Transport around the body

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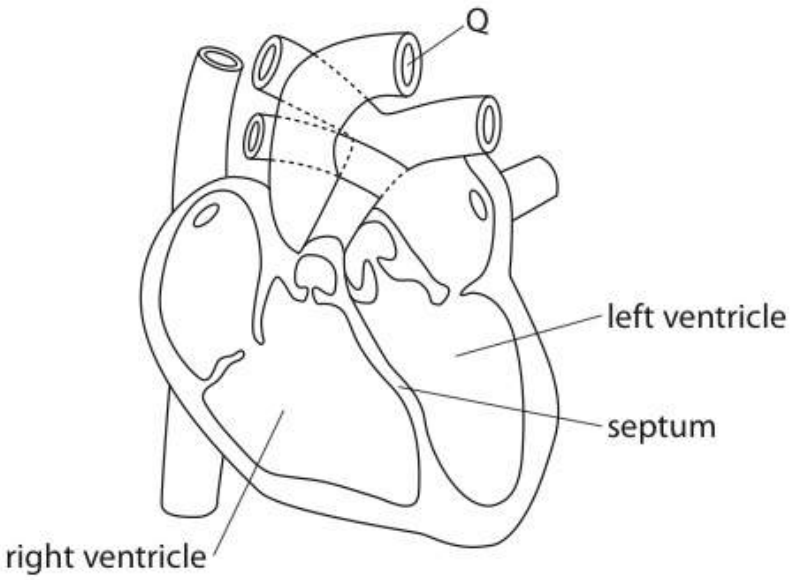
1 The heart is part of the mammalian circulatory system.

The diagram below shows a section through the human heart.



(a) Put a cross ☒ in the box that completes the following statement.
The blood vessel labelled Q in the diagram is the

(1)

- ☒ **A** aorta
- ☒ **B** coronary artery
- ☒ **C** pulmonary vein
- ☒ **D** vena cava

(b) Explain how the structure of a capillary is related to its function.

(2)

Capillaries

Function: Delivery of oxygen & nutrients & removal of CO_2 & Waste products by **diffusion**

Structure & adaptations:

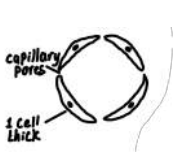
Very thin wall (1 cell thick – endothelium only): to shorten diffusion distance

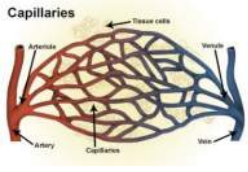
Has capillary pores: to facilitate exchange of substances in the plasma.

Large Surface Area (network of capillaries): faster rate of diffusion (more oxygen and glucose in plasma able to leave)

Small diameter (so branch between cells): Ensures all surrounding cells are near a capillary for efficient exchange + Blood travels slowly through them, giving more time for diffusion to occur

Pressure: Higher than veins but lower than arteries.





QWC

*(c) Describe the role of the heart valves in the cardiac cycle. (6)

Atrioventricular (AV) valves are situated between the atria and the ventricles. During diastole, they open to allow the ventricles to fill with blood. They also remain open during atrial systole (AS), enabling the flow of blood from the atria into the ventricles. However, during ventricular systole (VS), the AV valves close to prevent the backflow of blood into the atria.

Semilunar (SL) valves are located at the base of the major arteries (the aorta and pulmonary artery). These valves open during ventricular systole to allow blood to be ejected from the ventricles into the arteries. They remain closed during atrial systole and diastole to prevent the backflow of blood into the ventricles.

Q) Describe the role of valves in the Cardiac cycle. [6]

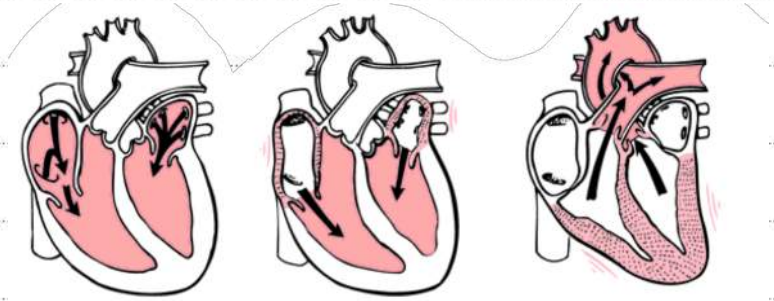
{ location
condition in each phase with expl.

AV Valves:

- AV valves are located between atria & ventricles
- They are open during diastole to allow for Ventricular filling
- They are open during AS to allow blood flow from Atria into Ventricles.
- They are closed during VS to prevent back flow of blood into atria.

SL Valves:

- SL valves are located at the base of major arteries.
- They are open during VS to allow blood flow from Ventricles into major arteries.
- They are closed during AS & diastole to prevent back flow of blood into ventricles.



(d) A small number of babies are born with a hole in the septum that separates the left and right ventricles. If the hole is not repaired these babies may not survive.

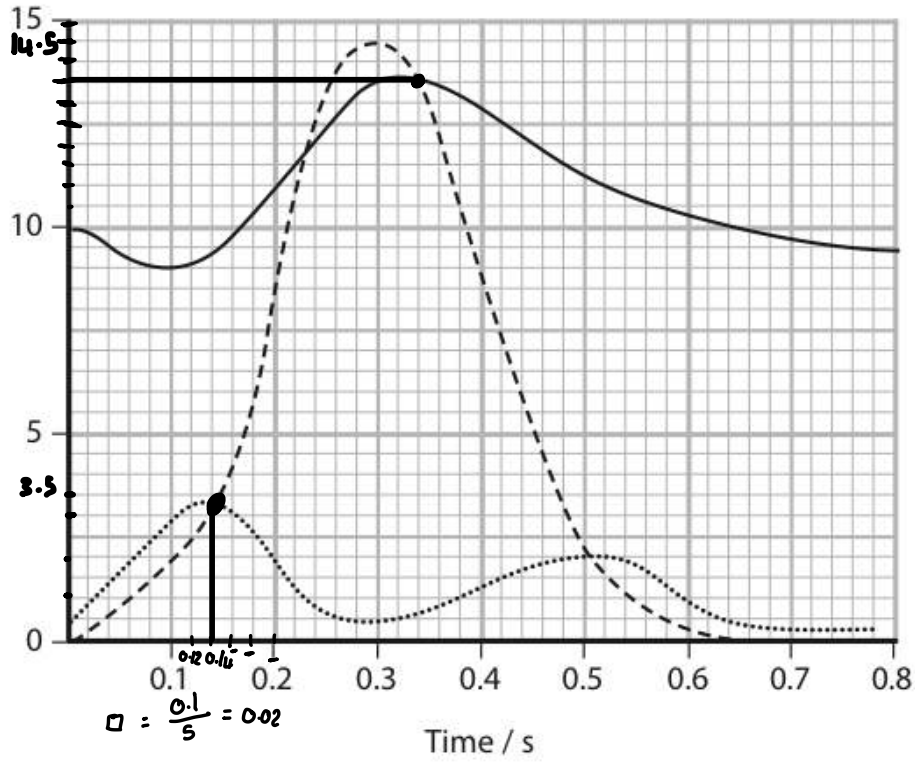
Suggest why these babies may not survive. (2)

- Mixing of oxygenated & deoxygenated blood occurs
- So blood pumped through the aorta has a lower oxygen concentration / ↓ O_2 delivered to the body / blood pumped to lungs has a higher O_2 conc] → less steep conc. gradient for gas exchange
- ↓ aer. resp → ↓ energy released → ↓ growth
- ⊕ Less blood pumped around the body (↓c.o) → so lower BP

2 During the cardiac cycle, muscles in the walls of the atria and ventricles contract and relax.

The graph below shows the changes in pressure that occur in the left side of the mammalian heart during one cardiac cycle.

