6 Fig. 6.1 is a diagram that represents the nephron in a mammalian kidney.

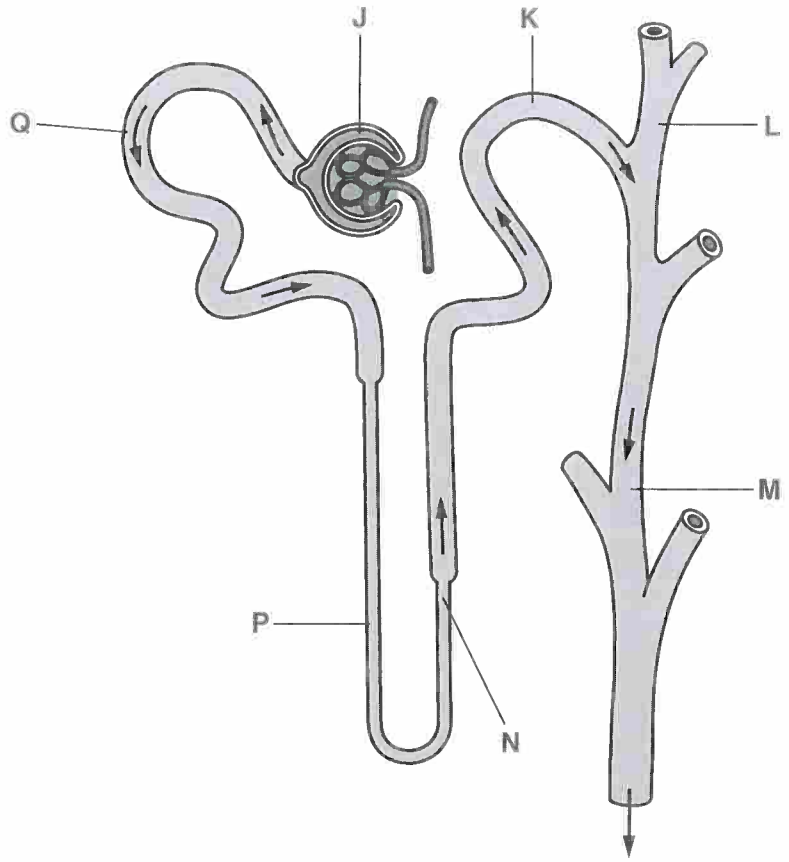

Fig. 6.1

(a) 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]**

(b) 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.

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..... **[2]**

(c) Urine can be tested to detect a person's misuse of certain drugs in body-building.

State the **type** of drug that can be misused in this way.

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

[Total: 6]

END OF QUESTION PAPER

4 Kidney failure is a serious condition. Many kidney patients receive some form of renal replacement therapy (RRT) such as dialysis.

The UK Renal Registry collects national data about the causes and treatment of kidney failure.

(a) Table 4.1 shows the number of adult patients who started RRT in the UK in 2011. The table also shows the estimated population of each country in the UK and the incidence rate of RRT in each country.

The incidence rate is the number of adult patients starting RRT in 2011 per million people.

Country	Number of adults starting RRT in 2011	Estimated population in 2011 (millions)	Incidence rate (per million people)
England	5774	53.0	109
Northern Ireland	203	1.8	113
Scotland	495	5.3	
Wales	363	3.1	117
UK	6835	63.2	108

Table 4.1

Using the data in Table 4.1, calculate the missing value for the incidence rate of adult patients starting RRT in **Scotland** in 2011.

incidence rate = ... **[2]**

(b) Fig. 4.1 shows the mean percentage of adult patients in the UK starting renal replacement therapy (RRT) in 2011 who were male and the age groups to which they belonged.

