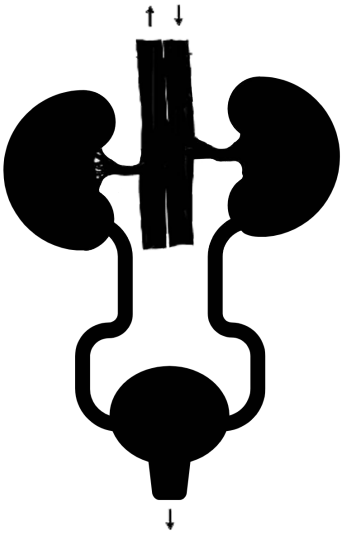
Department of Education

GOVERNMENT OF WESTERN AUSTRALIA

Year 11 ATAR Human Biology

The Excretory System



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Year 11 ATAR Human Biology

Topic: The Excretory System

Instructions to Students

This resource package provides you with learning materials for the Human Biology ATAR Year 11 course. The package focuses on the topic: **The Excretory System**.

This package is designed to support the program you are completing at your school. If feedback is required when completing this package, you should consult your teacher.

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This section is designed to develop the knowledge component of the syllabus. It also includes focus questions and activities to support your understanding. 3-25

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It is recommended that you further investigate concepts covered in this resource package by conducting your own research using the text/s that you use at school or the internet.

Syllabus Points Covered

Science Understanding:

- *the **excretory system regulates** the **chemical composition** of **body fluids** by removing **metabolic wastes** and retaining the proper amounts of water, salts, and nutrients; **components** of this system include the **kidneys, liver, lungs,** and **skin** functioning at the organ level*
- ***deamination** of **amino acids** in the **liver** produces **urea**, which then is transported to the kidneys for removal*
- *the **nephrons** in the kidney **facilitate** three basic processes: **filtration, reabsorption and secretion** during urine formation to maintain the composition of body fluids (hormone control is not required)*

Science as a Human Endeavour:

- *treatment of conditions due to **system or organ dysfunction** has changed through improvements in early **diagnosis** and appropriate use of drugs, **physical therapy**, **radiation therapy**, and removal and/or replacement of affected parts*
- ***lifestyle choices**, including being active or **sedentary**, the use of drugs and **type of diet**, can compromise body functioning in the short term and may have long term consequences*

Science Inquiry Skills:

- *represent data in meaningful and useful ways; organise and analyse data to identify trends, patterns and relationships; qualitatively describe sources of measurement error, and uncertainty and limitations in data; and select, synthesise and use evidence to make and justify conclusions*

Learning content and activities

To complete the activities and questions in this section, use your textbook (most schools will be using *Human Perspectives ATAR Unit 1 & 2* by TJ Newton and AP Joyce), references and the hyperlinks to webpages given below.

The Excretory System

Efficient functioning of the cells of the body depends on **regulation** of the **composition** of the **body fluids** surrounding the cells.

The **metabolic activities** of the body's cells result in the production of wastes which, if allowed to accumulate, are **toxic** to cells.

These waste products need to be removed from the body. The excretory system is responsible for removal of **metabolic wastes** from the body.

Metabolic wastes

The human body is made up of approximately 70% water by mass. This water contains many **dissolved** substances.

