be filtered out of glomerulus Examiner's Comments Additional information regarding the protein albumin was given in part (d) but many weaker candidates attempted to answer (ii) in terms of glucose in the urine. There was also confusion between ultrafiltration and selective reabsorption. Some candidates suggested that damage to the PCT meant that the protein could not be reabsorbed.
			Total	20	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
15	a		(because) they contain, group of / more than one type of / different / tissue(s); (because) they remove urea / metabolic waste / nitrogenous waste / product of amino acid breakdown;	2	<u>Examiner's Comments</u> Weaker candidates wrote in terms of toxins or waste without referring to metabolic waste. Some candidates wrote that urea was produced in the kidneys. The main reason for not scoring both marks was a failure to address the question which required some idea of the kidney as an organ and not just a definition of excretion. There are a number of 'compound' terms on the specification (eg autosomal linkage) which need to be 'unpicked' during teaching and this was a synoptic question with F221.
	b	i	T glomerulus; U Bowman's / renal, capsule; <i>region</i> (renal) cortex;	3	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks IGNORE ref to nephron
		ii	ions; ascending; water potential; medulla; permeable; osmosis;	6	Mark the first answer on each prompt line. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks DO NOT CREDIT 'and potassium' as this implies it is the metals that are transferred rather than the ions <u>Examiner's Comments</u> Parts (i) and (ii) were accessible to most candidates with the commonest mistake being to confuse the cortex and medulla or to answer 'nephron' for the region in part (i) despite the fact that this was given in the question.

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
	c	i	volume increases; plus any two from glucose (in filtrate) lowers water potential; (leading to) reduction in water potential gradient (between the filtrate and the cortex); less water reabsorbed (by osmosis), from descending limb / at X;	3	IGNORE ref to urine ACCEPT less water moves out (of loop) / less water leaves the filtrate <u>Examiner's Comments</u> Part (i) was a good discriminator. Weaker candidates implied that the extra glucose molecules added to the volume. Other candidates contradicted themselves and stated that more water would be reabsorbed but many good candidates could explain the reduction in water potential gradient leading to less water being reabsorbed.
		ii	<i>idea that</i> (condition is inherited so will assess) risk of passing disease to, children / AW; advise on, (genetic) testing / alternatives to having (own) children;	1	IGNORE ‘this is a genetic disease’ as this is implied by the question ACCEPT ‘children could inherit the disease’ as this implies a ‘risk’ <u>Examiner's Comments</u> Candidates were expected to identify the role of the counsellor in assessing the risk of children inheriting the condition and advising on the options for family planning. Weaker candidates wrote vague answers about advice on treatment.
			Total	15	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
16	a	i	<i>Factor</i> smoking / obesity / high altitude / sickle cell anaemia / (familial) hypercholesterolaemia / high blood pressure ; <i>Explanation</i> increases risk of, atherosclerosis / AW, (for smoking / obesity / hypercholesterolaemia / high blood pressure) OR carbon monoxide (in tobacco smoke) reduces oxygen transported by haemoglobin (smoking) OR lung damage reduces, gas exchange / uptake of oxygen (smoking) OR less haemoglobin saturation (in lungs) (high altitude) OR fewer red blood cells to transport oxygen (sickle cell anaemia);	2	One mark for named factor and one for correctly linked explanation. IGNORE ref to Diabetes ACCEPT 'high blood cholesterol' or 'high LDL' for hypercholesterolaemia CREDIT alternative biologically correct explanations for a named factor (one mark for factor and one for explanation). ACCEPT idea of less oxygen transported by red blood cells Examiner's Comments In part (d) many candidates could suggest a risk factor with high blood pressure appearing quite commonly. Again, a failure to read carefully the stem of the question meant that the cause of wet AMD (the <i>growth</i> of blood vessels) was then not addressed and weaker candidates suggested that high blood pressure meant the blood vessels leaked rather than explain why high blood pressure meant blood vessels would grow in the first place. Some very imaginative answers were seen in the form of high altitude or sickle cell anaemia as factors which increased the risk. In part (ii) some good explanations were seen although some weaker candidates assumed the antibody would engulf the VEGF. Part (d) was done well but in (e) the question required candidates to suggest what further information was needed for a

