Transport in Mammals

(Past Year Topical Questions 2010-2015)

May/June 2010 (21)

3 (a) Fig. 3.1 shows a cross-section of the heart at the level of the valves.

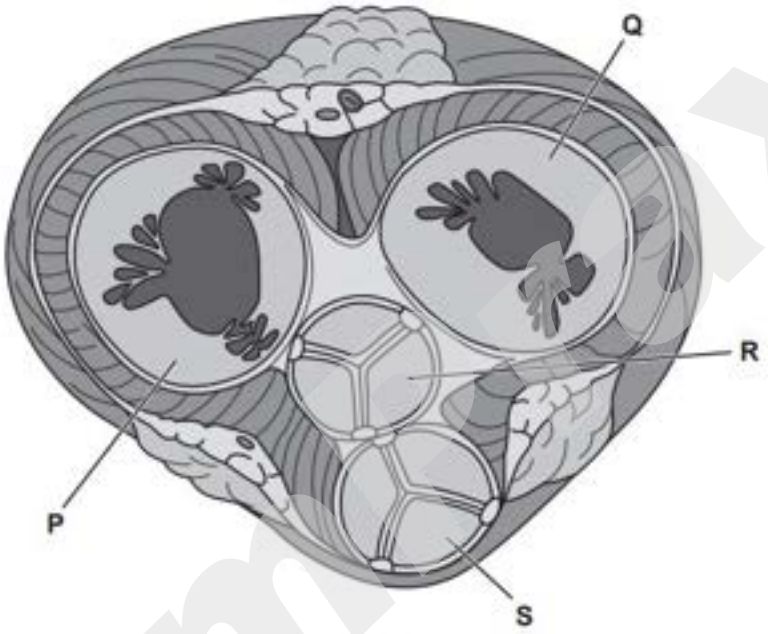

Fig. 3.1

(i) Complete the following flow chart to show the pathway of blood through the heart.

vena cava → right atrium → valve **P** → [ ] → valve **S**

valve **Q** → left ventricle → valve **R** → aorta ← [ ] ← lungs ← pulmonary artery ← left atrium

[2]

(ii) Explain how the valves **P** and **Q** ensure one-way flow of blood through the heart.

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..... [2]

(b) The cardiac cycle describes the events that occur during one heart beat.

Fig. 3.2 shows the changes in blood pressure that occur within the left atrium, left ventricle and aorta during one heart beat.