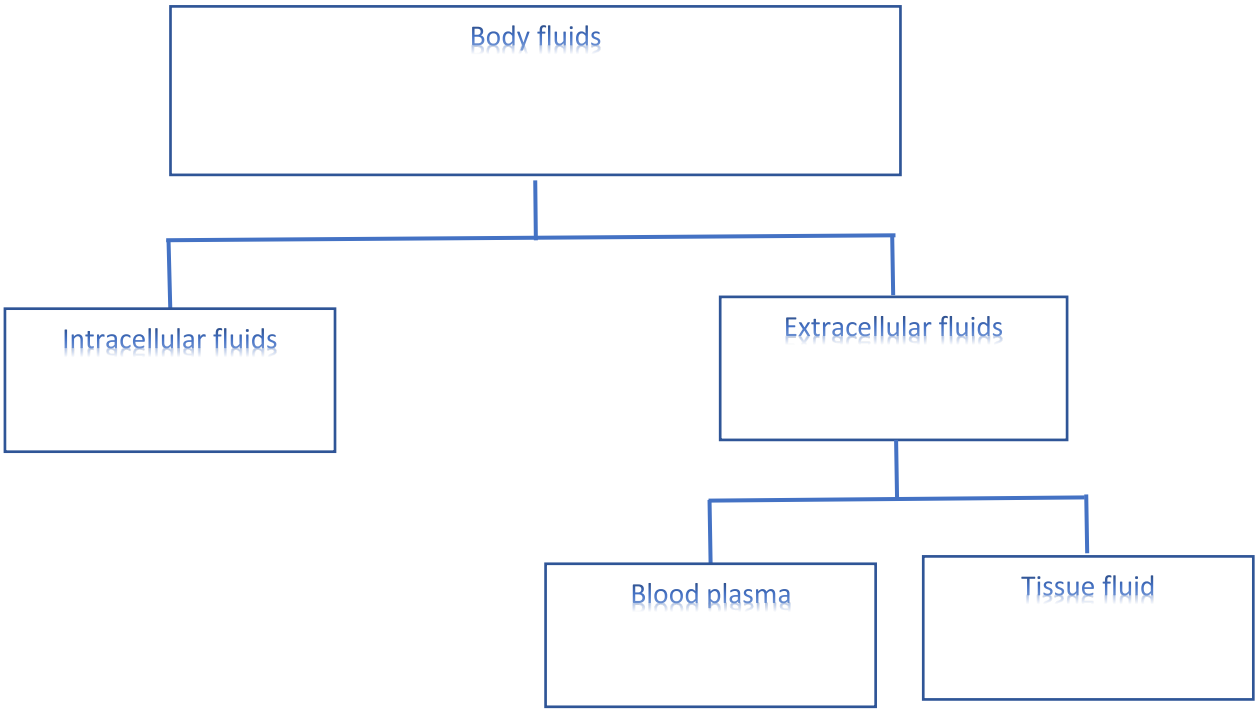
The body fluid lies in different locations in the body which can be referred to as fluid compartments.

There is continual movement of substances between the **fluid compartments** of the body.

- Nutrients and oxygen move from the blood, into **tissue fluid** and then into the cells.
- Waste products such as **carbon dioxide** and **urea** move from the cells, into the tissue fluid and then into the blood.

Activity One

1. Review the diagram below showing where the **body fluid compartments** are located in the body. Complete the boxes with a definition of each fluid compartment.



There is continual movement of substances between the fluid compartments of the body.

- Nutrients and oxygen move from the blood into tissue fluid and then into the cells.
- Waste products such as **carbon dioxide** and **urea** move from the cells into tissue fluid and then into the blood.

2. In the space below, draw an infographic, or a labelled diagram, to show the continual movement of substances such as nutrients and wastes between the capillary, cells via the tissue fluid.

What are examples of metabolic wastes?

Metabolic wastes are wastes produced by the body cells as they undergo biochemical reactions such as cellular respiration and deamination of proteins. Metabolic wastes are shown in **Table 1** below.

Table 1: List of metabolic wastes produced by body cells and their effect on pH

Metabolic waste	Produced by	Effect on pH of body fluids
Carbon dioxide	produced by all cells during cellular respiration (aerobic respiration)	lowers the pH
Urea	waste product of the breakdown of proteins during metabolism	raises the pH
Acids	formed in metabolism	lowers the pH

In addition to the need to remove these metabolic wastes, the levels of salt and water in the body fluids must also be **regulated**.

Too much or too little of these substances alters the **osmotic concentration** of the body fluids. For example, if the blood contains too much salt (sodium chloride), cells will lose water to the bloodstream by **osmosis**. The cells would become **dehydrated** and die.

Efficient functioning of the cells depends upon maintaining a **relatively constant internal environment** in the body. Therefore, the composition of the body fluids must be regulated.

Table 2 lists the organs involved in excretion of metabolic wastes (see next page).

Table 2 Organs involved in excretion of metabolic wastes

Organ	Metabolic wastes excreted
Lungs	excrete carbon dioxide and water in expired air
Kidneys	excrete urea, minerals and water in the urine
Skin	excretes salts, urea and lactic acid in sweat
Digestive tract	passes out bile pigments in the faeces. (**Note** that faeces are not considered a waste product of metabolism. It is material that never left the digestive tract, so it was not absorbed from the digestive tract into the bloodstream. This waste was not made by body cells.)
Liver	converts excess amino acids into carbohydrates and produces urea in a process called deamination.