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
					valid statement - rather than simply identify a variable that was controlled. So answers such as 'age' required more development....the age might well be known but if the age of the two groups was not the same then the statement would not be valid.
		ii	variable / complementary, region / AW, binds to VEGF ; VEGF no longer, fits / is complementary to, membrane receptor ; OR antibody , binds to / AW, receptor for VEGF ; (antibody) blocks receptor / prevents binding of VEGF ;	2	ACCEPT idea that antibody has same shape as the VEGF receptor (as this implies it is complementary) ALLOW ref to binding site for variable region. IGNORE references to the active site
	b	i	(treatment) improves visual acuity, (within 3 months) I AW ; (treatment) prevents decline of visual acuity I improvement is maintained I AW ;		CREDIT idea that visual acuity declines with placebo
		ii	size of samples ; same test of visual acuity ; ref to double blind trial I randomised design ; AVP;	1	Mark the first answer. If the answer is correct and an additional answer is given that is incorrect or contradicts the correct answer = 0 marks e.g. gender balance (between groups) e.g. not having any other treatment e.g. age profile similar (in both groups) e.g. ethnicity profile similar e.g. size of doses / how often treatment was given

Mark Scheme

Question			Answer/Indicative content				Marks	Guidance																			
			Total				7																				
17			<table><tr><th>Medical condition or disease</th><th>Healthcare Professional</th><th>Diagnostic Test</th><th>Treatment</th></tr><tr><td>1. osteoporosis ;</td><td></td><td></td><td></td></tr><tr><td></td><td></td><td>2. (red) blood cell count ;</td><td>3. RhEPO ;</td></tr><tr><td>4. PKU/cystic fibrosis / AW ;</td><td>5. genetic counsellor ;</td><td></td><td></td></tr><tr><td>6. hyperthermia / heat stroke ;</td><td></td><td></td><td></td></tr></table>	Medical condition or disease	Healthcare Professional	Diagnostic Test	Treatment	1. osteoporosis ;						2. (red) blood cell count ;	3. RhEPO ;	4. PKU/cystic fibrosis / AW ;	5. genetic counsellor ;			6. hyperthermia / heat stroke ;				6	MP2 CREDIT erythrocyte count / (total) blood cell count / haemoglobin concentration / haemocytometer count / haematocrit MP3 CREDIT erythropoietin / EPO. IGNORE Iron tablets MP4 CREDIT alternative examples of an inherited or genetic condition or disease Examiner's Comments This was answered well although vague descriptions to 'blood tests' could not be credited. Some candidates did not pick up on the reference to chronic kidney disease and answered in terms of iron tablets or even transfusions.		
Medical condition or disease	Healthcare Professional	Diagnostic Test	Treatment																								
1. osteoporosis ;																											
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			Total				6																				