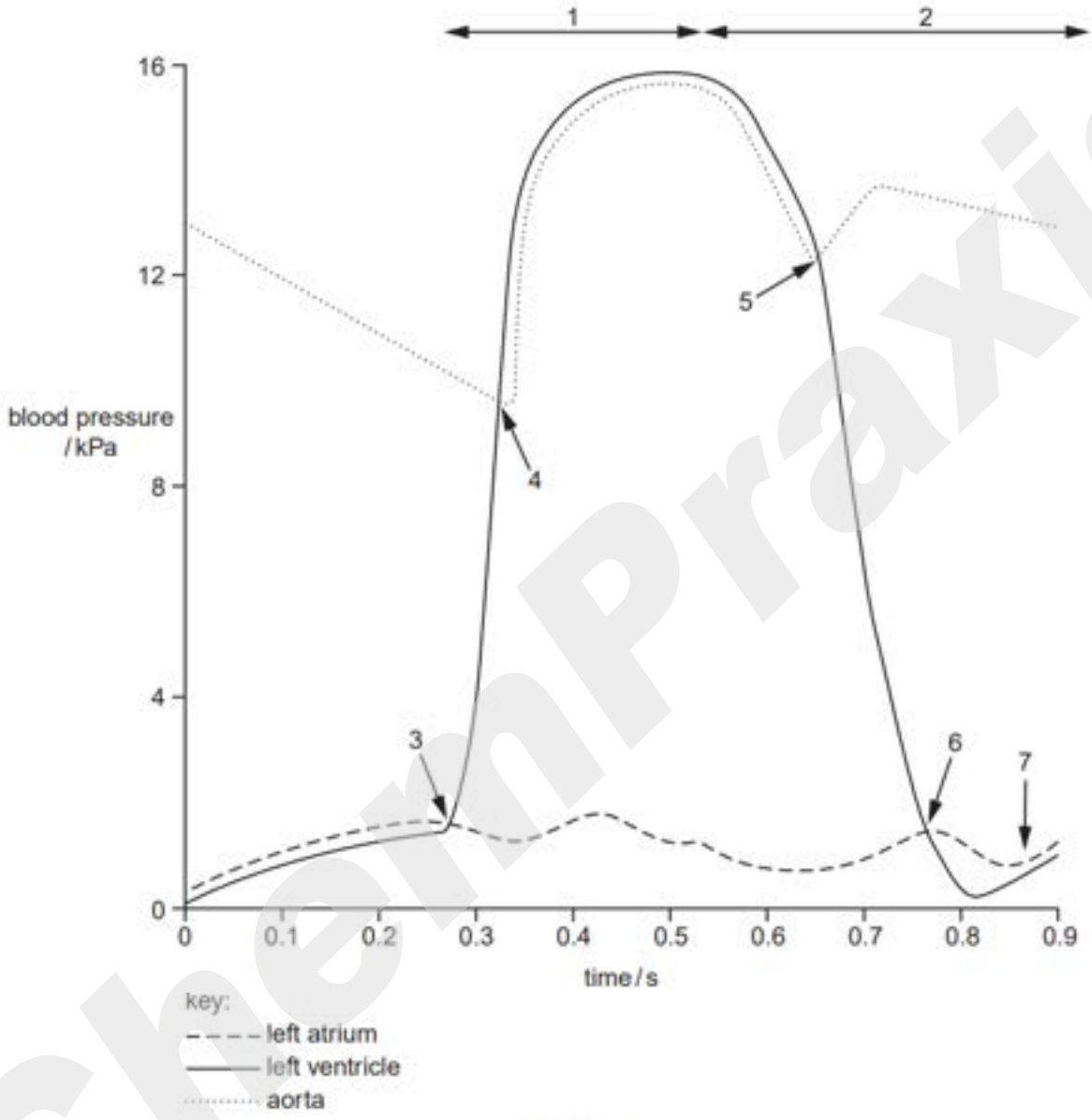

Fig. 3.2

+6018 – 375 2833

In the table below, match up each event during the cardiac cycle with an appropriate number **1** to **7** on Fig. 3.2.

You should put only one number in each box. You may use each number once, more than once or not at all.

The first answer has been completed for you.

event during the cardiac cycle	number
atrioventricular (bicuspid) valve opens	6
ventricular systole	
semilunar (aortic) valve closes	
left ventricle and left atrium both relaxing	
semilunar (aortic) valve opens	

[4]

(c) Explain the roles of the sinoatrial node (SAN), atrioventricular node (AVN) and the Purkyne tissue during one heart beat.

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..... [5]

May/June 2010 (22)