Activity Two – Metabolic wastes

1. Define the term metabolism.

2. Write the overall word equation for cellular respiration

3. Draw a flow chart to show the **fluid compartments** and the paths that metabolic wastes move through from the cells to the blood.

4. The pH of the blood is about 7.5. State if this is acidic or basic.

5. Define osmosis. Explain why an increase in the solute concentration in the cells would cause the cells to swell. Draw a diagram to illustrate your explanation.

6. Describe the pathway of bile once it has been produced by the liver. List the waste products excreted in the bile.

7. Explain the process of deamination in the liver.

The urinary system

Many of the waste products of metabolism end up in the blood. These include:

- urea
- excess salts
- excess water.

The function of the urinary system is to remove these wastes from the blood and excrete them in the urine.

The urinary system consists of:

- two **kidneys**
- two **ureters**
- the **urinary bladder**
- the **urethra**.

The kidneys lie against the dorsal or back wall of the abdominal cavity. Each kidney is 11 cm in length and is protected by a layer of fat.

The blood carrying wastes to the kidneys travels down the **aorta** and then enters the **renal arteries.** The blood is filtered, and the wastes removed. Then the filtered blood travels out of the kidney in the **renal veins** and returns to the heart via the **vena cava.**

Activity Three – The urinary system

Explore the structure of the Urinary system and the kidneys by visiting InnerBody website https://www.innerbody.com/image/urinov.html

1. Draw a labelled diagram of the urinary system. Use all of the **bold terms** on the previous page (page 9).

2. On your diagram above indicate the direction of blood flow in the vessels.

3. Describe the role of the ureters, bladder and urethra in excretion.

4. If a kidney is cut lengthwise, you would see a longitudinal section of the kidney. The kidney is enclosed in a protective **capsule**. Three regions can be identified:
    - the outer region called the **cortex**
    - the inner region called the **medulla** and
    - an area called the **pelvis** where the ureter joins the kidney.

Draw a diagram of a longitudinal section of the kidney and label the parts described.

Urine formation

Each kidney is made up of approximately one million microscopic structures called **nephrons**. The nephrons filter the blood and **reabsorb** particular molecules from the filtrate back into the blood.

- The nephron consists of a closed tube with a cup-like end called the **glomerular capsule** or **Bowman's capsule**.
- The Bowman's capsule encloses a network of capillaries called the **glomerulus**.
- A tube leaves the Bowman's capsule and becomes convoluted (coiled) and is called the **proximal convoluted tubule**.
- The convoluted tubule joins to a U-shaped section called the **loop of Henle**
- This then joins to another convoluted tubule called the **distal convoluted tubule** and then forms the **collecting duct**.
- The **collecting duct** receives urine for several nephrons and empties it into the **pelvis** of the kidney.

Activity Four –The nephron

Draw a simplified diagram of a kidney nephron. Pay attention to the colours used for the blood vessels. Label the parts. Refer to you text or refer to the webpage below (click the link):
http://humanbiologylab.pbworks.com/w/page/81765305/Organ%20Histology%20of%20the%20Kidney

Urine formation

Urine formation involves three processes:

- filtration
- selective reabsorption
- secretion

Filtration

When blood flows into the glomerulus, fluid is forced out of the blood into the Bowman's capsule. This is called **filtration**.

There are several features of the **nephron** that make this process more efficient.

- Blood coming from the aorta into the renal artery is under high pressure. This means that the blood in the **afferent arterioles** (small artery carrying blood to the glomerulus) is under high pressure.
- The afferent arteriole has a larger diameter than the **efferent arteriole** (small artery carrying blood away from the glomerulus), providing a resistance to blood flow and therefore a higher pressure in the glomerulus.
- The coiled **glomeruli** are very long, so they have a large surface area for filtration to take place.

Selective Reabsorption

Many substances that are filtered are useful to the body so are **reabsorbed** back into the blood from the tubules. These include:

- water
- sodium ions
- chloride ions
- amino acids
- glucose.

Secretion

Secretion refers to the movement of substances from the blood in the **peritubular capillaries** into the tubule. Substances such as **hydrogen ions**, **potassium ions** and certain drugs are secreted into the urine.

Activity Five – Urine formation

You will need to make notes from your text and watch nephron animations to understand and appreciate the complex job of the nephrons and how they form urine. Click on the links below to watch some videos that show the function of the nephron.