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance																																																																
18		i	1. <i>Evidence for:</i> <i>Idea that</i> countries / named country with the high(est) number of donors all have opt out policies; 2. Data quoted correctly in support with correct units; 3. <i>Evidence against</i> Same rates in some countries where policy is different; 4. Data quoted correctly in support with correct units; 5. <i>Idea that</i> countries / named countries with the lowest number of donors all have opt out policies OR <i>Idea that</i> countries / named country with opt in policy has more donors than, countries / named country with opt out policy; 6. Data quoted correctly in support with correct units;	4 max	<table><tr><th>OPT IN COUNTRY</th><th>DONORS PER MILLION PEOPLE</th><th>OPT OUT COUNTRY</th><th>DONORS PER MILLION PEOPLE</th></tr><tr><td>IRELAND</td><td>21</td><td>SPAIN</td><td>34</td></tr><tr><td>SLOVENIA</td><td>18</td><td>LATVIA</td><td>24</td></tr><tr><td>ENGLAND</td><td>13</td><td>AUSTRIA</td><td>24</td></tr><tr><td>NETHERLANDS</td><td>13</td><td>PORTUGAL</td><td>22</td></tr><tr><td>GERMANY</td><td>12</td><td>BELGIUM</td><td>22</td></tr><tr><td></td><td></td><td>FRANCE</td><td>20</td></tr><tr><td></td><td></td><td>ITALY</td><td>18</td></tr><tr><td></td><td></td><td>HUNGARY</td><td>17</td></tr><tr><td></td><td></td><td>NORWAY</td><td>14</td></tr><tr><td></td><td></td><td>DENMARK</td><td>13</td></tr><tr><td></td><td></td><td>POLAND</td><td>13</td></tr><tr><td></td><td></td><td>SWEDEN</td><td>11</td></tr><tr><td></td><td></td><td>GREECE</td><td>6</td></tr><tr><td></td><td></td><td>BULGARIA</td><td>1</td></tr><tr><td>Mean</td><td>15</td><td></td><td>17</td></tr></table> CREDIT data quotes using calculated differences IGNORE data quotes using total donors IGNORE references to more countries having opt out policies as this is a sample	OPT IN COUNTRY	DONORS PER MILLION PEOPLE	OPT OUT COUNTRY	DONORS PER MILLION PEOPLE	IRELAND	21	SPAIN	34	SLOVENIA	18	LATVIA	24	ENGLAND	13	AUSTRIA	24	NETHERLANDS	13	PORTUGAL	22	GERMANY	12	BELGIUM	22			FRANCE	20			ITALY	18			HUNGARY	17			NORWAY	14			DENMARK	13			POLAND	13			SWEDEN	11			GREECE	6			BULGARIA	1	Mean	15		17
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		i	QWC;	1	Look for mps, 1 and 2 AND 3 and 4 OR 5 and 6																																																																

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	<i>Idea that</i> can lead an independent life / AW; AVP;	1	CREDIT examples e.g. not needing regular / frequent periods on dialysis machine / able to work regular hours IGNORE ref to better quality of life unqualified or cost e.g. less need to control sodium intake <u>Examiner's Comments</u> Part (i) was answered well although a failure to refer to the figures correctly was not uncommon among weaker candidates - 1 donor rather than 1 donor per million people. The best responses made their arguments clear using terms such as 'However' or 'On the other hand' to structure their statement. In part (ii) some explanation was required of what a 'better quality of life' was.
			Total	6	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
19	a		urea / creatinine / uric acid;	1	DO NOT CREDIT urine or creatine or ammonia Examiner's Comments Overall, this question was probably the most challenging on the paper. A surprising number of candidates answered incorrectly with ammonia and amino acids being among the more common incorrect responses.
	b	i	120 μm ;;	2	Correct answer with units = 2 marks Correct answer without units or unrounded = 1 mark If answer is incorrect look for 36 000 $\div$ 300 OR 36 $\div$ 300 OR 3.6 $\div$ 300 AWARD 1 MARK for an error carried forward from an incorrect measurement / : Answer must be a whole number have units e.g. 117 μm = 1 mark (from 35 mm measurement)
		ii	<i>idea that</i> collecting ducts are, combining / merging OR so volume of, urine / filtrate / fluid, will be larger;	1	IGNORE ref to water Examiner's Comments In (i) the most common mistake was not converting correctly between units while only the more able candidates successfully answered (ii) in terms of merging collecting ducts or increasing volume. Numerous diagrams of the nephron have these 'branches' indicated suggesting that the significance of these is rarely brought to the attention of candidates.
	c	i	ADH / Antidiuretic hormone and (posterior) pituitary;	1	Both parts correct for 1 mark ACCEPT phonetic spelling