□ : 5/10 = 0.5



□ : 0.1/5 = 0.02

How to describe a graph
1 General Trend
2. Pattern
3. D.M

(a) Use the graph to identify the following.

(i) The time at which the bicuspid (left atrioventricular) valve closes.

(1)

0.14 seconds

(ii) The pressure in the aorta when the semilunar (aortic) valve closes.

(1)

13.5 kPa

(b) Using the information in the graph, describe the pressure changes that take place in the left ventricle during each stage of this cardiac cycle.

(3)

1. pressure increases from 0 to 3.3 during {atrial systole / ventricular diastole / from 0 to 0.14s / eq} ;	1. ACCEPT between 3 and 3.5, to 0.12 to 0.14s
2. pressure increases to {14.5 / 14.4} {during ventricular systole / from 0.14s / eq};	2. ACCEPT calculated increase e.g. 11.2 (range 11 to 11.5), from 0.12s
3. pressure decreases to 0 (during diastole) / eq ;	3. ACCEPT calculated decrease e.g. 14.5 (range 14 to 14.5)

*(c) During this cardiac cycle, the changes in pressure that occur in the left atrium and in the left ventricle are different.

Using the information in the graph and your own knowledge, explain these differences.

(5)

(QWC – spelling of technical terms must be correct and the answer must be organised in a logical sequence)

D + E

Pressure in both the atria & the ventricles increase then decrease. The ventricle reach higher pressure compared to the atrium / Pressure changes in the atrium is smaller by 11.5

This occurs as the atrium has less cardiac muscles than the ventricle since the atrium doesn't have to push the blood as far as the ventricle has to

The increase in pressure happens in the atrium before the ventricle. as AS has to occur before VS to fill the ventricles with blood

Increase in atrial pressure causes increase in the volume/pressure in ventricles.

3 (a) The release of thromboplastin starts the blood clotting process.

For each of the statements below, put a cross ☒ in the box next to the correct answer.

(i) Thromboplastin is released from

(1)

- ☒ **A** muscle cells
- ☒ **B** platelets
- ☒ **C** red blood cells
- ☒ **D** white blood cells

(ii) Thromboplastin is a

(1)

- ☒ **A** carbohydrate
- ☒ **B** lipid
- ☒ **C** nucleic acid
- ☒ **D** protein

(iii) Thromboplastin converts

(1)

- ☒ **A** fibrin into fibrinogen
- ☒ **B** fibrinogen into fibrin
- ☒ **C** prothrombin into thrombin
- ☒ **D** thrombin into prothrombin

(b) Heparin is a chemical that affects blood clotting time.

The table below shows the effect of heparin concentration on blood clotting time.

G. Trend

Pattern

D. M

Heparin concentration / arbitrary units	Blood clotting time / seconds
0.0	30.1
0.5	30.1
1.0	29.6
1.5	28.8
2.0	27.3
3.0	39.4
4.0	186.8

(i) Using the information in the table, describe the effect of heparin concentration on blood clotting time.

(3)

- As heparin concetration increases, blood clotting time decreases then increases again / Overall increase in clotting time as heparin concentration increases
- … clotting time starts to decrease at heparin concentration above 0.5
- … & decreases up to 2 a.u
- … the clotting time increases again after 2 au
- Overall increase is 520%

4 Ehlers-Danlos syndrome (EDS) is an inherited disorder caused by a mutation.

In EDS, the structure of collagen may be altered or less collagen is produced. Collagen is a fibrous protein.

(c) One problem associated with EDS is a weakening of the structure of the arteries. This may cause arteries to rupture (burst).

Suggest why an alteration in the structure of collagen, or less collagen being produced, could cause arteries to rupture.

(3)

- As the walls of artries contains collagen ✓
- to withstand the high blood pressure in the artries ✓
- ↓collagen → weaker artery wall ✓→ ruptures from the high BP

5 Pulmonary thrombosis is a condition in which blood clots form in the lungs.

(a) Put a cross ☒ in the box that completes each of the following statements.

(i) The role of thrombin in blood clotting is to

(1)

☐ **A** stimulate the release of prothrombin from platelets

☒ **B** catalyse the conversion of fibrinogen to fibrin

☐ **C** stimulate the release of thromboplastin from platelets

☐ **D** catalyse the conversion of fibrin to fibrinogen

(ii) The ion required in the conversion of prothrombin to thrombin is

(1)

☒ **A** calcium

☐ **B** chloride

☐ **C** potassium

☐ **D** sodium

(iii) Blood clots form only when required because the clotting factors used are

(1)

☐ **A** pre-synthesised in an active form in the blood

☒ **B** present in an inactive form in the blood

☐ **C** synthesised in an active form when required

☐ **D** synthesised in an inactive form when required

6 Many animals have a heart and circulatory system.

(a) Explain why animals need a heart and circulatory system.

(4)

- **The heart acts as a pump generating high pressure to move blood towards areas of low pressure over a long distance**
- **This movement is known as mass flow (all substances within the blood (e.g. oxygen, glucose) move together in one direction due to a pressure gradient) & it maintains steep concentration gradient**
- **This helps to overcome limitations of diffusion**

Q) Adaptations of Small Organisms to Survive Without Circulation:

- Large Surface area to Volume ratio
- Short distance of diffusion
- Steep concentration gradient
- Low energy (nutrient/oxygen) requirements (low metabolic rate)

So there are no limitations of diffusion (diffusion is sufficient to supply the oxygen & the nutrients)

Question Number	Answer	Additional Guidance	Mark
6(a)	1. idea that animals have a small surface area to volume ratio ; 2. idea that diffusion alone is not sufficient ; 3. heart needed to {pump / move / eq} blood (around the body) ; 4. reference to mass flow ; 5. transport of {a named molecule / heat} ; 6. idea that animals have a high metabolic rate ;	**ALLOW** low surface area to volume ratio 4. **IGNORE** mass transport 6. **ACCEPT** animals have a high energy demand	(4)

(b) When the human heart contracts, blood from the left ventricle enters the aorta.

Describe how the structure of the aorta is related to its function.

(4)

Adaptations:

- **Thick wall:** to withstand high pressure
- **Narrow lumen:** to maintain high blood pressure
- **No valves in the lumen:** As blood is flowing under high pressure.
- **Tunica intima:**
  - Smooth to reduce friction with moving blood
  - Folded to allow stretching without endothelial damage w artery expands
- **Tunica media:**
  - **Elastic fibers:** allow stretching during ventricular systole prevent blood pressure from getting too high & recoiling dur diastole to prevent blood pressure from getting too low (help maintain blood flow by keeping blood pressure within a narr range.)
  - **Smooth muscles**: for redistribution of blood through vasoconstriction & vasodilation.
- **Tunica adventitia**: Collagen fibers to protect from bursti external traumas.