- A Journey Through the Nephron: https://www.youtube.com/watch?v=c05mJaeIQuY
- Function of the Nephron made easy: https://www.youtube.com/watch?v=8UVIXX-9x7Q

1. (a) Draw a nephron with the associated blood vessels or find an image of one that includes the labels in the table below. Add labels from the table in question 1b (on the next page), to the diagram.

(b) Complete the table with a relevant heading for each column

• Branch of renal artery
• Afferent arteriole
• Efferent arteriole
• Peritubular capillaries
• Venule
• Branch of renal vein
	• Renal corpuscle
	  ○ Glomerulus
	  ○ Glomerular capsule
	• Proximal convoluted tubule
	• Descending limb
	• Loop of Henle
	• Ascending limb
	• Distal convoluted tubule
	• Ascending limb

(c) On your diagram in question 1a, draw a line across the nephron to show the boundary between the cortex and medulla.

2. (a) List the substances that are **filtered** at the **glomerulus.**

(b) List the substances that cannot be filtered at the **glomerulus** and remain in the blood.

(c) Indicate on your diagram in question 1a where **filtration** occurs.

3. (a) List the substances that are **reabsorbed**.

(b) Indicate on your diagram in question 1a where **selective reabsorption** occurs.

(c) For most dissolved substances, reabsorption occurs by **active transport**. Outline this process and explain why it is necessary.

(d) Water is **reabsorbed** by **osmosis** which is a **passive process**. Explain the process of osmosis. Illustrate with a diagram.

4. (a) List the substances that are **secreted** from the blood back into the tubule.

(b) Explain why **secretion** is necessary.

(c) Indicate on the diagram in question 1a where **secretion** occurs.

5. Samples of fluid were taken from three regions in a functioning nephron:

A: blood plasma (contained in the afferent arteriole leading into the nephron)

B: filtrate (in the glomerular capsule)

C: urine (as it leaves the collecting duct).

The composition of the samples is shown in the table below.

	A Blood plasma	B Filtrate	C Urine
Urea (g/100 mL)	0.03	0.03	2.00
Glucose (g/100 mL)	0.10	0.10	0.00
Proteins (g/100 mL)	8.00	0.00	0.00

a) Explain why the concentration of urea higher in the urine than in the filtrate.

b) Explain the processes that result in the glucose concentrations shown in the table.

c) Explain the process that results in the protein concentration shown in the table.

Water regulation

More than 99% of the water filtered by the glomerulus is reabsorbed. This water is reabsorbed at the proximal convoluted tubule and the loop of Henle by osmosis, which is a passive process.

Water is also reabsorbed at the distal convoluted tubule and the collecting duct, but here it is by active reabsorption often referred to as **facultative reabsorption**. This means that the cells use energy to reabsorb water.

The amount of water reabsorbed actively is controlled by a hormone called the **antidiuretic hormone (ADH)**.

ADH is secreted by the **pituitary gland**, which is located at the base of the brain.

Activity 6
In this space sketch a transverse section diagram to show the position of the pituitary gland in the brain.

If there is a decrease in water content in the blood, ADH is released into the bloodstream and travels to the kidneys. Here the ADH increases the reabsorption of water (back into the blood) by increasing the permeability of the walls of the **distal convoluted tubule** and the **collecting duct**. Conversely an increase in the water content in the blood reduces the amount of ADH released and this in turn decreases the reabsorption of water by reducing the permeability of the distal convoluted tubule and the collecting duct.

Activity Seven – Water regulation

1. In the space below, draw a concept map to summarise the information written in the shaded box on the previous above.

2. Sometimes people go missing at sea in a lifeboat with very little water to drink. Explain why they cannot drink sea water.

3. After their aerobics class Jenny and James both noticed that they were sweating and produced little urine for several hours. Explain their observations.

4. Alcohol reduces the secretion of ADH. Describe the effect would this have on the volume and concentration of urine produced.

Activity 8 – Learning Tactic – Glossary: The Excretory System

For each topic you need to build a glossary of key words, or terms. Key words and terms are used for concepts within the topic you are studying.

You need to use these key words and terms to demonstrate that you understand the concepts studied.

1. Go back to the Syllabus content for this topic. Key words have been written in **bold**.
2. List these bold words in the left-hand column of the Glossary table below.
3. Use your text or the internet to write a definition
4. Draw a diagram to help you remember this term
5. Continue working through this document and list other key words and terms that appear in **bold** text. Repeat steps 3 and 4.
6. Re-read this document and add any other key terms that you do not understand yet.
7. Copy and paste the template below to complete your glossary.