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		ii	(membrane) would have, microvilli / brush border / AW;	1	ACCEPT idea that it would be more folded. DO NOT CREDIT basal membrane more folded Examiner's Comments In (i) it was disappointing to see how many candidates identified ADH and then assigned it to the wrong endocrine gland with pancreas being the most common incorrect response. A number of candidates referred to the anterior pituitary. This issue has occurred in previous sessions - pituitary alone could be credited without reference to posterior but anterior pituitary is incorrect. In (ii) although some candidates did correctly identify microvilli in the proximal convoluted tubule, a large number failed to take into account the scale they were working to as indicated in the photomicrograph. While it is certainly true that various transport proteins would be present in the PCT membrane, they would not be visible on a photomicrograph.
	d	i	carbonic anhydrase;	1	
		ii	(mitochondria) for synthesis of / AW, ATP, for active transport / transport of ions;	1	CREDIT hydrogen ions / H^+ / protons / chloride ions / Cl^- / hydrogen carbonate ions / HCO_3^- IGNORE mitochondria providing energy

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iii	gas exchange (system);	1	Mark the first answer IGNORE 'lungs' or 'brain' or a region of the brain since these are not organ systems CREDIT 'respiratory' system CREDIT nervous system Examiner's Comments Biochemistry is often a weakness with Human Biology candidates and very few were able to identify carbonic anhydrase in (i). In (ii) although many correct statements were made regarding active transport and ATP, candidates failed to link this to the role of mitochondria in synthesising ATP while in (iii) many candidates did not spot that it was an organ system that was required rather than an organ and answers such as 'lung' or 'medulla oblongata' could therefore not be credited.
	e	i	<i>Diabetes insipidus</i> – no glucose present;	1	CREDIT glucose present for Diabetes mellitus IGNORE references to concentration, solute concentration and volume
		ii	<i>idea that</i> levels of dehydration can be monitored (quickly);	1	CREDIT idea of monitoring (overall) water loss
		iii	(urine) volume;	1	Mark the first answer IGNORE pH, glucose, erythrocytes