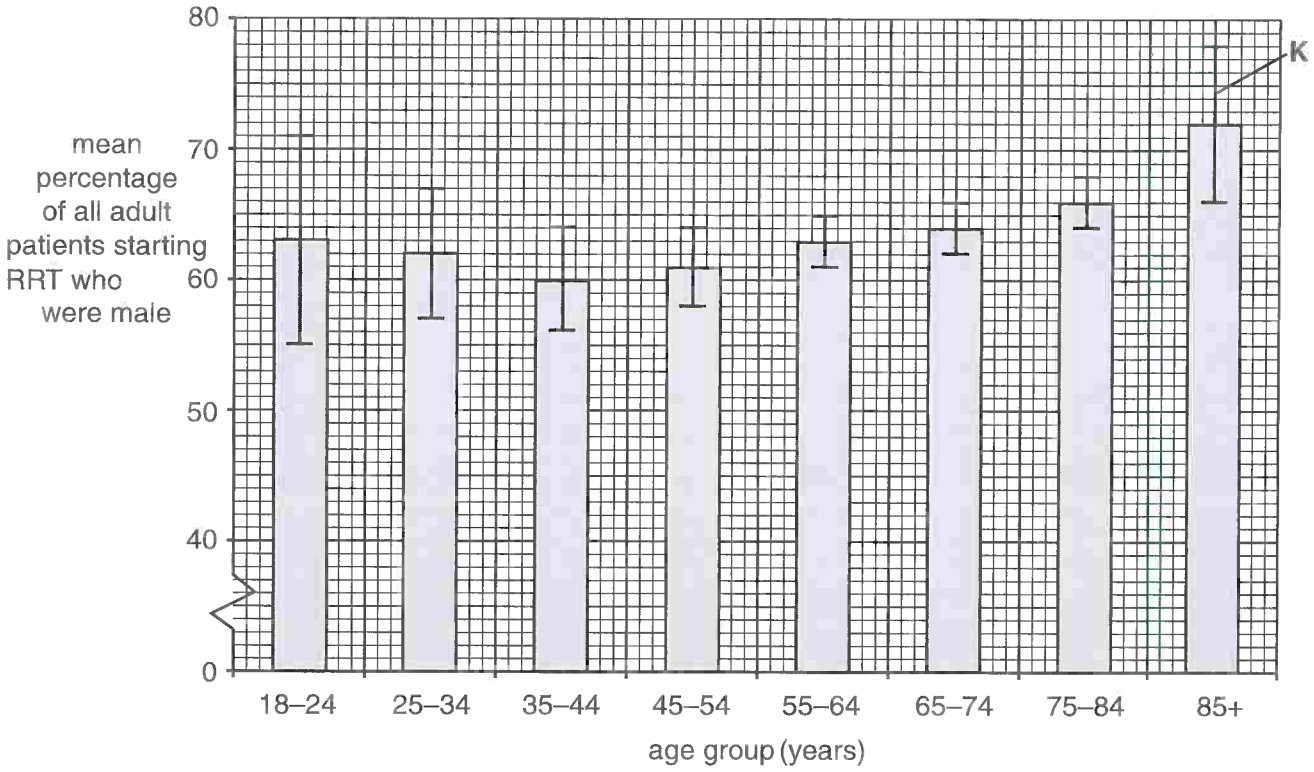

Fig. 4.1

(i) State the name given to the feature indicated by the letter **K** on Fig. 4.1.

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

(ii) What information can be deduced from the data in Fig. 4.1 about the gender of adult patients starting RRT in 2011?

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..... **[2]**

(c) Many causes of kidney failure can be diagnosed.

Table 4.2 shows the percentage of patients starting RRT in 2011 who were diagnosed with different causes of kidney failure. The percentages are given for patients belonging to two different age groups, and for patients of all age groups.

Cause of kidney failure	Patients with kidney failure (%)		
	Aged below 65 years	Aged 65 + years	All age groups
Diabetes	27.2	22.4	24.80
Glomerulonephritis	17.4	9.2	13.30
Pyelonephritis	7.8	6.5	7.15
Hypertension	6.7	7.4	7.05
Polycystic kidney	10.6	3.8	7.20
Renal vascular disease	2.3	11.5	6.90
Other causes	16.0	16.6	16.30
Uncertain diagnosis	12.0	22.6	17.30

Table 4.2

(i) Suggest why 'uncertain diagnosis' occurs more often in the group of patients aged 65+ years compared with the group below 65 years of age.

