**Model Answers: Medium**

1a

a) Urea is present in urine because…

Any **three** of the following:

- Excess amino acids are converted into urea / urea is produced from excess amino acids; [1 mark]
- Urea is transported from the liver to the kidneys in the blood (plasma); [1 mark]
- Urea is filtered out of the blood / undergoes ultrafiltration in the kidneys/glomerulus/bowmans capsule; [1 mark]
- Urea is not reabsorbed by the kidneys (so ends up in the urine); [1 mark]

**[Total: 3 marks]**

This is an 'outline' question so no marks are available for details of the processes taking place in the liver or kidneys.

1b

(b) (i) Molecules **X** is…

- Ammonia; [1 mark]

(b) (ii) Molecule **X** cannot remain in the blood because…

Any **one** of the following:

- It is (highly) soluble and therefore dissolves in the blood/plasma (to form toxic ammonium hydroxide) / is not diluted enough by the blood; [1 mark]
- It raises blood pH / makes the blood more alkaline; [1 mark]
- It interferes with cell metabolism / respiration / cell signalling; [1 mark]

*Reject 'it is toxic' or 'it is soluble' with no other detail provided.*

**[Total: 2 marks]**

1c

(c) Control of blood water balance is a negative feedback mechanism because…

Any **three** of the following:

- Receptors/osmoreceptors in the brain detect a change in the water balance of the blood (this is the stimulus); [1 mark]
- Impulses are sent along (sensory) neurones to the posterior pituitary gland; [1 mark]
- The posterior pituitary gland releases (more or less) hormones/ADH in response (it is the effector); [1 mark]
- The change in water balance / stimulus is corrected/reversed **OR** the kidney reabsorbs more/less water to reverse the change in water balance; [1 mark]

**[Total: 3 marks]**

Negative feedback mechanisms involve receptors that detect a change in conditions, transfer of information to a co-ordination centre, effectors that respond, and a response that reverses the initial change. Your answer should explain how each of these elements can be seen in the control of water balance.

1d

(d) It is essential that the water balance of the blood is regulated because…

- This prevents water from moving into/out of body/blood cells by osmosis; [1 mark]
- This could damage the cells / cause cells to burst/lyse **OR** reduce cell function / cause cells to shrivel/shrink; [1 mark]

**[Total: 2 marks]**

2a

(a) The structure marked **A-C** are...

- **A** = Bowman's capsule; [1 mark]
- **B** = loop of Henle (descending limb); [1 mark]
- **C** = collecting duct; [1 mark]

**[Total: 3 marks]**

2b

(b) (i) A feature visible in Fig. 2 that aids ultrafiltration is...

- Podocytes; [1 mark]

(b) (ii) This aids ultrafiltration because...

- It allows dissolved substances / small molecules to pass from the capillary/blood/glomerulus into the nephron/Bowman's capsule/structure A **OR** prevents the passage of large molecules/proteins/blood cells from the capillary/blood/glomerulus into the nephron/Bowman's capsule/structure A; [1 mark]

**[Total: 2 marks]**

2c

(c) (i) The percentage decrease in protein between the blood and filtrate is...

- 77.95 78; [1 mark]
- 99.9 (%); [1 mark]

***Accept*** *correct answer for full marks in the absence of other calculations.*

(c) (ii) An explanation for this difference is that..

- The capillary endothelium has pores / holes / gaps between the cells **OR** the basement membrane is mesh-like / made up of a network of fibres (which prevents large proteins from filtering out of glomerulus); [1 mark]

**[Total: 3 marks]**

No marks are available for references to podocytes as these were covered in part (b).

The equation for calculating percentage decrease is:

$$\text{percentage decrease} = \frac{\text{change}}{\text{starting point}} \times 100$$

Calculate the change in protein concentration:

from table 2.1

Blood concentration = 78 g $dm^{-3}$

Filtrate concentration = 0.05 g $dm^{-3}$

78 − 0.05 = 77.95

Substitute numbers into equation:

$$\text{percentage decrease} = \frac{77.95}{78} \times 100 \quad \text{[1 mark]}$$

$$= 99.9\ (\%) \quad \text{[1 mark]}$$

2d

(d) High blood pressure might affect the ultrafiltration process in the patient's kidneys in the following way...