2 Fig. 2.1 is a diagram of a vertical section through a healthy mammalian heart.

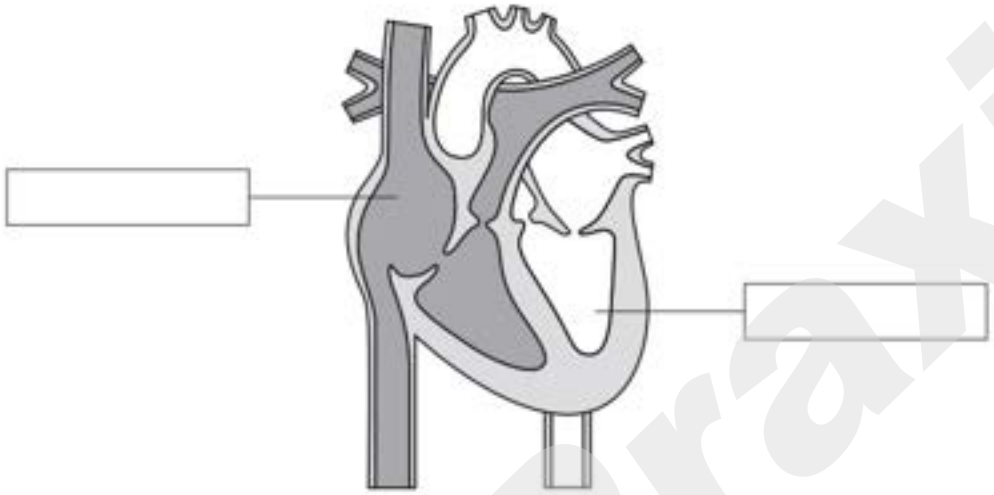

Fig. 2.1

(a) (i) Label the **two** chambers of the heart by writing in the boxes provided on Fig. 2.1. [1]

(ii) State two ways in which the **composition** of blood entering the right atrium is different to blood entering the left atrium.

1. .....

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2. .....

.....[2]

Some people are born with structural defects of the heart and its associated blood vessels. This is known as congenital heart disease. The dotted circles labelled **A** to **G** on Fig. 2.2 show some areas that are affected by different types of congenital heart disease.

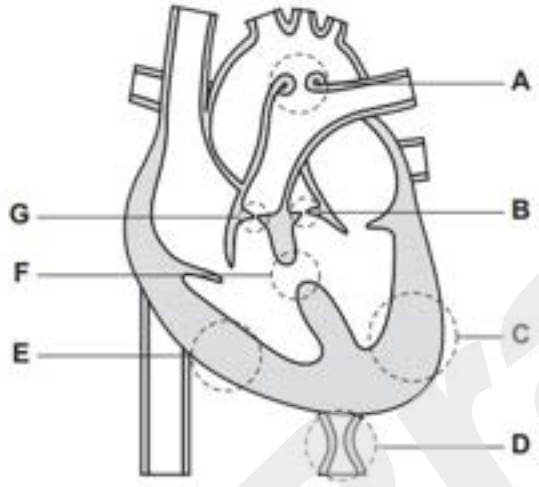

Fig. 2.2

The structural defects causing four types of congenital heart disease are described below:

- **patent ductus arteriosus** – a link between the pulmonary artery and aorta fails to close after birth
- **pulmonary stenosis** – a narrowing of the semilunar valve of the pulmonary artery
- **coarctation of the aorta** – a localised narrowing of the aorta
- **ventricular septal defect** – a hole in the septum between the ventricles.

(b) Match the **one** correct area from **A** to **G** on Fig. 2.2 with each of the congenital heart diseases.

The first one has been completed for you.

patent ductus arteriosus ..... **A** .....

pulmonary stenosis .....

coarctation of the aorta .....

ventricular septal defect ..... [3]

(c) Suggest and explain how the flow of blood in a person with patent ductus arteriosus differs from that of a person with a healthy heart.

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May/June 2010 (23)

2 Fig. 2.1 shows a diagram of a section through a human heart.

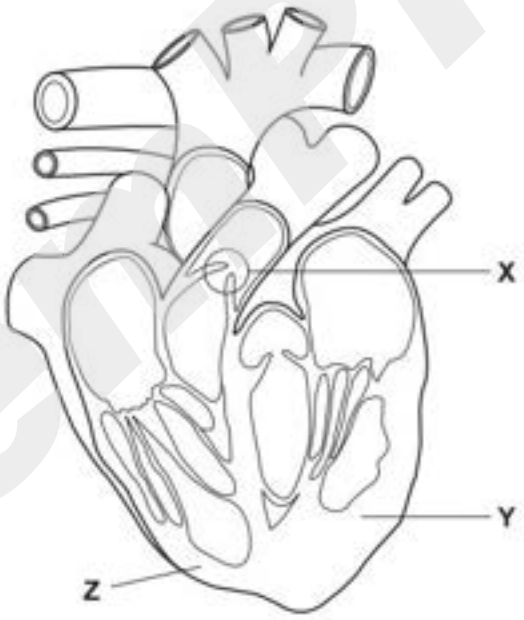

Fig. 2.1

(a) State the name and function of the circled structure labelled **X**.

name .....

function .....

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.....[3]

(b) Explain why the region labelled **Y** is thicker than the region labelled **Z**.

