Answer **all** the questions.

1. **Fig. 11.1** shows the heat flow through the skin of an athlete during vigorous exercise. Exercise starts at 400 seconds.

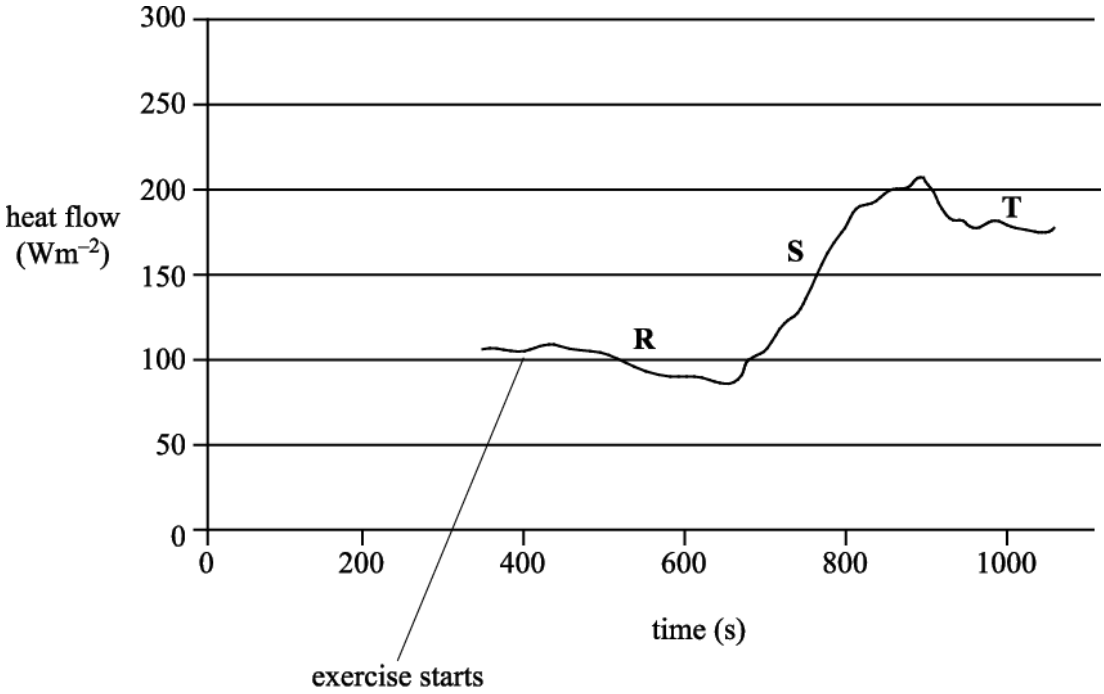


Fig. 11.1

Blood flow can be directed to those parts of the body that make the greatest demands.

Which row gives the best explanation of the stages in **Fig. 11.1**?

	R	S	T
A	Blood directed away from skin to avoid excess heat loss	Blood directed towards skin to release excess heat	Balance achieved between loss of excess heat and the need for oxygen in the muscles
B	Blood directed away from skin and towards the muscles to supply more oxygen for respiration	Blood directed towards skin to release excess heat	Balance achieved between heat loss and excess heat created in the muscles
C	Blood directed away from skin to avoid excess heat loss	Blood directed towards skin to gain heat from the environment	Balance achieved between heat loss and excess heat created in the muscles
D	Blood directed away from skin and towards the muscles to	Blood directed towards skin to gain heat from the environment	Balance achieved between loss of excess heat and the need for

	supply more oxygen for respiration		oxygen in the muscles

Your answer

[1]

2. Which of the following is / are interventions in the control of blood glucose concentration?

Statement 1: Insulin injection.
Statement 2: Regular cardiovascular exercise.
Statement 3: Glucagon injection.

A 1, 2 and 3
B Only 1 and 2
C Only 2 and 3
D Only 1

Your answer ☐

[1]

3. During pregnancy, the hormone human chorionic gonadotrophin (hCG) is produced by the placenta. Fig. 16.1 shows how levels of hCG change throughout pregnancy.

Fig. 16.1

At birth, the production of another hormone, oxytocin, increases. Oxytocin causes rapid contractions of the uterus. These contractions cause more oxytocin to be released.