Any **two** of the following:

- Increased protein concentration in the filtrate; [1 mark]
- Blood/blood cells in the filtrate; [1 mark]
- Higher glomerular filtration rate; [1 mark]

***Reject*** *any references to high blood pressure and reabsorption.*

**[Total: 2 marks]**

You may not have learned about the effects of high blood pressure, but given what you know about the processes and structures involved with ultrafiltration you should be able to come up with some suggestions here. It is the high pressure generated in the glomerulus that overcomes the effects of water potential and increases glomerular filtration rate (GFR), so it is logical to think that higher blood pressure might increase GFR still further. High pressure forces small molecules from the capillary into the filtrate, so higher pressure might be able to force larger structures such as proteins and cells through as well. This can damage the glomerulus and Bowman's capsule and lead to further kidney problems.

3a

(a) The concentration of glucose decreased after 60 minutes despite the blood containing no insulin because:

Any **two** of the following:

- Glucose is used in (cellular) respiration / as an energy source / in metabolism; [1 mark]
- Glucose enters cells **OR** glucose is converted to glycogen within cells; [1 mark]
- Glucose is excreted **OR** glucose exits body in urine; [1 mark]

**[Total: 2 marks]**

You must specify exactly what is happening to the glucose; it is not enough to simply say that glucose is used, or that it is removed from the blood. Glucose can enter the cells without the need for insulin (though more slowly) where it is stored as glycogen or used in respiration. Glucose can also be filtered by the kidneys and lost in the urine.

3b

(b) (i) Results for a non-diabetic patient would show...

- A line from 75 mg that increases **AND** remains below the line in Fig. 1 **AND** then drops back down to 75 mg; [1 mark]

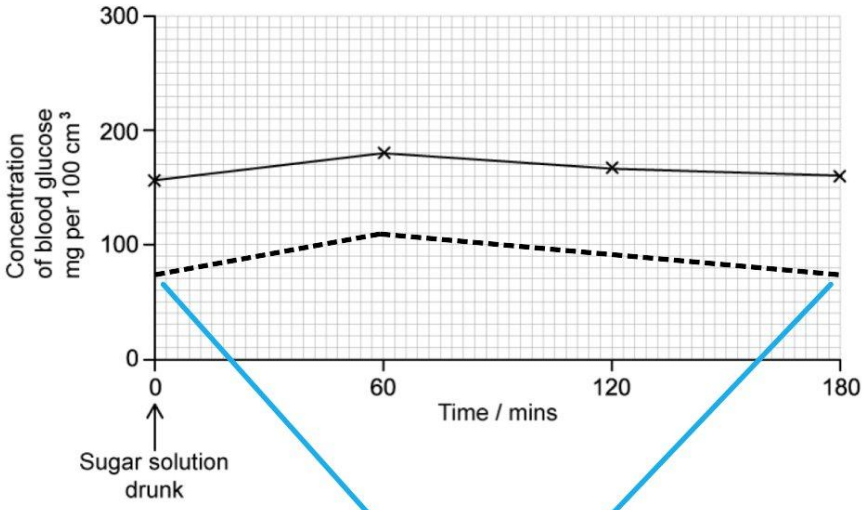
(b) (ii) The reason for this line would be...

Any **three** of the following:

- The beta cells (in the islets of Langerhans) release insulin in response to an increase in blood glucose; [1 mark]
- Liver/muscle/fat cells increase uptake of glucose / remove more glucose from the blood **OR** more glucose is transported into liver/muscle/fat cells; [1 mark]
- Glucose is converted to glycogen / glycogenesis takes place; [1 mark]
- More glucose is used in respiration / the rate of respiration increases; [1 mark]

**[Total: 4 marks]**

Note that part (ii) is an 'outline' question, meaning that the details of the the action of insulin at a cellular level are not required.