Concept, Term or Vocabulary	Description	Draw it / Apply it

Concept, Term or Vocabulary	Description	Draw it / Apply it

Activity Nine – Learning Tactic – Concept Mapping: The Digestive System

Figure 1 below shows an example of a concept map. It is a description of a nutrient called resistant starch. To read it start in the middle and read along each arrow in turn. You should be able to write a paragraph describing resistant starch.

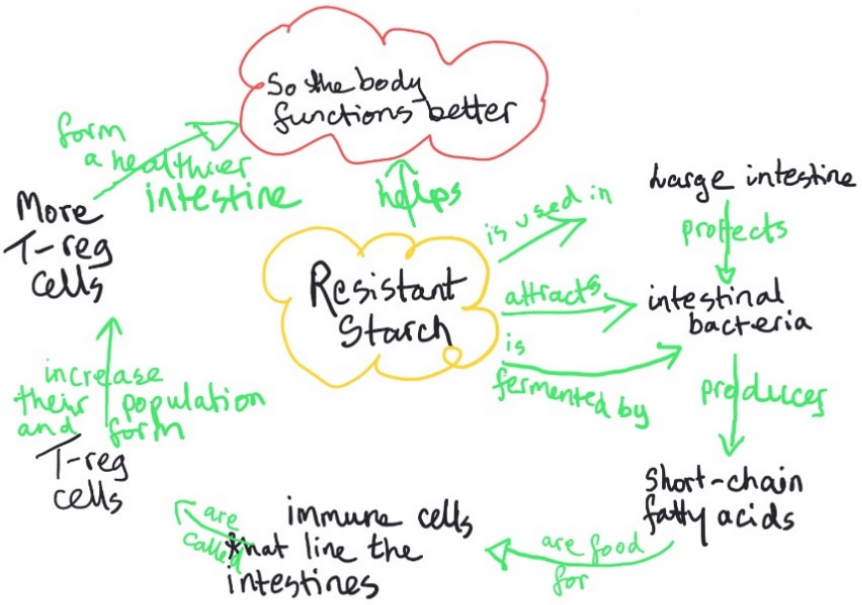


Figure 1: Concept map made from reading text on resistant starch

Image Supplied by Catherine Morritt

Now you have a go at building a concept map for the topic of excretion.

1. Find the syllabus dot points for this topic.
2. For each syllabus dot point:
    a) Write out the syllabus dot point
    b) Pick out the key terms, or concepts from the syllabus dot point and arrange them on a page.
    c) Draw arrows between the ideas that are related.
    d) Complete a sentence along the arrow to show the relationship between the key words or concepts.
3. When you have finished the concept map you should be able to write a paragraph, or two using it as a guide.

Practice Examination Questions

Year 11 ATAR Human Biology 2020

Topic: The Excretory System

Practice Examination Questions (30 marks)

Answer the Practice Exam questions below to check your understanding.

1. Human red blood cells are placed in pure, distilled water and left for two hours.

a) Describe what would happen to the red blood cells. (2 marks)

_____

_____

_____

b) Explain why this would happen. (2 marks)

_____

_____

_____

2. In a kidney nephron, salt is reabsorbed in the loop of Henle so there is an increased salt concentration in the capillaries around the distal tubule. Describe how water will move between the distal tubule and the surrounding capillaries. (3 marks)

_____

_____

_____

_____

_____

3. There are three processes that occur in the kidney nephron during excretion.
   a) Name the three process that occur in a nephron during excretion.

(3 marks)

_____

_____

_____

   b) For each process that occurs in a nephron during excretion, describe what is happening in terms of the type of materials and their movements.

(9 marks)

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

4. When kidney disease occurs, dialysis is one treatment option.
   Haemodialysis is a method of removing wastes from the blood, using a machine with thousands of very fine tubes immersed in a bath of fluid. The walls of the fine tubes are made of a differentially permeable membrane. The fluid concentration is the same as that of blood, but without the wastes and urea components. Patients usually spend 4 to 5 hours attached to the dialysis machine about three times per week.