What term is used to describe this kind of interaction?

_____ **[1]**

4(a). The measurement of kidney filtration rate provides an indication of the health of the kidneys.

A filtration rate of below 60 $cm^3\ min^{-1}$ 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 $cm^3\ min^{-1}$

Month 2: $4.85 \times 10^{-5}\ m^3\ min^{-1}$

Month 3: 1.12 $cm^3\ s^{-1}$

Month 4: $9.70 \times 10^{-7}\ m^3\ s^{-1}$

Do these results suggest the patient has chronic kidney disease?

Explain your conclusion using the information given.

---**[2]**

(b). 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.

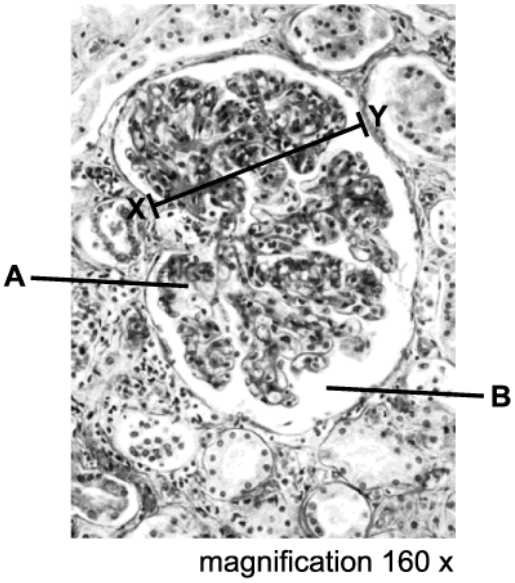


Fig. 2.1

(i) Name the parts of the kidney labelled **A** and **B**.

A

B

---

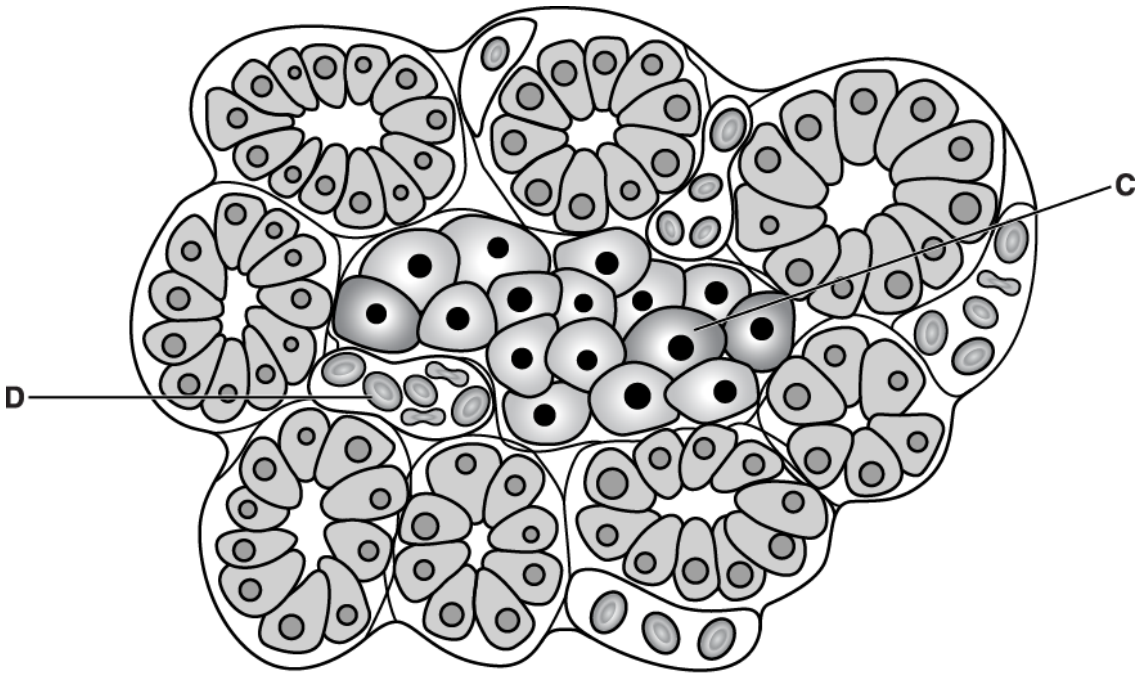
[2]

(ii) Calculate the length of the line labelled **X** to **Y**.