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.....

..... [1]

(ii) Identify the cause of kidney failure with the **most significant** increase in the group of patients aged 65+ years compared with the group below 65 years of age.

Justify your answer.

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..... [1]

(d) The main forms of 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.

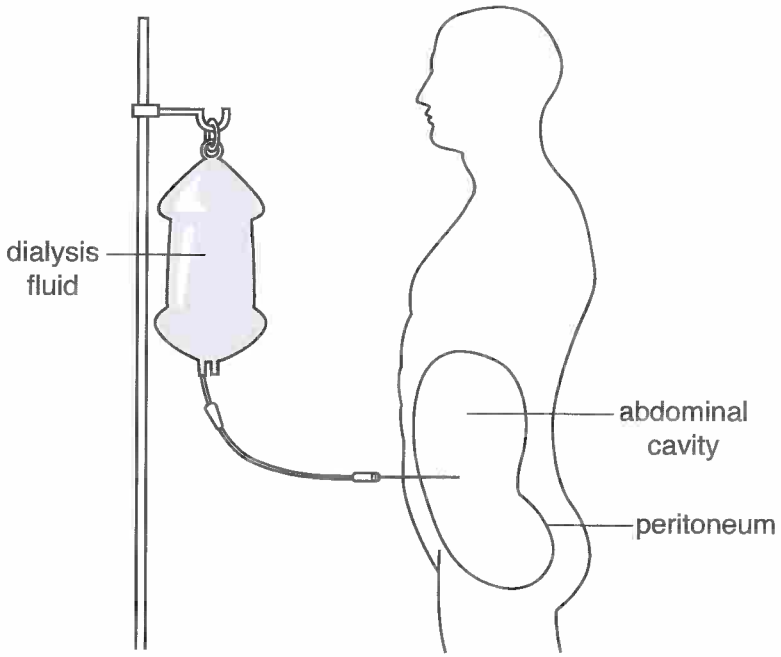

Fig. 4.2

- 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?

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..... [1]

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

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..... [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.

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..... [2]

(e) One function of healthy kidneys is to make the hormone erythropoietin (EPO), which stimulates the production of red blood cells. Patients with kidney failure may need to be given supplements of EPO.

State the type of cell from which red blood cells are formed **and** where this type of cell is located.

type of cell .....

location ..... [1]

[Total : 13]

6 The kidney is a vital organ in the body and is responsible for excretion. It also plays an important role in homeostasis.

(a) Complete the passage, using the **most suitable** term in each case.

The blood in the glomerulus has a high ..... pressure, which forces small molecules, such as glucose and ....., out of the glomerulus and into the lumen of the Bowman's capsule. This process is known as ..... .

In the proximal convoluted tubule, the glucose, most of the ..... and some of the salts are reabsorbed into blood ..... that surround the nephron at this point. **[5]**

(b) One aspect of the kidney's homeostatic role is the ability of anti-diuretic hormone (ADH) to increase the number of aquaporins in the plasma membranes of the cells lining the collecting duct. This increases the amount of water reabsorbed.

ADH is released in response to a decrease in the water potential of the blood plasma.

(i) State precisely where the cells that detect a decrease in the water potential of the blood plasma are found.

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

(ii) Name the cells that detect this decrease.

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

(c) Fig. 6.1 outlines some of the events that take place if the blood volume decreases, for example, due to a significant loss of blood.