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(c) Cardiac muscle is described as myogenic as it naturally contracts and relaxes. With reference to the structures and tissues within the heart, describe how the cardiac cycle is initiated and coordinated.

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Oct/Nov 2010 (21)/Q3

Red blood cells each contain about 240 million molecules of haemoglobin that transport oxygen and carbon dioxide.

(c) Describe the role of haemoglobin in the **transport** of oxygen and carbon dioxide.

oxygen .....

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carbon dioxide .....

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.....[4]

(d) The haematocrit is the proportion of the blood that is composed of red blood cells. Samples of blood were taken from an athlete who lived at sea level since birth and moved to live and train at an altitude of 5000 m for three weeks. The haematocrit and the number of red blood cells per mm^3 were determined before moving to high altitude and after three weeks at that altitude. The results are shown in Table 3.2.

Table 3.2

altitude	haematocrit	number of red blood cells × 10^6 per mm^3
sea level	0.45	6.1
5000 m (after three weeks)	0.53	7.3

(i) Calculate the percentage increase in the number of red blood cells per mm^3 after three weeks at 5000 m. Show your working.

Answer = ... % [2]

(ii) Explain why the haematocrit increases at altitude.

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.....[3]

May/June 2011 (21)

2 (a) Carbon dioxide is transported in the blood in various forms.

Describe how carbon dioxide molecules reach red blood cells from respiring cells.

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.....[2]

Fig. 2.1 shows part of a capillary network and some cells of the surrounding tissue.

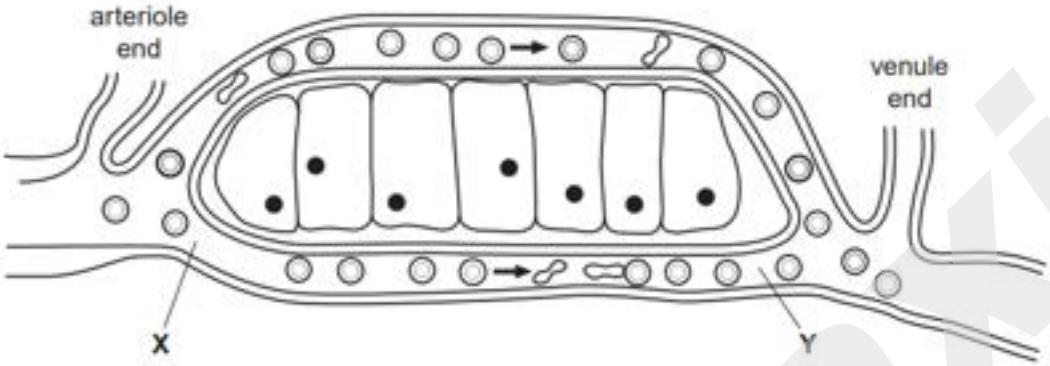

Fig. 2.1

(b) State three ways in which the blood at **Y** differs from the blood at **X** **other than** in the concentration of carbon dioxide.

1. .....

2. .....

3. .....[3]

An enzyme in red blood cells catalyses the reaction between carbon dioxide and water as blood flows through respiring tissues.

$$CO_2 + H_2O \xrightarrow{\text{enzyme}} H_2CO_3 \longrightarrow H^+ + HCO_3^-$$

(c) (i) Name the enzyme that catalyses this reaction.

.....[1]

(ii) Explain the significance of this reaction in the transport of carbon dioxide.

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(d) Fig. 2.2 shows the effect of increasing the carbon dioxide concentration on the oxygen haemoglobin dissociation curve.