Give your answer in micrometres (μm) to **two** significant figures.

Answer = _____ μm **[2]**

5(a). The figure represents a cross-section of part of the pancreas.



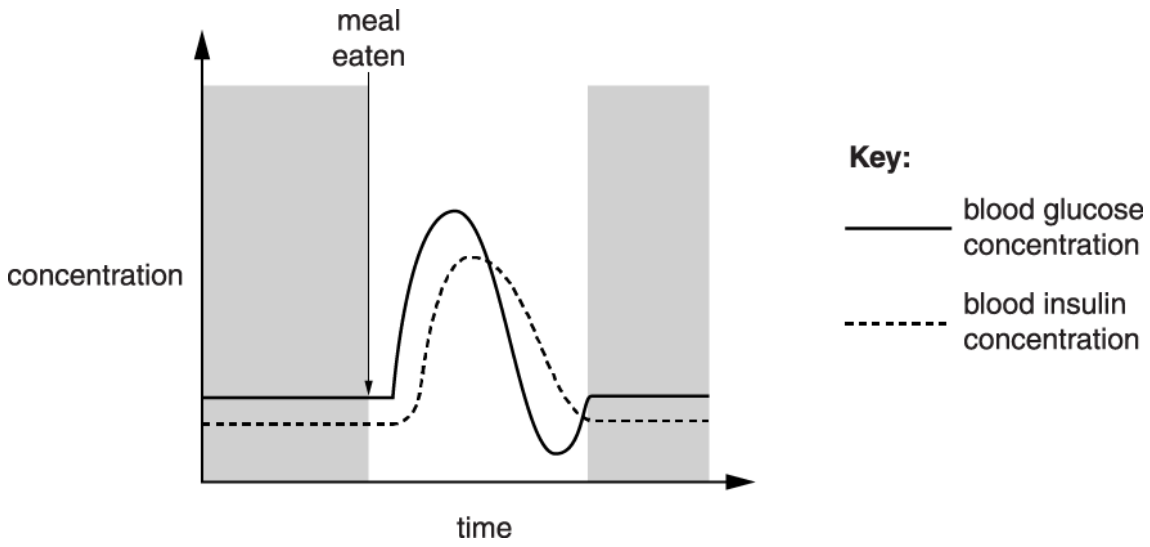
(i) Name the **group** of cells that include the cell labelled **C**.

_____ **[1]**

(ii) Identify the structure labelled **D**.

_____ **[1]**

(b). The figure shows the concentrations of glucose and insulin in the blood of an individual before and after a meal.



(i) After the meal, the concentrations of glucose and insulin in the blood increase.

Explain why there is a delay in the increase of insulin concentration following the increase in blood glucose concentration.

---

[2]

(ii) The shaded parts of the graph are over-simplified representations of the blood glucose and insulin concentrations.

Describe **and** explain how these concentrations should be represented on the graph accurately.

In your answer, you should use appropriate technical terms, spelled correctly.

---

[4]

6. A patient shows severe symptoms of unregulated blood glucose concentration. Under certain circumstances this condition may need to be treated with glucagon injections.

(i) Under what circumstances might this patient need to be given a glucagon injection?

---**[1]**

(ii) Describe how glucagon is involved in the regulation of blood glucose concentration in a person who is able to regulate their blood glucose concentration correctly.

In your answer, you should use appropriate technical terms, spelled correctly.

---**[5]**

7. Within the mammalian body, different systems of communication are used to coordinate and control activities.

Complete the following passage by using the **most suitable** term in each case.

The pancreas and the adrenal glands are both examples of _____ glands. Adrenaline is a _____ that is secreted by the adrenal glands. These glands also secrete steroids such as corticosteroids from cells in the _____ region. The chemicals secreted by these glands are transported by the blood to their _____ cells and tissues.

[4]

8(a). The desert kangaroo rat, *Dipodomys deserti*, lives in dry and hot conditions. It excretes a very small volume of urine relative to its size.

The loops of Henle in the kidneys of these mammals are longer than those found in mammals of a similar size that do not live in desert conditions.

Explain how the longer loop of Henle is able to assist the desert kangaroo rat in preventing excessive water loss.