Line starts and ends at 75 mg AND remains below existing line throughout [1 mark]

3c

(c) The role of ADH in osmoregulation is...

Any **five** of the following:

- (ADH is) released from the posterior pituitary gland in response to a decrease in blood water potential; [1 mark]
- (ADH) binds to receptors on the cell surface membranes of the cells/lining of the collecting duct/distal convoluted tubule; [1 mark]
- Cyclic AMP/cAMP is produced (this is a second messenger); [1 mark]
- (cAMP) initiates a series/cascade of enzyme-controlled reactions; [1 mark]
- Vesicles containing aquaporins move to the cell surface membrane (of the cells lining the collecting duct); [1 mark]
- Vesicles fuse with the cell surface membrane; [1 mark]
- Cells / wall of collecting duct/distal convoluted tubule becomes more permeable to water; [1 mark]
- More water moves out of the collecting duct / is reabsorbed into the blood; [1 mark]
- Water moves (out of the collecting duct) down its concentration/water potential gradient; [1 mark]

**[Total: 5 marks]**

4a

(a) (i) The results shown in Fig. 1 can be described as follows...

Any **three** of the following:

- Blood glucose concentration rises in both individuals when (glucose) drink is taken; [1 mark]
- The diabetic individual has higher blood glucose concentration at the start; [1 mark]
- The diabetic individual has a higher peak of / steeper rise in blood glucose concentration; [1 mark]
- The diabetic individual has a slower fall in blood glucose **OR** the blood glucose of the diabetic individual does not return to normal in 3 hours; [1 mark]

(a) (ii) The location of the receptors in a non-diabetic person that detect a change in blood glucose concentration is…

- β cells / pancreas / islets of Langerhans; [1 mark]

***Accept*** *hypothalamus*

(a) (iii) The homeostatic mechanism by which blood glucose concentration is maintained is…

- Negative feedback; [1 mark]

**[Total: 5 marks]**

4b

(b) (i) Enzymes A and B are…

- A = glucose oxidase; [1 mark]
- B = (hydrogen) peroxidase; [1 mark]

(b) (ii) One advantage of using a biosensor and one advantage of using a dipstick to measure glucose concentration could be…

- Biosensor = rapid/immediate result **OR** (more) accurate / precise / provides a quantitative reading **OR** shows current blood glucose **OR** reusable; [1 mark]
- Dipstick = non-invasive / painless / easy to use / cheap **OR** less risk of infection; [1 mark]

**[Total: 4 marks]**

Read the question carefully here; it asks for an **advantage** of **both** methods of measuring glucose concentration.

4c

(c) The role played by insulin in the control of blood glucose concentration is…

Any **five** of the following:

- Insulin binds to receptors on liver / muscle / adipose (cells); [1 mark]
- GLUT(4 transporters) are added to the surface membrane of cells / cause an increase in (glucose) permeability of cells; [1 mark]
- Glucokinase phosphorylates glucose in liver cells **OR** there is an increased rate of diffusion of glucose into liver cells;
- There is an increase in respiration of glucose; [1 mark]
- Glycogen synthase is activated / glycogenesis occurs / glycogen is synthesised; [1 mark]
- Lipid/triglyceride synthesis occurs **OR** there is a decrease in glycogenolysis / gluconeogenesis; [1 mark]
- Blood glucose concentration decreases; [1 mark]

**[Total: 5 marks]**

5a

(a) (i) High blood pressure is achieved as follows…

- afferent arteriole is wider than efferent arteriole; [1 mark]

(a) (ii) The main filtration barrier in the nephron that allows creatinine to pass into the Bowman's capsule but stops red blood cells from passing through is the...

- Basement membrane; [1 mark]

**[Total: 2 marks]**

5b

(b) (i) The relationship shown in Fig. 2 can be described as follows...