If aorta:

- **Relatively large lumen** to accommodate the large volume of blood ejected from the left ventricle
- **Has Aortic Semilunar valve** at the origin to prevent back flow of blood during diastole.

(b) The circulatory system is vital for efficient gas exchange in mammals. Explain how the circulatory system in mammals enables efficient gas exchange. *(5)*

1. **The heart acts as a pump generating high pressure to move blood towards areas of low pressure over a long distance**
   - **This movement is known as mass flow (all substances within the blood (e.g. oxygen, glucose) move together in one direction due to a pressure gradient) & it maintains steep concentration gradient** → faster rate of diffusion
3. **- This helps to overcome limitations of diffusion**

Capillaries

2. **Very thin wall (1 cell thick – endothelium only):** to shorten diffusion distance
   Has capillary pores: to facilitate exchange of substances in the plasma.
   Large Surface Area (network of capillaries): faster rate of diffusion (more oxygen and glucose in plasma able to leave)
   Small diameter (so branch between cells): Ensures all surrounding cells are near a capillary for efficient exchange

7 Blood clots can form if the lining of an artery becomes damaged and affected by atherosclerosis.

One cause of a myocardial infarction (heart attack) is a blood clot in a coronary artery that supplies the muscle of the heart with blood.

(a) Read through the following passage about the blood clotting process then write on the dotted lines the most appropriate words to complete the passage.

(3)

The cell fragments called platelets stick to the site of damaged tissue.

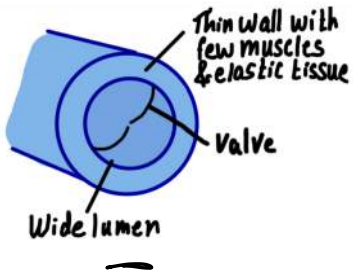
This causes thromboplastin to be released, resulting in Prothrombin being converted into an enzyme. This enzyme catalyses the conversion of a soluble plasma protein into long, insoluble strands of fibrin.

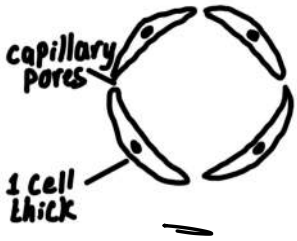
This insoluble protein traps red blood cells to form a clot.

(ii) Give **one** difference between the structure of a capillary and the structure of a vein.

(1)

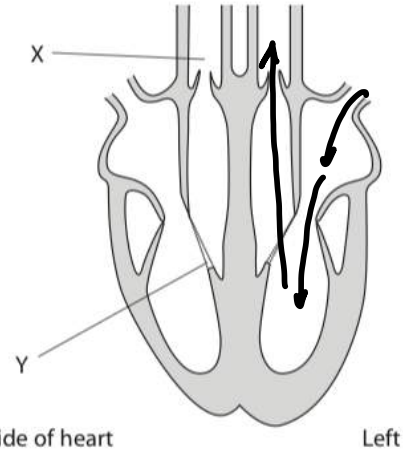
1. capillary wall is one cell thick while vein wall is thicker / eq
2. capillary has no {collagen/ muscle}
3. capillaries do not have valves
4. smaller lumen in capillaries than veins ;





8 The diagram below shows a section of a human heart and its blood vessels.

a) On the diagram, draw arrows to show the flow of blood through the left side of the heart.



b) Put a cross ☒ in the box that completes each of the following statements.

(i) The blood vessel labelled X carries

(1)

- ☒ **A** blood low in oxygen to the heart
- ☒ **B** blood low in oxygen from the heart
- ☒ **C** oxygen rich blood from the heart
- ☒ **D** oxygen rich blood to the heart

(ii) The structure labelled Y

(1)

- ☒ **A** pulls the semilunar valve open
- ☒ **B** pushes the atrioventricular valve closed
- ☒ **C** stops blood flowing from the ventricle to blood vessel X
- ☒ **D** stops the atrioventricular valve opening the wrong way

(c) In mammals, blood passes through the heart twice for each circulation of the body.

Suggest how this type of circulation enables mammals to carry out effective gas exchange.

(3)

Q) Advantages of a double circulation

- To ensure complete **separation of oxygenated blood from deoxygenated blood maintaining a steep concentration gradient** in the lungs (alveoli) and in the tissues (more oxygen carried) for gas exchange
- The **right side pumps deoxygenated blood at a lower pressure to the lungs** to prevent damage of delicate capillaries around alveoli.
- The **left side pumps oxygenated blood at a higher pressure** to ensure delivery of Oxygen & Nutrients to all the tissues over a long distance.**This mass flow helps to overcome the limitations of diffusion**

[5]

9 Thrombophilia can be caused by major surgery. The blood of a person with thrombophilia has an increased tendency to clot.

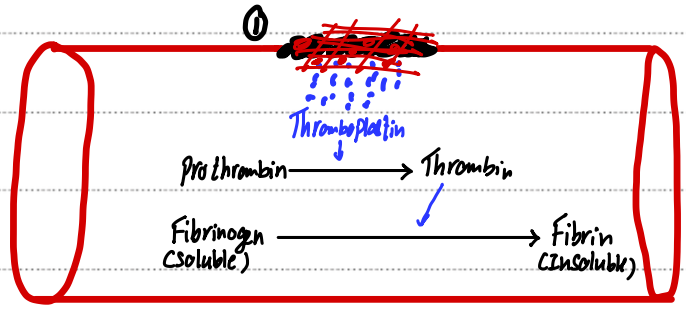
*(a) Suggest how major surgery could cause thrombophilia and why this might be a dangerous complication after surgery.

(5)

1. tissues damaged (during surgery) ;
2. stimulate platelets ;
3. to release thromboplastin ;
4. starting the clotting cascade ;
5. and resulting in the production of blood clots ;
6. blood clots could block blood vessels ;
7. resulting in tissues being deprived of {oxygen / nutrients / blood } ;

Mechanism of blood clotting

- Platelets form a platelet plug which **secretes thromboplastin.**
- Then the **coagulation cascade** goes as follows:
- Thromboplastin **catalyzes the conversion of Prothrombin into Thrombin** (active enzyme).
- Thrombin **converts fibrinogen into fibrin** (insoluble protein).
- Fibrin forms a mesh that **traps red blood cells & platelets** producing a blood clot.
- This coagulation cascade requires both **Calcium ions & Vitamin K**.



(b) Several anticoagulants are available to reduce the risk of thrombophilia in major surgery.

One anticoagulant drug, METHRO II, developed for the treatment of thrombophilia, has been tested on patients.

Each patient was randomly placed in one of four groups receiving a different dose of METHRO II.

Some results from the trial are shown in the table below.

Dose of METHRO II / a.u.	Percentage of patients (%)	
	With serious clotting	With excessive bleeding
1.0	37.8	0.8
1.5	24.1	1.2
2.3	23.7	3.5
3.0	15.1	5.5

(i) Describe the effect of METHRO II on thrombophilia.

(1)

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(i)	increasing the concentration of METHRO II decreases { clotting / thrombophilic events } / negative correlation ;	Accept 'dose' for 'concentration'	**(1)**

(ii) Using the information in the table, suggest why a dose of 1.5 a.u. of METHRO II should be given to patients undergoing major surgery.