---**[2]**

(b). Fig. 6.1 is a diagram that represents the nephron in a mammalian kidney.

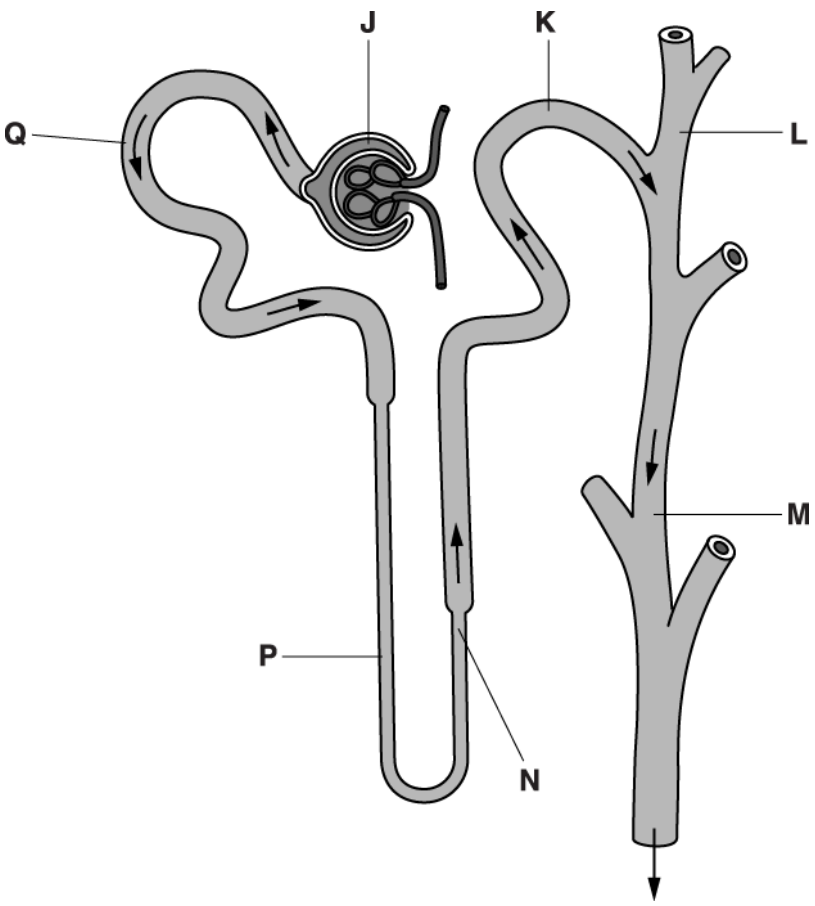


Fig. 6.1

Use the letter or letters from Fig. 6.1 to identify:

(i) the region or regions where glucose is selectively reabsorbed into the blood capillaries

_____ **[1]**

(ii) the region or regions present in the cortex

_____ **[1]**

(iii) the region or regions where podocytes are located.

_____ **[1]**

9. Insulin is secreted from the beta cells of the pancreas in response to increased blood glucose concentration.

Fig. 2.1 is a diagram representing the sequence of events leading to the secretion of insulin from the beta cell.