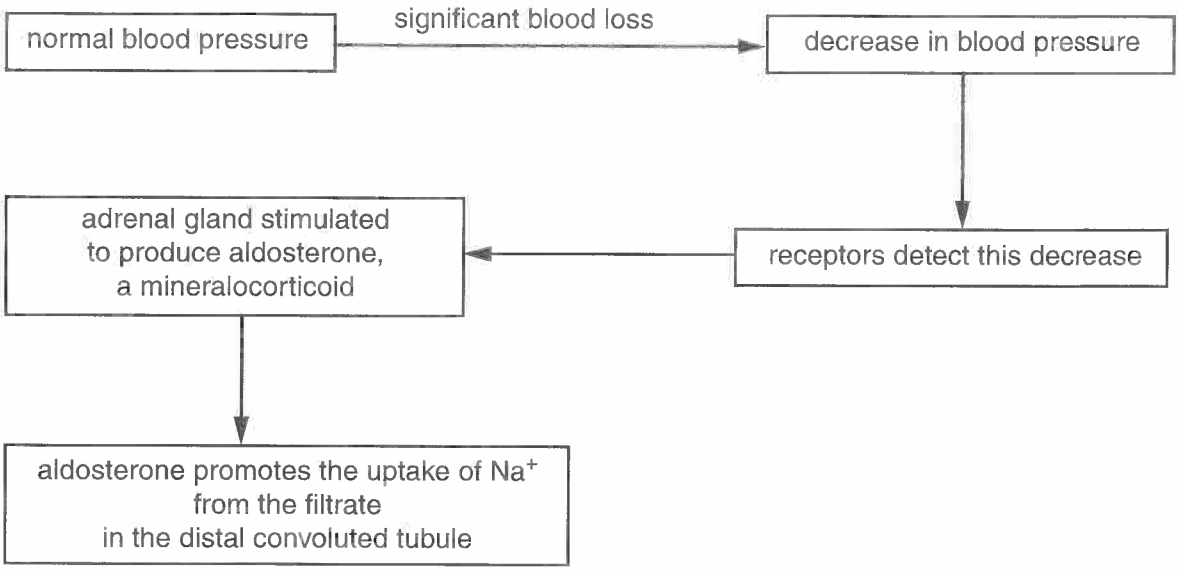

Fig. 6.1

(i) Name the part of the adrenal gland that releases aldosterone.

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

(ii) Suggest **and** explain what effect the action of aldosterone will have on the secretion of ADH.

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..... **[2]**

(iii) As the action of aldosterone takes effect, this is detected by receptors in the body and secretion of aldosterone decreases.

State the name of the mechanism that results in this decrease in aldosterone secretion.

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

[Total: 11]

END OF QUESTION PAPER

3 As blood passes through the kidney it is filtered and the urine formed in the nephron leaves the kidney through the ureter.

Table 3.1 below shows the concentration of some of the components of blood, glomerular filtrate and urine.

Component	Blood ($g\,100cm^{-3}$)	Glomerular filtrate ($g\,100cm^{-3}$)	Urine ($g\,100cm^{-3}$)
Glucose	0.10	0.10	0.00
Urea	0.03	0.03	1.80
Amino acids	0.05	0.05	0.00
Large proteins	8.00	0.00	0.00
Inorganic ions (total)	0.90	0.90	variable, up to 3.60

Table 3.1

Table 3.2 below shows the presence or absence of erythrocytes in blood, glomerular filtrate and urine.

Component	Blood	Glomerular filtrate	Urine
Erythrocytes	present	absent	absent

Table 3.2

(a) Explain the changes in fluid composition shown in Table 3.1 and Table 3.2.

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

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[5]

(b) Kidney function can be assessed by measuring the Glomerular Filtration Rate (GFR). GFR is a measure of the rate at which blood is filtered by the kidneys.

The GFR is estimated using the concentration of creatinine in the blood plasma. This compound is produced naturally by the body and is normally filtered from the blood by the kidneys and excreted.

(i) Suggest what a high concentration of creatinine in the blood plasma indicates about kidney function. Give a reason for your answer.

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

(ii) A formula is used to obtain a value for GFR that takes into account the various factors that contribute to concentration of creatinine in the blood.

GFR is expressed as $cm^3 min^{-1}$.

A typical person is assumed to have a body surface area of $1.73\,m^2$.