(2)

Question Number	Acceptable Answers	Additional Guidance	Mark
7(b)(ii)	1. higher concentrations (of METHRO II) would cause an big increase in the risk of bleeding ; 2. higher concentrations (of METHRO II) would cause a relatively small decrease in the risk of clotting ; 3. credit appropriate use of data ;	Accept: 'a compromise dose' if neither MP1 or MP2 awarded. Comparison of increase in bleeding with decrease in clotting when dose is increased from 1.5 to 2.3 a.u. **or** Comparison of decrease in bleeding with increase in clotting when dose is decreased from 1.5 to 1 a.u.	**(2)**

10 Cigarette smoke contains substances that increase the risk of the formation of blood clots and of developing cardiovascular disease (CVD).

(a) For each of the statements below, put a cross ☒ in the box that corresponds to the correct statement.

(i) Blood clotting is needed to reduce

(1)

☐ **A** atherosclerosis

☐ **B** blood pressure

☒ **C** infection

☐ **D** obesity

(ii) Platelets are

(1)

☐ **A** antibodies

☐ **B** antioxidants

☒ **C** cell fragments

☐ **D** enzymes

(iii) Fibrin is

(1)

☐ **A** a soluble protein

☐ **B** an amino acid

☐ **C** an enzyme

☒ **D** an insoluble protein

(iv) Thrombin is

(1)

☐ **A** a cell fragment

☐ **B** a fibrous protein

☒ **C** an enzyme

☐ **D** an organelle

11 During the cardiac cycle, muscles in the atria and ventricles contract and relax.

(a) The table below shows the pressures in the aorta, left atrium and left ventricle at three different times, **P**, **Q** and **R**, in the cardiac cycle.

Time in the cardiac cycle	Pressure / kPa		
	Aorta	Left atrium	Left ventricle
P	9.0	4.0	2.5
Q	10	0.5	0
R	12.5	0.5	12.5

AS
D
VS

(i) Put a cross (☒) in the box to complete the following sentence.

At time **Q**, the heart is

(1)

☐ **A** hypertensive

☐ **B** in atrial systole

☒ **C** in diastole

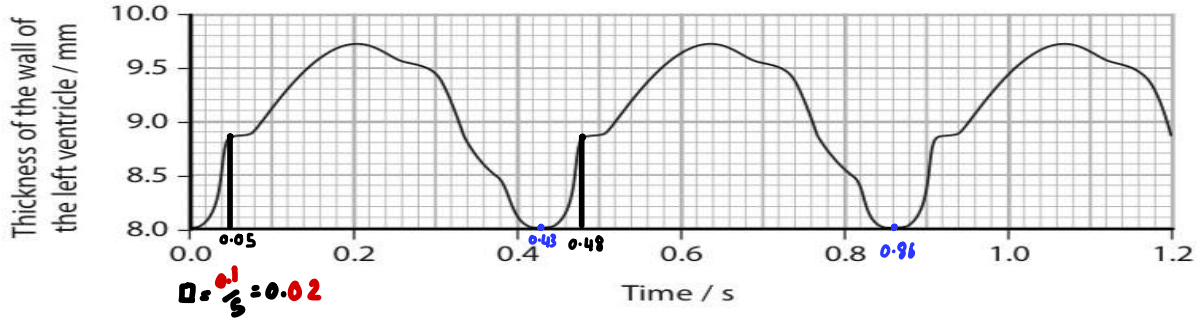
☐ **D** in ventricular systole

(ii) Put a cross (☒) in the box next to the row in the table that correctly describes the heart valves at time **P**.

(1)

		Atrioventricular valves	Semilunar valves
☐	**A**	Closed	Closed
☐	**B**	Closed	Open
☒	**C**	Open	Closed
☐	**D**	Open	Open

(b) The graph below shows the change in thickness of the wall of the left ventricle during the cardiac cycle.



$\square = \frac{0.1}{5} = 0.02$

(i) Using the information in the graph, calculate the heart rate in beats per minute.

Show your working.

(2)

$0.48 - 0.05 = 0.43$

$0.86 - 0.43 = 0.43$

$HR = \frac{60}{0.43}$

Answer 12 1L bpm

(ii) Name the blood vessel through which blood leaves the left ventricle.

(1)

Aorta

12 Blood loss from damaged vessels is reduced by the clotting process.

(a) Name the factor released by platelets that initiates the clotting process.

(1)

Thromboplastin

(b) When blood is stored, it is mixed with EDTA.

EDTA binds strongly to calcium ions.

Suggest why EDTA is added to blood before storage.

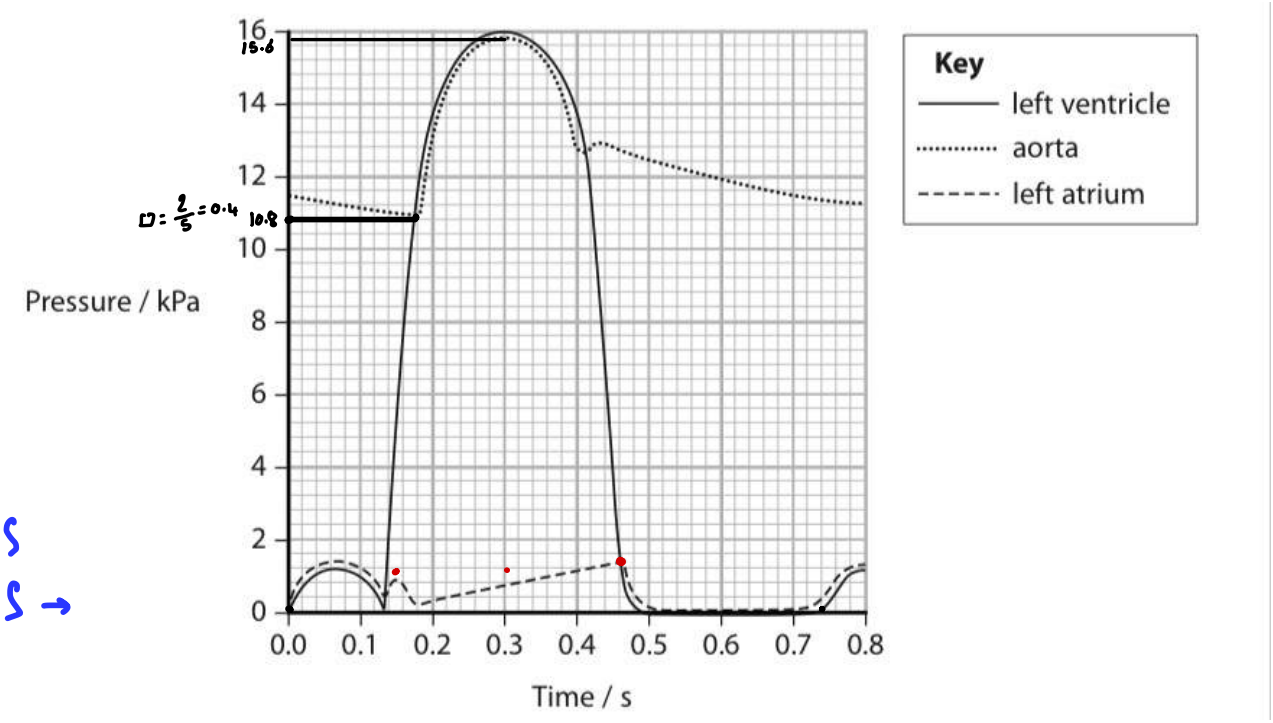
(2)

1. EDTA {stops/reduces/eq} clotting of (stored) blood ;	
2. credit detail of role of calcium ions in blood clotting ;	**2 e.g.** involved in conversion of prothrombin to thrombin / involved in formation of (insoluble) fibrin / aids formation of prothrombin activator

prothrombin $\xrightarrow{\text{Thromboplastin (or)}}$ Thrombin

13 The cardiac cycle describes the sequence of events taking place in the heart to bring about changes in blood pressure.