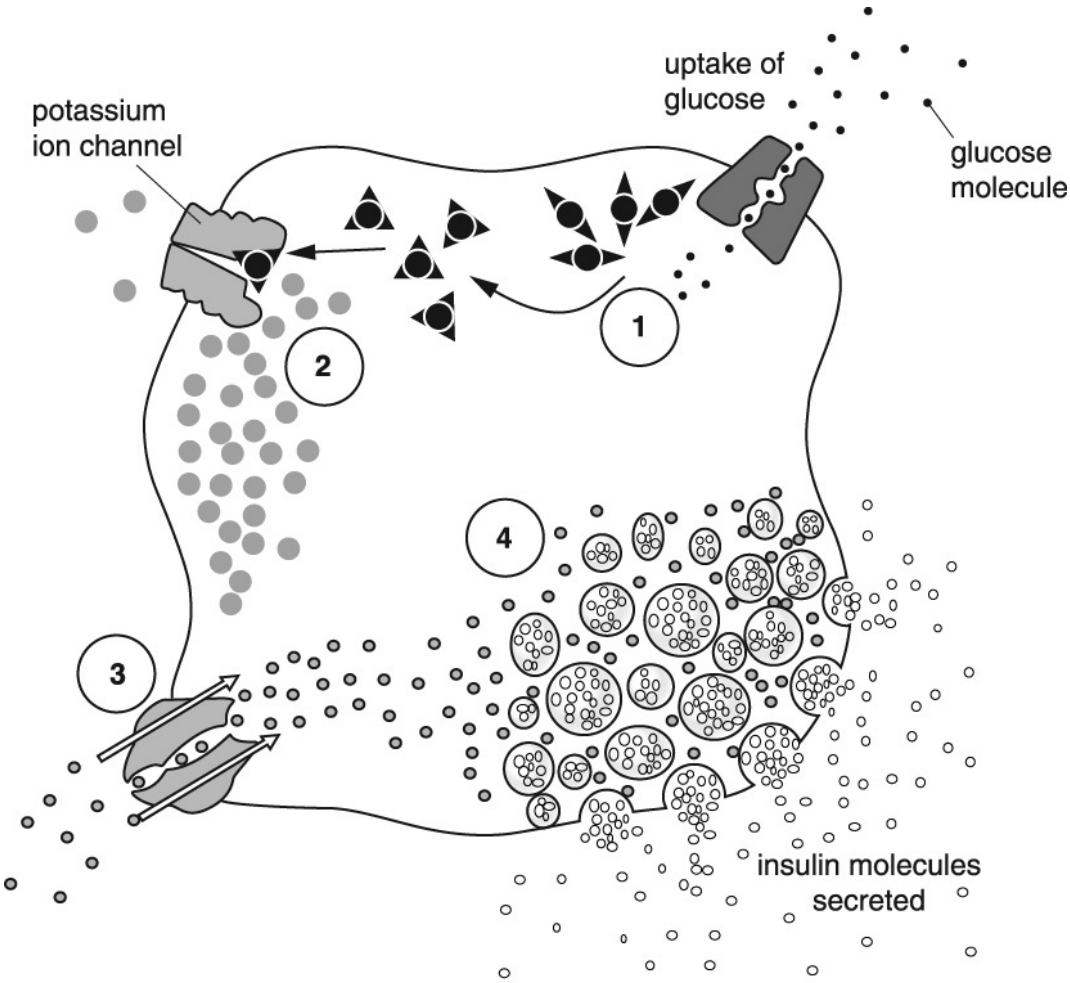


Fig. 2.1

(i) With reference to Fig. 2.1, describe the events occurring at the stages labelled **1** to **4**.

1

2

3

4

[4]

(ii) After the initial release of insulin from the beta cell, insulin secretion continues even when there is no further glucose intake.

Suggest and explain why the cell continues to secrete insulin.

[2]

10. 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.

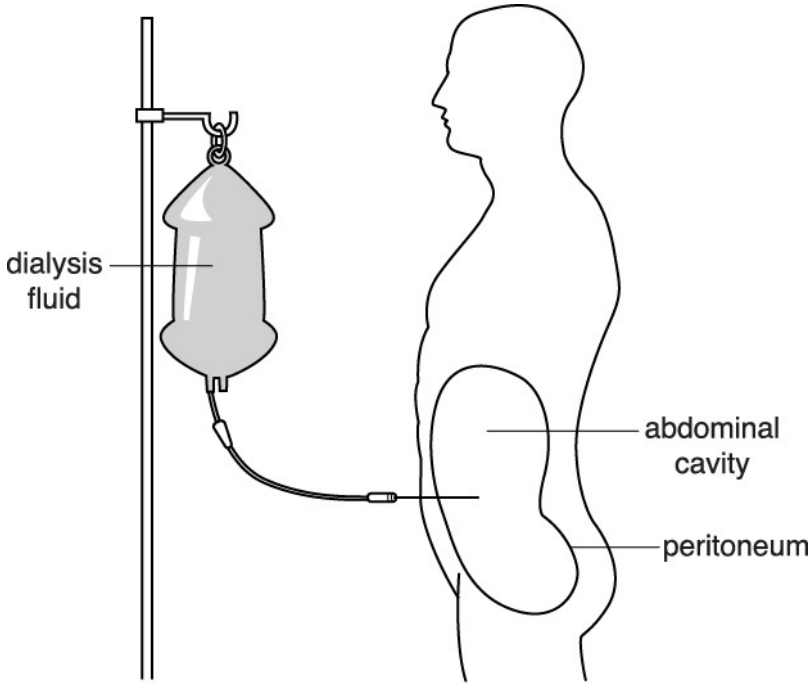


Fig. 4.2

- 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.