In order to obtain an estimate of GFR (eGFR) for individuals who are smaller or larger than a typical person, the following calculation is performed:

$$eGFR = GFR \times \frac{1.73}{\text{individual's body surface area}}$$

A man has a GFR of $82\,cm^3 min^{-1}$ and a body surface area of $2.56\,m^2$.

Calculate the eGFR for this man.

Show your working and give your answer to the nearest **whole number**.

eGFR = ... $cm^3 min^{-1}$ **[2]**

(iii) Chronic Kidney Disease (CKD) is divided into five stages according to the eGFR value.

These stages are listed in Table 3.3 below.

CKD stage	eGFR ($cm^3 min^{-1}$)	Effect on kidney
1	greater than 90	little or no damage
2	60 – 90	some or no damage
3	30 – 59	moderate reduction in function
4	15 – 29	severe reduction in function
5	less than 15	kidney failure

Table 3.3

Use the information in Table 3.3 to:

- identify the CKD stage indicated by the eGFR that you calculated in **(b)(ii)**
- determine the effect on the kidney of this man.

stage .....

effect on kidney .....

[1]

Question 3(c) begins on page 12

(c) The following are some of the pieces of information relating to kidney transplantation that have appeared in some news items during the last 15 years.

November 2002

The trade in human organs is growing. One woman sold her kidney for £400 (two year's worth of her wages) to an agent. The agent then sold it for an estimated £20 000 to a man who was in desperate need of a transplant.

November 2010

A private medical group has admitted to the charge of carrying out illegal kidney transplants at one of its hospitals. The people from whom the kidneys were taken were poor and some were below the legal age of consent. They were paid for the kidneys, which were sold to wealthy people who needed transplants.

April 2011

The number of people donating one of their kidneys for transplant is increasing year by year. The donor receives no payment, undergoes months of medical and psychiatric tests, and cannot specify who receives their kidney. While the numbers of donors are still small compared to the numbers needing a kidney transplant, each kidney donated is making the difference between life and death for someone.

Discuss, with reference to the information given on page 12, whether it is ethical for live donors to be used as a source of kidneys for transplantation.

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..... **[3]**

[Total: 12]

5 Fig. 5.1 is a photomicrograph of a horizontal section through the cortex of a mammalian kidney.

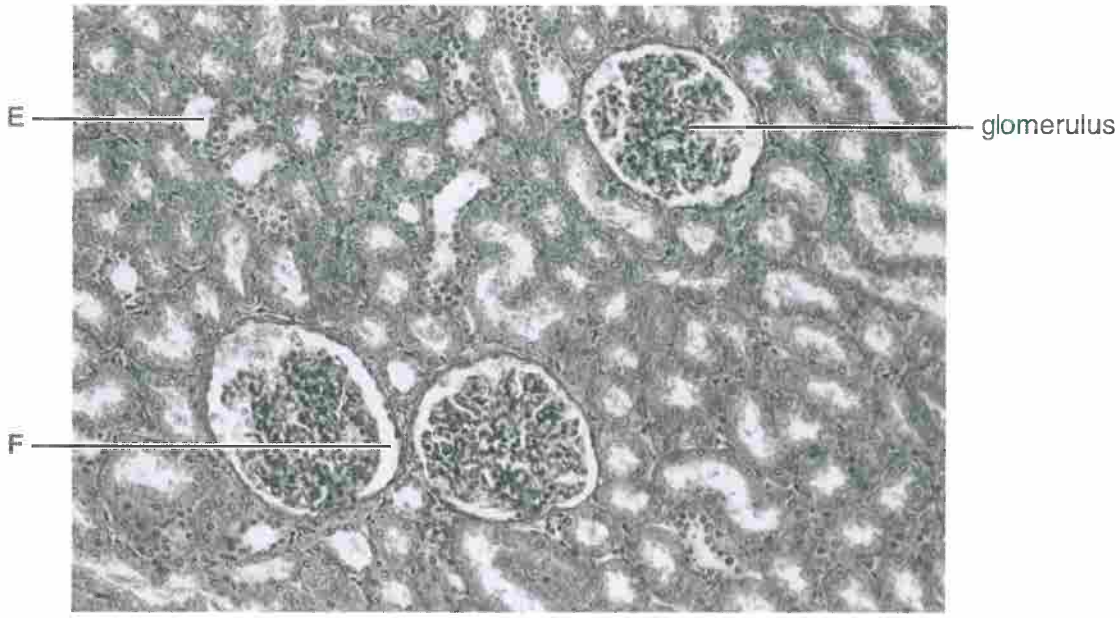

Fig. 5.1

(a) Identify the structures labelled **E** and **F** in Fig. 5.1.