(a) The graph below shows the changes in blood pressure in the aorta, left ventricle and left atrium.



D
AS
VS →

(i) Using the information in the graph, calculate the heart rate.

Show your working.

(2)

Time for 1 cardiac cycle = 0.74s

$HR = \frac{60}{0.74} = 81.08$

81.08 beats per minute

(ii) Using the information in the graph, calculate the maximum change in pressure in the aorta.

Max - Min

(1)

15.6 - 10.8

4.8 kPa

4.8 - 5.1

(iii) Using the information in the graph, state the time at which the atrioventricular valve closes.

(1)

0.14

(b) Explain the pressure changes in the left atrium between 0.0 s and 0.1 s.

(2)

- Pressure inc.
→ as atrium contracts (ASI)
- then pressure decreases
→ as blood flows from atrium to ventricle / atrial diastole

(c) The maximum pressure in the right ventricle is lower than the maximum pressure in the left ventricle.

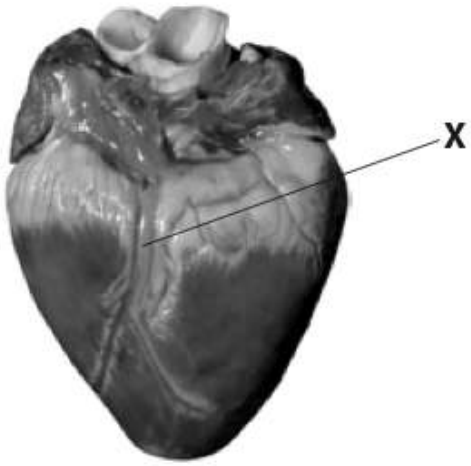
Explain the importance of this pressure difference.

(2)

Q) Explain the difference in pressure between the left ventricle and right ventricle .

- The right ventricle pumps blood at lower pressure to the lungs (shorter distance) to avoid damaging the delicate capillaries around the alveoli.
- It has a thinner muscular wall so it contracts with less force.
- The left ventricle pumps blood at a higher pressure to the entire body over a longer distance.
- It has a thicker muscular wall to generate stronger contractions.

14 The photograph shows a mammalian heart.



The blood vessel labelled **X** is a branch from the aorta.

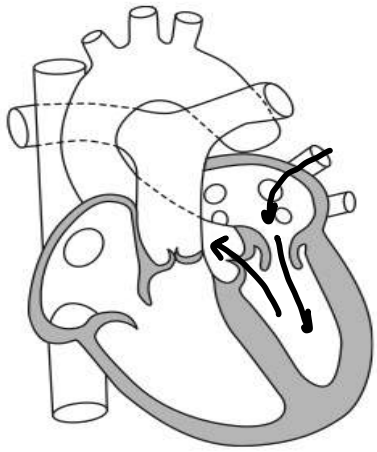
The aorta is one of the major blood vessels of the heart.

(a) Explain why it is important that blood vessel **X** branches directly from the aorta.

(3)

- To receive blood that have the highest oxygen level (& pressure)
- … this allows the heart muscle to be supplied efficiently with oxygenated blood
- … for aerobic respiration releasing energy required for contraction
- .. so the heart can pump blood to the whole body

(b) The diagram shows the internal structure of a mammalian heart.



(i) Explain which stage of the cardiac cycle is shown in this diagram.

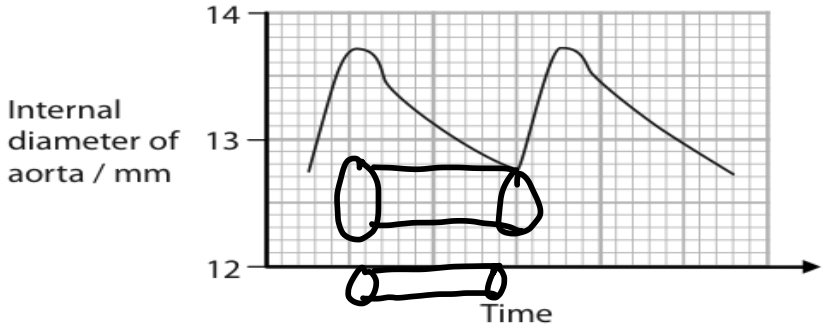
(2)

• diastole / atrial systole / ventricular diastole (1)	
• because the {atrioventricular / AV / bicuspid / tricuspid} valves are open (1)	**ACCEPT** semi lunar valves are closed

(ii) Draw arrows on the diagram to show the flow of blood through the left side of the heart and into the aorta.

(3)

(c) The graph shows the changes in the internal diameter of the aorta during two cardiac cycles.



Explain the changes in the internal diameter of the aorta.

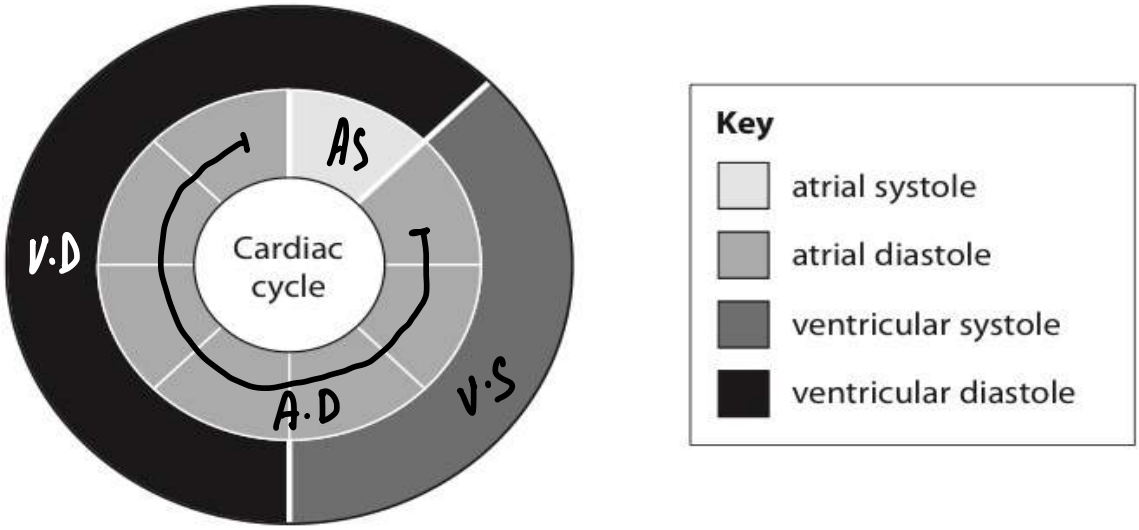
(3)

- ↑ in diameter as the elastic fibers allows stretching during VS as large volume of blood leaves the LV & enters the aorta ✓ (This prevents blood pressure from getting too high)
- ↓ in diameter due to recoiling of elastic fibers during diastole ✓

15 The cardiac cycle is the sequence of events that occurs when the heart beats.

A typical cardiac cycle takes 0.86 seconds.