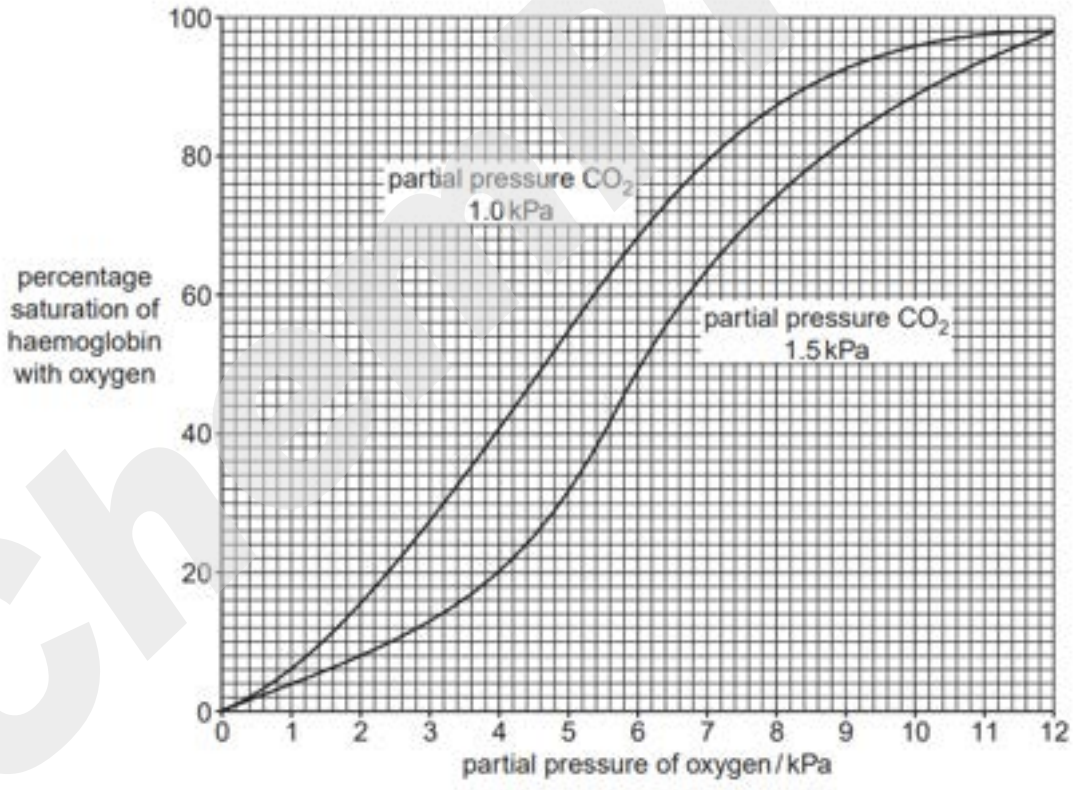

Fig. 2.2

(i) State the percentage saturation of haemoglobin with oxygen at a partial pressure of 5 kPa of oxygen when the partial pressure of carbon dioxide is:

1.0 kPa .....

1.5 kPa .....[1]

(ii) The percentage saturation of haemoglobin with oxygen **decreases** as the partial pressure of carbon dioxide increases.

Explain how this happens.

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.....[2]

(iii) Name the effect of increasing carbon dioxide concentration on the oxygen dissociation curve.

.....[1]

(iv) Explain the importance of the effect of carbon dioxide on haemoglobin as shown in Fig. 2.2.

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.....[3]

May/June 2011 (22)

3 (a) Explain how the structure of red blood cells is suited to their function of transporting oxygen to body tissues.

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.....[3]

Haemoglobin plays an important role in carrying oxygen and carbon dioxide.

Fig. 3.1 summarises some of the events that occur as blood enters a capillary located in an area of actively respiring cells.