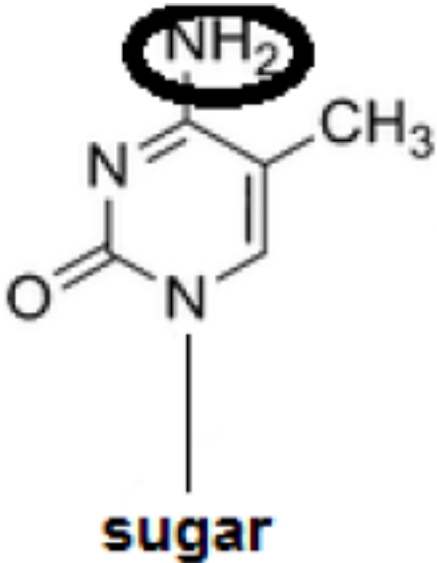
Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
		iv	<i>Diabetes insipidus – patient 1 (no mark - green dot)</i> <i>explanation</i> (patient 1) urine, stays dilute / does not become concentrated, (as person dehydrates); (because) no ADH (secreted) in, diabetes insipidus / patient 1 OR ADH secreted, normally / in patient 2; (idea that) water reabsorbed (more) with ADH / water not / less reabsorbed, in without ADH;	3	ACCEPT 'always more water in urine' (for patient 1) 'solute concentration is less throughout' ACCEPT more water reabsorbed by patient 2 / less water reabsorbed by patient Examiner's Comments This discriminated well although some candidates did not express their answer to (i) well enough for examiners to be certain which form of diabetes they were referring. Only the better candidates answered (ii) in terms of checking for dehydration or overall water loss. Some candidates responded in terms of monitoring body weight or even BMI, suggesting they had not picked up on the context of the question. This was similar in part (iii) with many other urine tests being suggested such as protein or blood. In part (iv) while many candidates correctly identified the correct patient, only the more able went on to 'use their biological knowledge' to explain the graph in terms of the absence of ADH and the lack of water reabsorption.
			Total	15	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
20			* Level 3 (7–9 marks) Details of apparatus and a method to produce reliable data are provided to include the use of a dilution series to construct a standard curve. Most variables are identified, and the method states how most variables are controlled. <i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i> Level 2 (4–6 marks) The apparatus and a method to provide reliable results are provided although some details may be missing. There is an outline of standard curve construction. Some variables are identified and the method states how some variables are controlled. <i>There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.</i> Level 1 (1–3 marks) Apparatus and an outline method are suggested to provide some results but information, such as standard curve construction, may be missing. Some variables are omitted. <i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i> 0 marks No response or no response worthy of credit.	9	Indicative scientific points could include: Apparatus & method: • cuvettes, test tubes • apparatus for volume measurement (pipettes, syringes) • distilled / deionised water • selection of appropriate filter (on colorimeter) • reference to zero or blank • details of quantitative preparation of dilution series (for salicylic acid) to include volumes and final concentration • standard curve construction • method of testing urine and obtaining a reading. Variables: • (curve) independent variable = dilution • dependent variable = colorimeter reading • correct units included • control variables e.g. filters (colorimeter), volumes, time, temperature. Reliability: • repeats (for dilutions and urine reading) • reference to quantitative processing of data e.g. calculation of means • reference to use of error bars on standard curve. Risk Assessment: • potential chemical hazards & control • potential electrical hazards & control • potential microbial hazards (urine) & control.
			Total	9	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
21	a	i	S	1	Any additional letter = no mark
		ii	8900 (kJ)	1	
	b	i	<i>Statement correct because;</i> <i>idea that extra calcium needed but no increase in DRV (1)</i> <i>idea that calcium needed for fetal bone formation (1)</i>	2	
		ii	<i>idea of increased reabsorption (of calcium ions) (1)</i> <i>idea of more (calcium ion) transport proteins / more active transport / more facilitated diffusion (1)</i>	2	DO NOT ALLOW reference to ultrafiltration
			Total	6	
22		i	(dinucleotide bond is) phosphodiester bond / covalent bond / formed by a condensation reaction (1) (base pair is) (3) hydrogen bonds (1)	2	
		ii	deoxyribose (1)	1	DO NOT ALLOW 'pentose' or 'ribose' as they are told that DNMT methylates DNA
		iii		1	
			Total	4	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance
23	a		any 3 from: (role is) to set up a range of water potential gradients between medullary tissue fluid and collecting duct (1) diffusion of water out of descending limb (1) ion concentration high at base of loop (1) sodium and chloride ions diffuse out of base of ascending limb (1) water cannot leave ascending limb / ascending limb impermeable to water (1) ions pumped out of upper ascending limb (1)	3	
	b	i	any 3 from: risk generally increased with a decrease in GFR (1) risk little affected by an increase in urinary protein (1) GFR of 60+ ml / min has little influence with urinary protein < 34 mg / mmol (1) correct quotation of figures in support of any statement (1)	3	
		ii	any 3 from: not a representative cross-section (1) in hospital so already sick (1) may have other illnesses / complications (1) limitation of medications they can use (1) may not have comparable treatments (1) probably skewed towards elders / younger people under-represented (1) doesn't account for subjects who died after a year (1) doesn't account for length of time with CKD before admission (1)	3	
		iii	enlarge the cohort (1) adapt method, e.g. more hospitals, over longer time, take records of non-hospitalised cases (1)	1	
			Total	10	

Mark Scheme

Question			Answer/Indicative content	Marks	Guidance									
24		i	<table><tr><td>Description</td><td>Name</td><td>Letter</td></tr><tr><td></td><td>Abomasum</td><td>U</td></tr><tr><td></td><td>Reticulum</td><td>S</td></tr></table>	Description	Name	Letter		Abomasum	U		Reticulum	S	2	One mark for each correct row
			Description	Name	Letter									
				Abomasum	U									
	Reticulum	S												
		ALLOW rumen and V												
		ii	<i>idea that</i> microbes in rumen are a protein source (microbial protein) hydrolysed into amino acids by protease enzymes	2										
		iii	(amino acids are) deaminated / AW	1										
			Total	5										