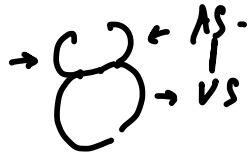
(a) The diagram illustrates the cardiac cycle.



(i) Which row of the table describes the atria and ventricles during atrial systole?

(1)

		Atria	Ventricles
☐	A	contracted	contracted
☒	B	contracted	relaxed
☐	C	relaxed	contracted
☐	D	relaxed	relaxed



(ii) Explain why there is a delay of 0.01 seconds between atrial systole and ventricular systole.

(2)

- Allowing time for complete emptying of the atria into the ventricles
- Time for AV valve to close
- To prevent backflow of blood into the atria

(iii) Using the information in the diagram, calculate the duration of ventricular systole in milliseconds.

Express your answer in standard form.

(2)

. The circle represents 100% of the cardiac cycle

. ... & is split into 8 equal segments

. VS spans 3 segments = 3/8 of the cardiac cycle

. 3/8 x 0.86 = 0.3225 s = 322.5 ms = 3.225×10^2 ms ≃ 3.23×10^2 ms

↳ 2 d.ps / 3 sig figs

Duration of VS: $\frac{\text{Measured angle}}{360^\circ}$ x 0.86 OR

Answer 3.23×10^2 ms

(iv) State what proportion of the cardiac cycle is spent in ventricular diastole.

(1)

5/8 / 0.63 / 63 %

(b) A typical cardiac cycle takes 0.86 seconds.

During exercise, the heart rate increases and the duration of the cardiac cycle decreases.

Calculate the increase in heart rate if the cardiac cycle decreases by 0.4 seconds.

(3)

HR at rest = $\frac{60}{0.86}$ = 69.77

dur. of 1 cycle during exercise = 0.46 s

HR during exercise = $\frac{60}{0.46}$ = 130.43

↑ = 130.43 - 69.77 = 60.66 ≃ 61 bpm

Answer 60 - 61 beats per minute

↑HR ↑SV VS

Q) Describe how the events of the cardiac cycle change during exercise.

During exercise, the demand of body cells for oxygen increases

So the cardiac cycle becomes faster / shorter / complete more frequently (Higher Heart rate)

During ventricular systole, ventricles contract more forcefully (Higher stroke volume)

This leads to higher cardiac output to ensure more oxygenated blood reaches the tissues

M. Rafat

16 Many animals have hearts that pump blood through a network of blood vessels.

(a) The table below refers to blood flow in the four major blood vessels of the human heart. If the statement is correct, place a tick (✓) in the appropriate box and if the statement is incorrect, place a cross (✗) in the appropriate box.

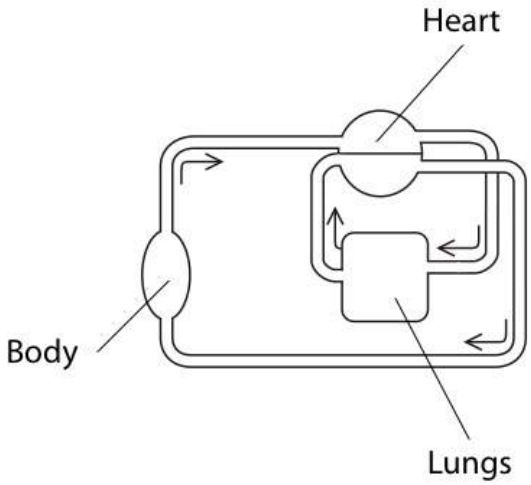
(4)

Name of blood vessel	Carries blood away from the heart	Carries oxygenated blood
Aorta	✓	✓
Vena cava	✗	✗
Pulmonary artery	✓	✗
Pulmonary vein	✗	✓

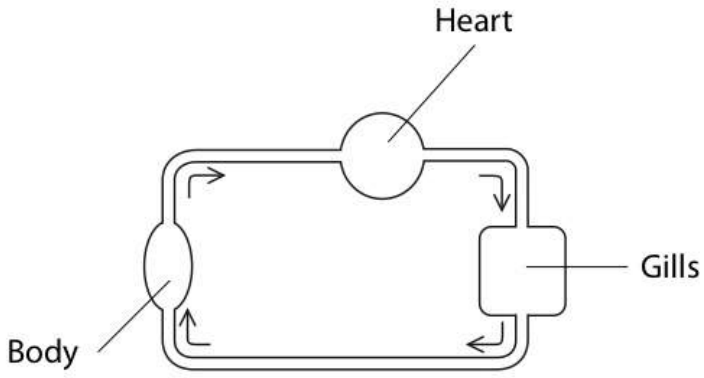
(b) Humans and fish are both animals that have a heart and a network of blood vessels. However, there are some differences in their circulatory systems.

The diagrams below illustrate a human circulatory system and the circulatory system in a fish.

Human circulatory system



Fish circulatory system



The arrows show the direction of blood flow.

(i) Using the information in the diagram, describe the circulation of blood in a fish.

(3)

1. (blood flows) from heart to gills ;
2. (blood flows) from gills to (rest of) body / eq ;
3. (blood flows) from body back to heart ;
4. ref to single circulation ;

(ii) Using the information in both diagrams, suggest the advantages that the human circulatory system has compared with that of a fish.

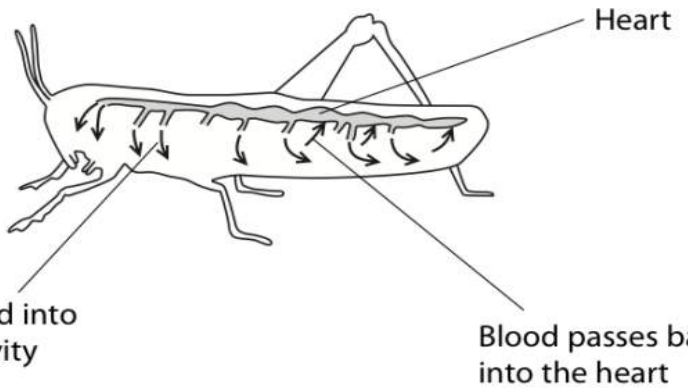
(2)

Q) Advantages of a double circulation

- To ensure complete **separation of oxygenated blood from deoxygenated blood maintaining a steep concentration gradient** in the lungs (alveoli) and in the tissues (more oxygen carried) for gas exchange
- The **right side pumps deoxygenated blood at a lower pressure to the lungs** to prevent damage of delicate capillaries around alveoli.
- The **left side pumps oxygenated blood at a higher pressure** to ensure delivery of Oxygen & Nutrients to all the tissues over a long distance.**This mass flow helps to overcome the limitations of diffusion**

(c) The heart of an insect is a long tube. It pumps blood into the body cavity so that blood surrounds the cells. The blood then passes back into the heart from the body cavity.