- The higher the creatinine concentration the lower the GFR; [1 mark]
- (Additional detail of relationship, e.g.) the curve shows an exponential decrease / is inversely proportional / two data points correctly quoted; [1 mark]

***Accept*** *'creatinine concentration is inversely proportional to the GFR' for 2 marks*

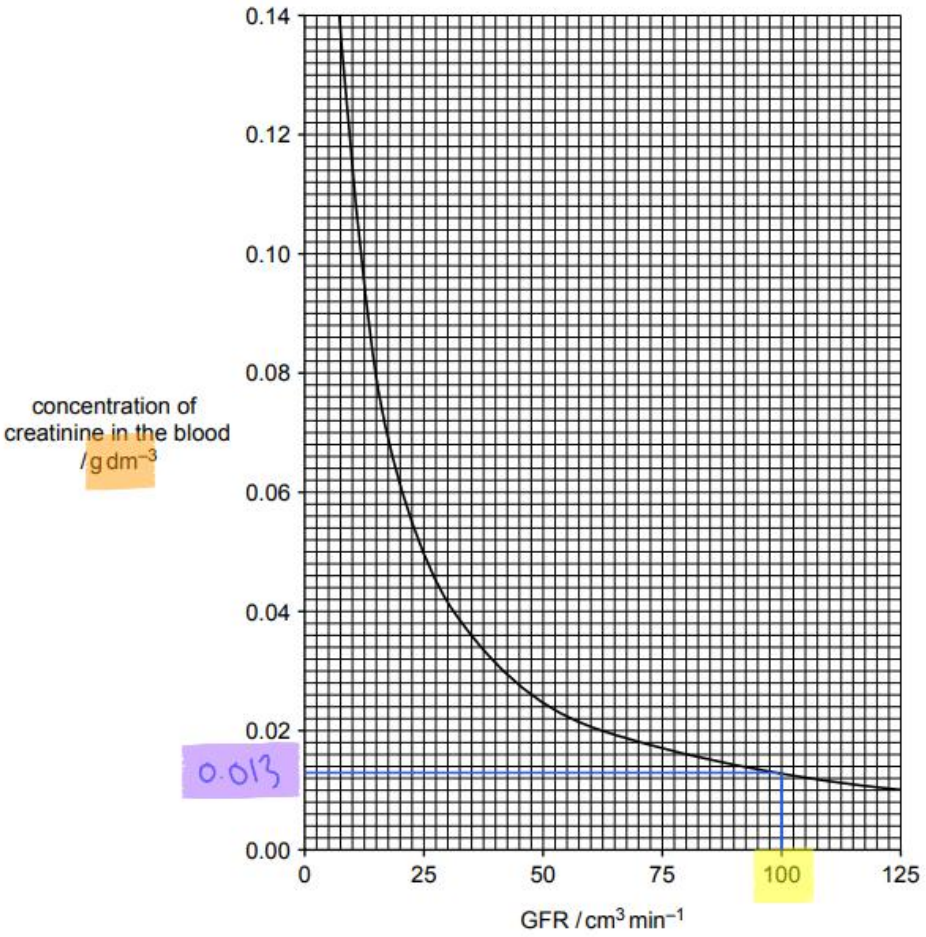
(b) (ii) The concentration of creatinine in the blood that indicates a normal GFR is...

- 0.013; [1 mark]
- g $dm^{-3}$; [1 mark]

The concentration of creatinine in the blood largely depends on the glomerular filtration rate (GFR). By measuring the concentration of creatinine in the blood, the GFR can therefore be estimated. The value of the GFR can be used to assess the efficiency of the kidneys.

In humans, a normal value of the GFR is 100 $cm^3$ $min^{-1}$.

Fig. 2 shows the relationship between the GFR and the concentration of creatinine in the blood.




The creatinine concentration at a GFR of 100 $cm^3$ $min^{-1}$ is:

[1 mark] 0.013 $gdm^3$ [1 mark]

(b) (iii) Reasons why the GFR of a person might decrease include...

Any **two** of the following:

- Kidney disease/damage; [1 mark]

- Cancer; [1 mark]
- Dehydration; [1 mark]
- Low blood pressure; [1 mark]
- Blood loss / low blood volume; [1 mark]

**[Total: 6 marks]**