E .....

F ..... **[2]**

(b) **(i)** Explain how the glomerulus is able to perform its function.

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

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..... [3]

(ii) **Name** the specialised cells present in structure **F** that assist in the function you described in **(b)(i)**.

..... [1]

(c) Kidney failure has serious consequences for the individual.

(i) Suggest the effects of complete kidney failure on the **composition of the blood**.

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..... [2]

(ii) One way of treating a person with kidney failure is by giving them a kidney transplant.

Explain the need for close matching of the donated kidney to the recipient.

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..... [3]

[Total: 11]

QUESTION 6 STARTS ON PAGE 16

2 The kidney is composed of many nephrons.

Fig. 2.1 is a diagrammatic representation of a nephron. The numbers represent the relative concentrations of solutes in the tubule and the tissue fluid surrounding the tubule.

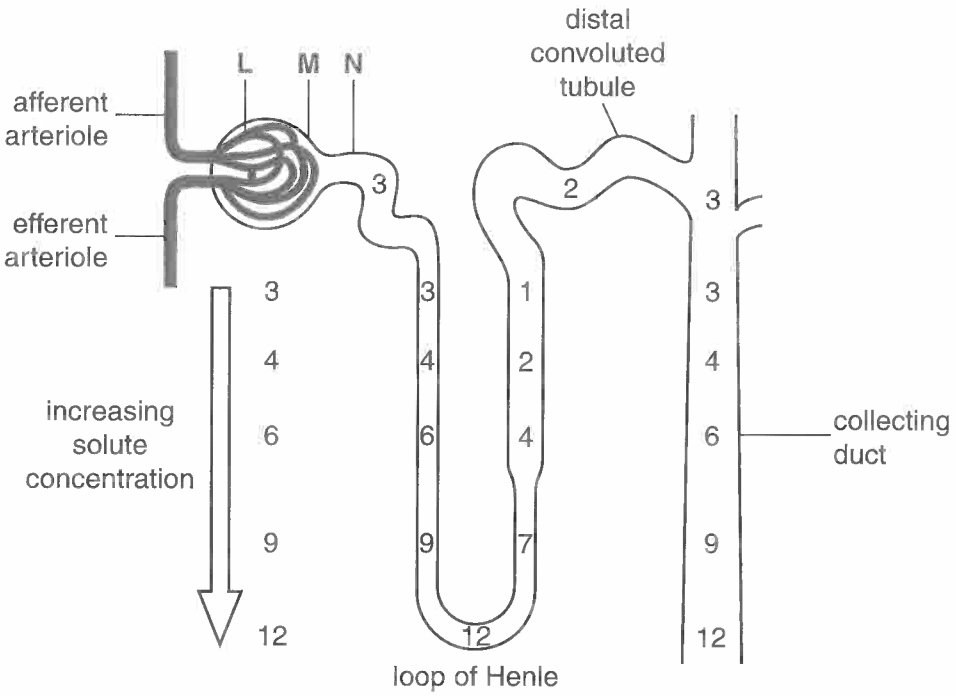

Fig. 2.1

(a) **Name** the parts of the nephron labelled **L**, **M** and **N**.

L .....

M .....

N ..... **[3]**

(b) Which part(s) of the nephron corresponds to each of the statements in the table below?

statement	part(s) of the nephron
walls are impermeable to water	
glucose is reabsorbed into the blood	
ADH acts on the walls	
contains podocytes	
most of the water is reabsorbed into the blood	

[5]

(c) With reference to Fig. 2.1, explain the role of the loop of Henle in the production of urine.