The diagram below illustrates the circulatory system of an insect.



Suggest why the insect does not need blood vessels to transport its blood around the body.

(2)

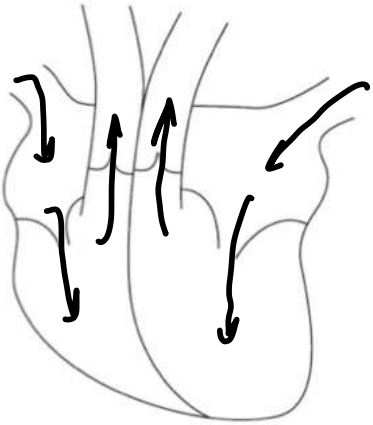
Q) Adaptations of Small Organisms to Survive Without Circulation:

- Large Surface area to Volume ratio
- Short distance of diffusion
- Steep concentration gradient
- Low energy (nutrient/oxygen) requirements (low metabolic rate)

So there are no limitations of diffusion (diffusion is sufficient to supply the oxygen & the nutrients)

17 A mammalian heart has four chambers and valves that control the direction of blood flow.

(a) The diagram below shows a section through a mammalian heart.



Add **arrows** to the diagram to show the direction of blood flow during one complete cardiac cycle. (2)

(b) The table below shows changes in the volume of blood in the left ventricle during one second. The volume is expressed as a percentage of the maximum volume of blood the ventricle can hold.

Time / s	Volume of blood as a percentage of the maximum (%)
0.0	70
0.1	100
0.2	70
0.3	30
0.4	0
0.5	35
0.6	60
0.7	70
0.8	70
0.9	100
1.0	70

AS

VS

Dias

AS

(i) Using the information in the table, state the length of one cardiac cycle.

(1)

0.8 seconds

(ii) Using the information in the table, explain what happened to the semilunar valves between 0.4 and 0.5 seconds.

(2)

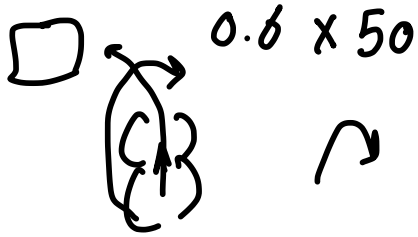
- SL valve closed
- As pressure in the pulmonary artery / aorta is greater than in the ventricle (blood collects in the pockets of the valve closing it)

(iii) The maximum volume of blood in the left ventricle is 50 cm^3.

Calculate the volume of blood in the left ventricle at 0.6 seconds.

Show your working.

(2)



Volume of blood: 30 cm^3

(c) Sandra told her doctor that she often felt breathless and lacked energy. Her doctor listened to her chest with a stethoscope. The doctor heard a sound characteristic of a faulty atrioventricular valve.

Suggest why a faulty atrioventricular valve could lead to Sandra's symptoms of breathlessness and lack of energy. (3)

- AV doesn't close properly
- So during ventricular systole …
- Some blood backflows from ventricle into atrium
- This decreases the oxygenated blood reaching the tissues (lowered BP)
- And increases blood pressure in lungs

18 Many animals, such as mammals, have a heart and circulation. This helps them to meet their requirements by overcoming the limitations of diffusion.

*(a) Describe the structure of the mammalian heart.

(5)

Q) Describe the structure of the heart

Chambers:

4 chambers

2 atria above & 2 ventricles below

The 2 sides of the heart are separated by muscular septum.

The chamber with the thickest wall is the LV

Valves

2 AV valves

Found between atria & ventricles

Tricuspid valve on the Rt. Side

Bicuspid v. on the Lt. side

2 SL valves

Found between the ventricles & the major vessels leaving the heart

Pulmonary Semilunar on the Rt. Side

Aortic Semilunar n the lt. Side

Vessels

Vena cava entering Rt. Atrium

Pulmonary artery exiting Rt. Ventricle

Pulmonary Vein entering Lt. Atrium

Aorta exiting Lt. Ventricle

The heart is supplied by Coronary arteries.

[11]

(b) Giraffes are very tall mammals found roaming the plains of Africa. Two giraffes are shown in the photograph below.

large

Using the information in the photograph and your own knowledge, explain the importance of the heart and circulation to the giraffe.

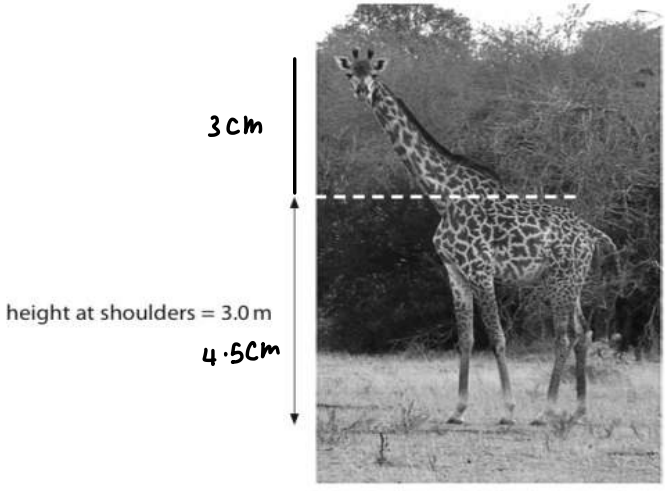
(4)

- Blood has to be pumped a long way against gravity & around the body of a giraffe

- **The heart acts as a pump generating high pressure to move blood towards areas of low pressure over a long distance**
- **This movement is known as mass flow (all substances within the blood (e.g. oxygen, glucose) move together in one direction due to a pressure gradient) & it maintains steep concentration gradient**
- **This helps to overcome limitations of diffusion**

[3]

19 The photograph shows an adult giraffe.



(a) Estimate the length of the neck of this giraffe from the shoulders, using the information in the photograph.

(1)

I : A

e.g: 4.5 cm : 3.0 m

3 cm : x

$x = \frac{3 \times 3}{4.5}$

Answer 2 m

1.3 - 2.4

(b) The heart of an adult giraffe can be 60 cm long.

Explain why the heart of a giraffe needs to be so large.

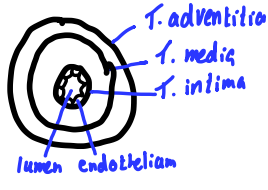
(2)

- To generate high pressure to be able to pump the blood against gravity to the upper parts of the body
- So that blood can reach the its head/brain

(c) The arteries near the heart of a giraffe are highly elastic.

(i) Draw a labelled diagram of an artery, as seen in section.

(3)



(ii) Explain why the arteries near the heart of a giraffe are highly elastic.

(2)

- **Elastic fibers**: allow stretching during ventricular systole to prevent blood pressure from getting too high & recoiling during diastole to prevent blood pressure from getting too low (helps maintain blood flow by keeping blood pressure within a narrow range.)

(d) Damage to the legs of the giraffe could result in excessive bleeding.

To prevent excessive bleeding, the capillaries near the surface of the skin are very narrow.

(i) Explain why very narrow capillaries prevent excessive bleeding.

(2)

- Less blood flowing near the surface of the skin
- Less blood lost while the clot is forming

(ii) The red blood cells of the giraffe are about one third the size of human red blood cells, so that they can pass through the very narrow capillaries.