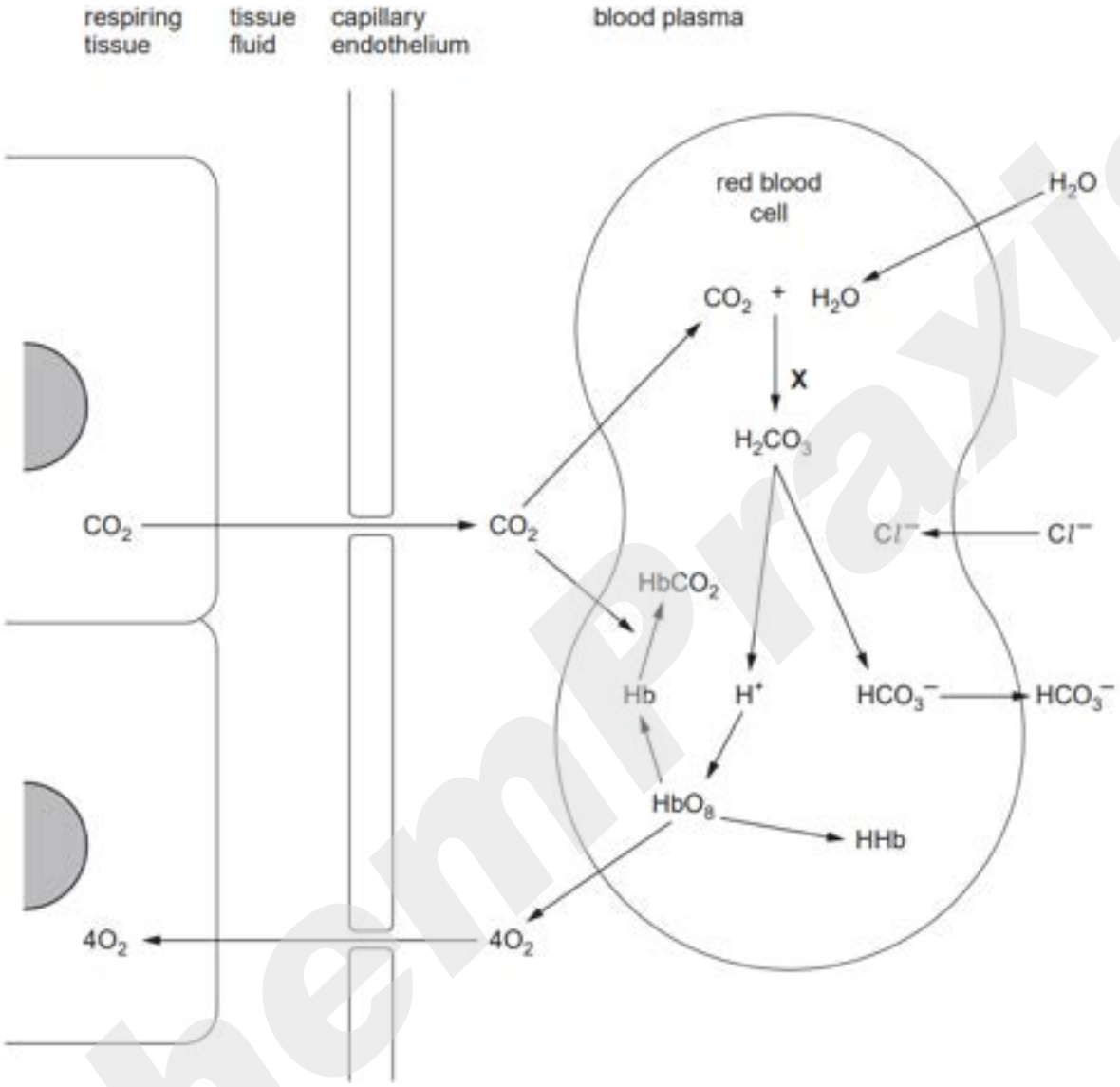

Fig. 3.1

(d) State the name of the enzyme that catalyses the reaction occurring at **X**.

.....[1]

(e) With reference to Fig. 3.1, describe **and** explain how carbon dioxide (CO_2) and hydrogen ions (H^+) play a role in the unloading of oxygen from haemoglobin.

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.....[5]

May/June 2011 (23)

4 In mammals, haemoglobin is used to transport oxygen and myoglobin is used to store oxygen in muscles.

Fig. 4.1 shows the oxygen dissociation curves for myoglobin, fetal haemoglobin and adult haemoglobin.