   Click this link to view a diagram which shows how kidney dialysis works: https://biology-igcse.weebly.com/uploads/1/5/0/7/15070316/7701856.jpg?647

Use the information, the diagram above and your knowledge of kidney structure and function to answer the following questions.

a) Complete the table with the corresponding parts of the kidney. (4 marks)

Parts of the haemodialysis machine	Parts of the Kidney
Fine tubes	
Dialysis fluid	
Tube for arterial blood	
Tube for venous blood	

b) Name the type of transport by which toxins and wastes move across the differentially permeable membrane in the haemodialysis machine. (1 mark)

_____

_____

c) Name the type of transport by which water moves across the differentially permeable membrane in the haemodialysis machine. (2 marks)

_____

_____

d) Predict what would happen to large plasma protein molecules in the blood in the haemodialysis machine. Justify the answer. (2 marks)

_____

_____

_____

_____

Practice Examination Questions Answer Key

Use the answer key below to mark your responses. Clarify areas where you had difficulty by revising or discussing with your teacher.

1. Human red blood cells are placed in pure, distilled water and left for two hours.

a) Describe what would happen to the red blood cells. (2 marks)

Description	Mark
Red blood cells would increase in volume.	1
until they burst.	1
Total	2

b) Explain why this would happen. (2 marks)

Description	Mark
Process is called osmosis	1
Water tends to moves from a region of low solute concentration to a region of high solute concentration	1
Until a new equilibrium s reached	1
This pressure is too great for the plasma membrane to hold	1
Total	4

2. In a kidney nephron, salt is reabsorbed in the loop of Henle so there is an increased salt concentration in the capillaries around the distal tubule. Describe how water will move between the distal tubule and the surrounding capillaries. (3 marks)

Description	Mark
Salt concentration is higher in capillaries than in the distal tubule	1
Therefore there is a net movement of water	1
Along the concentration gradient	1
Total	3

3. There are three processes that occur in the kidney nephron during excretion.

a) Name the three process that occur in a nephron during excretion.

(3 marks)

Description	Mark
• filtration	1
• selective reabsorption	1
• secretion	1
Total	3

b) For each process that occurs in a nephron during excretion, describe what is happening in terms of the type of materials and their movements.

(9 marks)

Description	Mark
Filtration – water, dissolved salts and other small molecules like glucose move from the capillary to the cortex	1 1 1
Selective reabsorption – water, ions, amino acids, vitamins (any two) Some (glucose, amino acids, NaCl) move by active transport, water moves by osmosis move from the proximal, distal tubules and loop of Henle to medulla	1 1 1
Secretion – adds some substances such as H^+ NH_4^+ ions to the filtrate Maintains pH of blood and urine Move from proximal, distal tubules	1 1 1
Total	9

4. When kidney disease occurs, dialysis is one treatment option.
Haemodialysis is a method of removing wastes from the blood, using a machine with thousands of very fine tubes immersed in a bath of fluid. The walls of the fine tubes are made of a differentially permeable membrane. The fluid concentration is the same as that of blood, but without the wastes and urea components. Patients usually spend 4 to 5 hours attached to the dialysis machine about three times per week.

Click this link to view a diagram which shows how kidney dialysis works: https://biology-igcse.weebly.com/uploads/1/5/0/7/15070316/7701856.jpg?647

Use the information, the diagram above and your knowledge of kidney structure and function to answer the following questions.

a) Complete the table with the corresponding parts of the kidney. (4 marks)

Parts of the haemodialysis machine	Kidney parts	Mark
Fine tubes	Tubules, (proximal, distal loop of Henle)	1
Dialysis fluid	Cortex, medulla, or collecting tubule	1
Tube for arterial blood	Renal artery	1
Tube for venous blood	Renal vein	1
	Total	4

b) Name the type of transport by which toxins and wastes move across the differentially permeable membrane in the haemodialysis machine. (1 mark)

Description	Mark
• diffusion	1 mark
Total	1 mark

c) Name the type transport by which water moves across the differentially permeable membrane in the haemodialysis machine. (2 marks)

Description	Mark
• Osmosis	1 mark
• Ultrafiltration	1 mark
Total	2 marks

d) Predict what would happen to large plasma protein molecules in the blood in the haemodialysis machine. Justify the answer. (2 marks)

Description	Mark
• large plasma protein molecules in the blood would tend to stay in the blood	1 mark
• large plasma protein molecules are too large to move through the pores of the differentially permeable membrane	1 mark
Total	2 marks