The small size of the red blood cells ensures that the legs of the giraffe have a good supply of oxygen.

Explain why smaller red blood cells increase the supply of oxygen to the legs.

When sizes are mentioned → SA

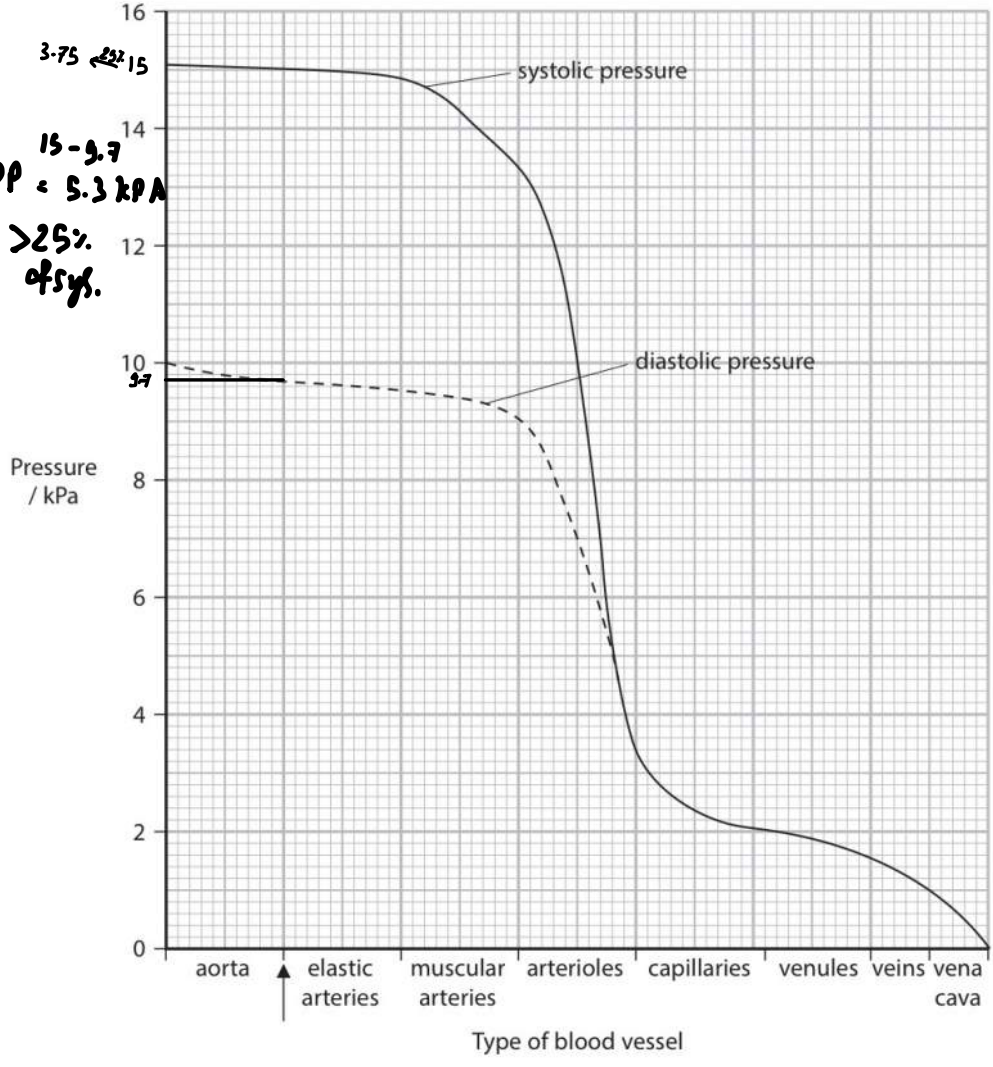
(2)

- because (the smaller red blood cells will have) a greater surface area (1)
- and therefore oxygen will be able to **diffuse** (into / out of the RBCs) faster (1)

20 Blood flow and blood pressure are affected by a number of factors.

Abnormal blood flow and abnormal blood pressure affect the health of a person.

(a) The graph shows the systolic pressure and the diastolic pressure as blood flows through human blood vessels.



(i) Pulse pressure is the difference between systolic pressure and diastolic pressure.

In a healthy person, pulse pressure should be at least 25% of the systolic pressure.

Determine whether this person is healthy, using the point indicated by the arrow on the *x*-axis of the graph.

(2)

- difference between systolic and diastolic pressure is 5.3 (kPa) (1)
- person is healthy (because pulse pressure is greater than 3.75 kPa) (1)

(ii) The mean arterial pressure (MAP) can be approximated using the formula

$$\text{MAP} = \text{diastolic blood pressure} + \frac{(\text{systolic blood pressure} - \text{diastolic blood pressure})}{3}$$

Estimate the MAP in the elastic arteries for this person.

(2)

$$9.7 + \frac{5.3}{3} = 11.5$$

Answer 11.5 kPa

(iii) If the mean arterial pressure (MAP) value is less than 8 kPa, the force pushing the blood through the vessels will be too low.

Explain how a low MAP could affect a person.

(2)

- Less oxygen & glucose deliviered to tissues
- Less aerobic respiration
- Lack of energy / dizziness

(b) Blood flow depends on the change in pressure (ΔP), the radius of the blood vessel lumen (r), the length of the blood vessel (λ) and the viscosity of the blood (η).

Blood flow can be calculated using the formula

$$\text{Blood flow} = \frac{\pi \Delta P r^4}{8 \eta \lambda}$$

Blood flow can also be calculated using the formula

$$\text{Blood flow} = \frac{\Delta P}{\text{resistance}}$$

$$\text{Resistance} = \frac{\Delta P}{\text{blood flow}} = \frac{\Delta P}{\frac{\pi \Delta P r^4}{8 \eta \lambda}} \times 8\eta\lambda = \frac{\Delta P \, 8\eta\lambda}{\pi \Delta P r^4} = \frac{8\eta\lambda}{\pi r^4}$$

(i) Which formula can be used to calculate resistance?

(1)

☐ **A** $\frac{8\eta\lambda}{\pi\Delta Pr^4}$

☐ **B** $\frac{\pi\Delta Pr^4}{8\eta\lambda}$

☐ **C** $\frac{\pi r^4}{8\eta\lambda}$

☒ **D** $\frac{8\eta\lambda}{\pi r^4}$

(ii) A change in which factor has the biggest effect on resistance? "r^4"

(1)

☐ **A** blood pressure

☐ **B** length of the blood vessel

☒ **C** radius of the blood vessel lumen

☐ **D** thickness of the blood vessel wall

(iii) Explain how arteries are adapted to reduce resistance to blood flow.

(2)

- **Tunica intima:**

- Smooth endothelium to reduce friction with moving blood

(c) Blood vessels can expand to accommodate increased blood flow. This is known as compliance.

(i) Explain how arteries are adapted to accommodate sudden increases in blood flow.

(2)

- because elastic fibres (in wall of arteries) can {stretch / expand} (1)
- therefore {widening the lumen / increasing the diameter (of the artery)} (1)
- wall contains collagen to increase the strength (1)

IGNORE recoil

DO NOT ACCEPT recoil

- Classified is for studying

- Checklist < Notes Classified

- Qz

M. Rafat