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

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..... **[5]**

[Total: 13]

5 **(a)** Fig. 5.1 is a drawing representing a vertical section through a mammalian kidney.

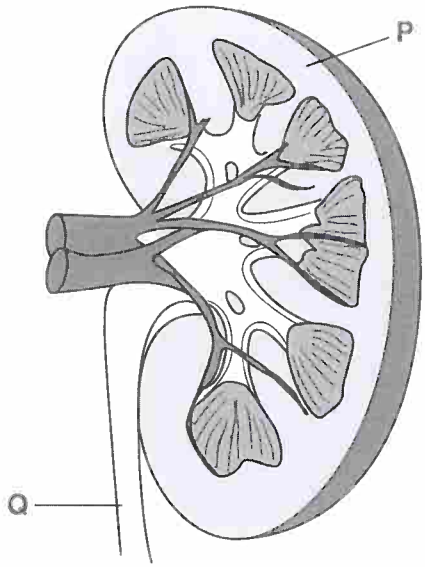

Fig. 5.1

Name the region **P** and the structure **Q**.

P .....

Q ..... **[2]**

(b) (i) Each kidney contains approximately one million nephrons. Each section of a kidney nephron is adapted to perform its function effectively.

Describe the features of the **glomerulus** and **Bowman's capsule** that allow them to perform their function effectively.

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

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..... **[4]**

(ii) Nephritis is a condition in which the tissue of the glomerulus and proximal convoluted tubule becomes inflamed and damaged.

Suggest **two** differences in the composition of the urine of a person with nephritis when compared to the urine of a person with healthy kidneys.

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.....

..... **[2]**

QUESTION 5(c) STARTS ON PAGE 14

(c) Caffeine is a mild diuretic. Caffeine prevents the introduction of additional aquaporins into the wall of the collecting duct of the nephron and therefore additional water is not removed from the urine.

Aquaporins are channels in the cell surface membrane that allow water molecules to pass through.

Fig. 5.2 represents an aquaporin.

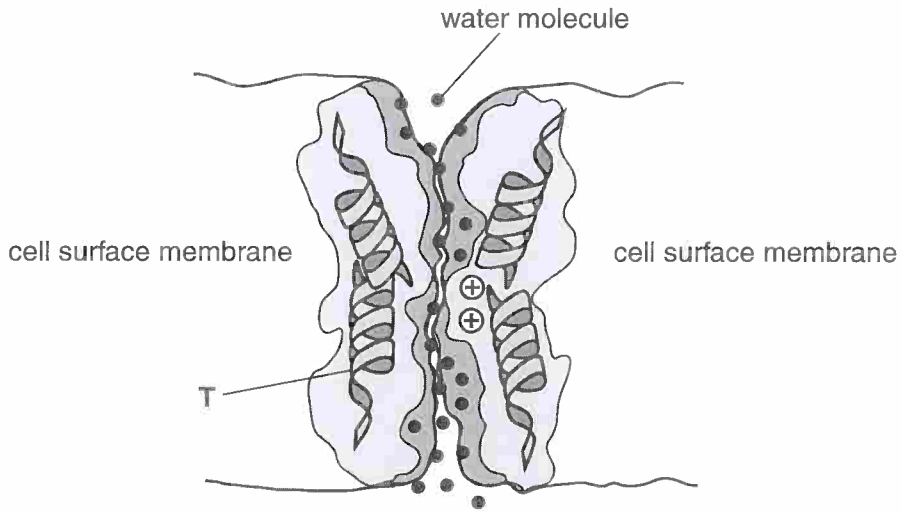

Fig. 5.2

(i) Identify the type of molecule labelled **T**.

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

(ii) The aquaporin allows water to travel from the collecting duct into the surrounding tissues but prevents the passage of ions such as sodium ions and potassium ions.

With reference to Fig.5.2, suggest **two** ways in which the structure of this aquaporin prevents the passage of ions.

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..... **[2]**

[Total: 11]