(i) How might the peritoneum differ in its **function** from the artificial membrane in a dialysis machine used in

haemodialysis?

---**[1]**

(ii) Why does the dialysis fluid used in peritoneal dialysis contain dextrose solution rather than water alone?

---**[2]**

(iii) 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]**

END OF QUESTION PAPER

Question			Answer/Indicative content	Marks	Guidance
1			B	1	
			Total	**1**	
2			D	1	
			Total	**1**	
3			positive feedback	1	
			Total	**1**	
4	a		Conclusion: No because month 3 is above 60 cm^3 min^{-1} (1) Month 2: 48.5 cm^3 min^{-1} Month 3: 67.2 cm^3 min^{-1} Month 4: 58.2 cm^3 min^{-1} (1)	2	The second mark is for 3 correct calculations
	b	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
			Total	**6**	
5	a	i	islet(s) of Langerhan(s);	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** **ACCEPT** α and β / alpha and beta, cells **DO NOT CREDIT** a / b / A / B **,** cells **DO NOT CREDIT** acinar cells **Examiner's Comments** Most candidates correctly identified the islets of Langerhans. Some candidates, however, mentioned only alpha or beta cells (although had both been mentioned the mark would have been awarded).

Question			Answer/Indicative content	Marks	Guidance
		ii	erythrocyte / red blood cell;	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** RBC **IGNORE** ref to blood vessel **Examiner's Comments** Erythrocytes were commonly seen, although some candidates identified a blood vessel instead.
	b	i	1 increase (in blood sugar) is detected (by α cells); 2 *idea that takes time for* depolarisation (in α cells); 3 *time needed for* αcells to, produce / release, insulin;	2 max	**DO NOT CREDIT** 'B' or 'b' cell on first occasion then apply ecf A description of a *sequence* of events provides a timeline 2 *time for* making sure that there is enough ATP / ion channels open / to pump out K^+ / for Ca^{2+} to enter 3 **DO NOT CREDIT** ref to α cell(s) **Examiner's Comments** Poor communicators were not able to convey the idea of a timeline as the account was muddled. Some excellent accounts were seen, however, although many went into excessive descriptions about the mechanism of secretion of insulin that the mark tariff did not warrant. Some otherwise good answers failed to mention that insulin was secreted by the beta cells or that they were also responsible for detecting the increased glucose levels.

Question			Answer/Indicative content	Marks	Guidance
		ii	1 there should be no straight line(s) (on the graph) **or** line(s) (should), rise and fall / fluctuate; 2 glucose and insulin levels fluctuate; 3 insulin levels (should) rise (and fall) after those of glucose; 4 (glucose) level, maintained around / returned to, the **norm**(al) / a **set** point / a **set** value; 5 ref to **negative feedback** / **homeosta**sis;	3 max	**DO NOT CREDIT** in the context of eating a meal 2 Must be a statement that implies both levels change 4 **CREDIT** 'within narrow limits' / 'relatively constant' **IGNORE** optimum **CREDIT** maintained at, 80 – 120 mg $100cm^{-3}$ / 4 – 6 mmol dm^{-3} for the glucose value
		ii	QWC;	1	Award if **3** of the following terms have been used in a correct context with correct spelling: **set** (point / value) **norm**(al) **negative feedback homeosta**sis **Examiner's Comments** This was challenging for many candidates. Some just referred to axis labels and scales but others attempted to describe the way in which the lines should have been portrayed. It was all too tempting for many candidates to refer to what was happening before, during and after a meal and they then launched into details of insulin and glucagon and their effects on the cells. Few conveyed the idea that the fluctuation of the blood glucose and insulin concentrations were out of phase. The Quality of Written Communication mark (QWC) was rarely awarded.
			Total	**8**	

Question			Answer/Indicative content	Marks	Guidance
6		i	**1** if blood glucose falls, extremely / dangerously / too / very, low; **2** if patient, cannot produce (enough) glucagon / produces little glucagon; **3** *idea that* glucose source cannot be taken by mouth;	1 max	**1 CREDIT** hypoglycaemic / hypoglycaemia **IGNORE** 'below normal' alone **2 CREDIT** ref to dysfunctional, α cells / glucagon receptors **3 CREDIT** a suitable reason (e.g. fitting or in a coma) **Examiner's Comments** Most candidates gained a mark in this section for stating that the circumstance under which the patient would need to be given a glucagon injection would be a very low blood glucose level. Some also commented that the alpha cells may not be functioning properly, resulting in an inadequate secretion of glucagon. It was insufficient to refer to 'low blood glucose' or 'below normal blood glucose concentration'.

Question			Answer/Indicative content	Marks	Guidance
		ii	*when blood glucose concentration decreases* **1** (glucagon) released by the, **alpha** / α, cells in, **islet**s of Langerhans / **pancreas**; **2** promotes / AW, conversion of **glycogen** to glucose / **glycogenolysis**, in, liver / muscle / **effector**, cells; **3** ref **gluconeogenesis** / described; **4** ref conversion of triglycerides to (free) fatty acids / lipolysis / increased use of fatty acids in respiration; **5 negative feedback**, reduces / inhibits, the secretion of glucagon; **6** glucagon, reduces / inhibits, insulin secretion;	4 max	**IGNORE** ref to insulin or events following an increase in blood glucose concentration **1 DO NOT CREDIT** 'alpha cells are produced' **2 Any description must** correspond correctly to term **DO NOT CREDIT** if glucagon *converts* glycogen directly **3 Any description must** correspond correctly to term **IGNORE** imprecise ref to glucagon *doing the conversion* **4 Any description must** correspond correctly to term **IGNORE** imprecise ref to glucagon *doing the conversion* **5 DO NOT CREDIT** stopping glucagon secretion **6 DO NOT CREDIT** stopping insulin secretion

Question			Answer/Indicative content	Marks	Guidance
		ii	**QWC** – technical terms used appropriately and spelled correctly;	1	Use of **three** terms from: **alpha, islet,** **pancreas, glycogen,** **glycogenolysis, effector,** **gluconeogenesis, negative feedback** **Please insert a QWC symbol next to the pencil icon, followed by** **a tick (☐) if QWC has been awarded** **or a cross (×) if QWC has not been awarded You should use the green dot to identify the QWC terms that you are crediting.** **Examiner's Comments** The role of glucagon in the regulation of blood glucose concentration produced variable responses. Better candidates achieved all marks available for a good description of the secretion of glucagon from the alpha cells of the islets of Langerhans in the pancreas and its subsequent effects on liver or muscle cells. Most appreciated that glucagon would stimulate glycogenolysis and gluconeogenesis, or described the processes, although some failed to gain the second marking point for either failing to identify the effector cells or stating that glucagon itself would convert glycogen into glucose. Some contradicted their answers by referring to the breakdown of glycogen to glucose as glycolysis. While many also recognised that more fatty acids would be used in respiration, some simply that fats or lipids would be used. There were comparatively few references to glucagon reducing insulin secretion (most stated that insulin secretion was stopped) and hardly any to negative feedback reducing glucagon secretion once blood glucose levels had been restored to normal. Most candidates were awarded the QWC mark for three technical terms spelled correctly and used in an appropriate context.

Question			Answer/Indicative content	Marks	Guidance
			Total	**6**	
7			endocrine; hormone; cortex / cortical; target / effector;	4	**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 then = **0 marks** **Examiner's Comments** Many candidates were able to complete the passage using suitable terms. Common errors were to confuse endocrine with exocrine and cortex with medulla. Very occasionally, neutrotransmitter was used in place of hormone.
			Total	**4**	

Question			Answer/Indicative content	Marks	Guidance
8	a		**1** more (sodium and chloride) ions pumped, out of ascending limb / into medulla; **2** builds up greater water potential gradient; **3** allows, reabsorption / removal, of *more* water from, collecting duct / M;	2	**1 CREDIT** active transport / AW, for 'pumped' **IGNORE** salts / diffusion **2 ACCEPT *even more*** negative water potential in medulla (than other mammals) **Examiner's Comments** This question was a good discriminator. Most candidates had a good idea of the role of the loop of Henle but they found it less easy to clearly communicate the significance of the loop being 'longer' in the desert mammal. There was often imprecise use of terminology - selective reabsorption of water / movement of salts / greater concentration gradients etc. Reabsorption of water often centred on the descending limb or distal convoluted tubule rather than on the collecting duct as urine formation was often thought to have been completed before this part was reached. The main reasons for marks not being awarded were for not clearly stating locations or using correct comparative terms - more / even more / greater etc.
	b	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.

Question			Answer/Indicative content	Marks	Guidance
		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	**5**	

Question			Answer/Indicative content	Marks	Guidance
9		i	1 glucose, respired / phosphorylated / metabolised, to produce ATP; 2 ATP, blocks / closes, potassium ion channel(s) **and** potassium ions / K^+, build up (inside cell) / cannot leave; 3 (voltage-gated) calcium ion / Ca^{2+}, channels open **and** calcium ions / Ca^{2+}, enter (cell by diffusion); 4 (more) calcium ions / Ca^{2+}, resulting in, movement of vesicles to membrane / exocytosis / described;	4	**IGNORE** the numbered prompt lines, but the events **must** be in the correct sequence. 1 **IGNORE** 'glucose is broken down to form ATP' 2 ion must be indicated at least once If symbol used, must have correct charge **IGNORE** ref to 'depolarisation' (as not indicated on fig.) 3 ion must be indicated at least once If symbol used, must have correct charge **IGNORE** ref to polarisation 4 if ion had been mentioned in stage 3, then allow 'calcium' alone for this mp **ACCEPT** ecf ***for this mp*** if mp 3 not awarded because Na^+ stated instead of Ca^{2+} **IGNORE** 'secretion' as given in question **Examiner's Comments** Well prepared candidates were able to interpret the stimulus material in Figure 2.1 and provide good accounts of the events taking place at the various stages leading to the secretion of insulin from the beta cell. Most recognized that glucose would be respired to produce ATP, although some stated that glucose would be converted to ATP which was not credited. While many went on to describe how ATP would block the potassium ion channels, a significant number neglected to add that this would cause an accumulation of potassium ions within the beta cell as they were no longer able to leave. Most understood that the depolarisation of the cell would cause the calcium ion channels to open, leading to an influx of calcium ions and then linked this influx to the movement

Question			Answer/Indicative content	Marks	Guidance
					of vesicles containing neurotransmitter towards the cell surface membrane and subsequent fusion to it. However, some made the mistake of stating that the vesicles, rather than insulin, would leave the cell by exocytosis. Candidates who did not fully express the mark points tended to be repeating a learned sequence rather than interpreting the information in the diagram.

Question			Answer/Indicative content	Marks	Guidance
		ii	1 (continues to be secreted) as long as blood / plasma, glucose (concentration), remains high / is higher than normal; 2 (sufficient) ATP is still present and so K^+ channels remain closed; 3 (exocytosis) still being triggered by, calcium ions / Ca^{2+};	2 max	**IGNORE** ref to what happens once the glucose level returns to normal and secretion stops (as Q asks about the continued secretion of insulin) 3 **CREDIT** Ca^{2+}, still present / remain high **CREDIT** exocytosis continues until Ca^{2+} can be removed from cell **Examiner's Comments** This question proved challenging. Candidates who did gain marks usually recognised that calcium ions were still present in the cell (triggering secretion of insulin). Several candidates knew that the calcium ion channels remained open but did not develop the idea further. Many mentioned that ATP was still present, others stated that potassium ion channels were closed, but few mentioned both conditions. Many of those who mentioned high glucose levels referred to levels in the cell rather than in the blood or to trying to reduce the glucose to zero. Some candidates answered in terms of the time taken for insulin to reach the target cells, rather than in terms of the levels of blood glucose and its effect on the cells. Many candidates did not note the reference to continuing insulin secretion, and referred to what would happen when glucose levels returned to normal (when little or no insulin secretion would take place) and negative feedback.
			Total	**6**	

Question			Answer/Indicative content	Marks	Guidance
10		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 / Ψ (of dialysis fluid) **or** (dextrose / sugar, solution) has a lower, water potential / Ψ (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.

Question			Answer/Indicative content	Marks	Guidance
		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**	