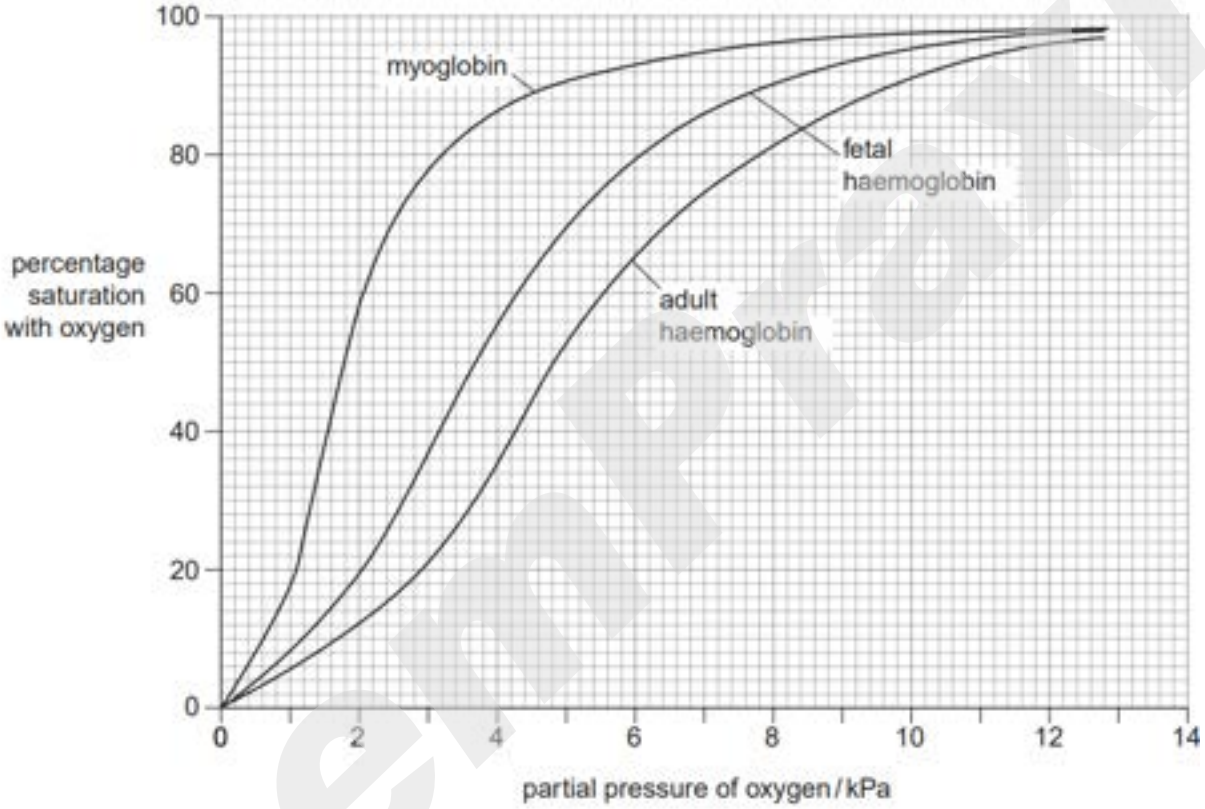

Fig. 4.1

(a) (i) Name the cells in which haemoglobin is found.

..... [1]

(ii) Use Fig. 4.1 to determine the percentage saturation of **myoglobin** and **adult haemoglobin** when the partial pressure of oxygen is 3 kPa.

myoglobin .....

adult haemoglobin ..... [1]

(iii) There is a large difference between the percentage saturation of myoglobin and that of adult haemoglobin at **low** partial pressures of oxygen. Suggest reasons for this.

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..... [2]

(b) Fetal haemoglobin has a different oxygen binding affinity to that of adult haemoglobin, as shown in Fig. 4.1. Normally, after birth, the production of the fetal form stops and the adult form is produced.

In a rare condition known as Hereditary Persistence of Fetal Haemoglobin (HPFH), fetal haemoglobin continues to be produced well into adulthood in addition to adult haemoglobin. This condition, however, usually lacks any symptoms.

(i) Explain, with reference to Fig. 4.1, the significance of the difference in oxygen binding affinity between fetal and adult haemoglobin.

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..... [2]

(ii) Suggest why HPFH usually lacks symptoms.

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..... [1]

(c) Sketch on Fig. 4.2 the dissociation curve you would expect for adult haemoglobin if the concentration of carbon dioxide is increased. [2]

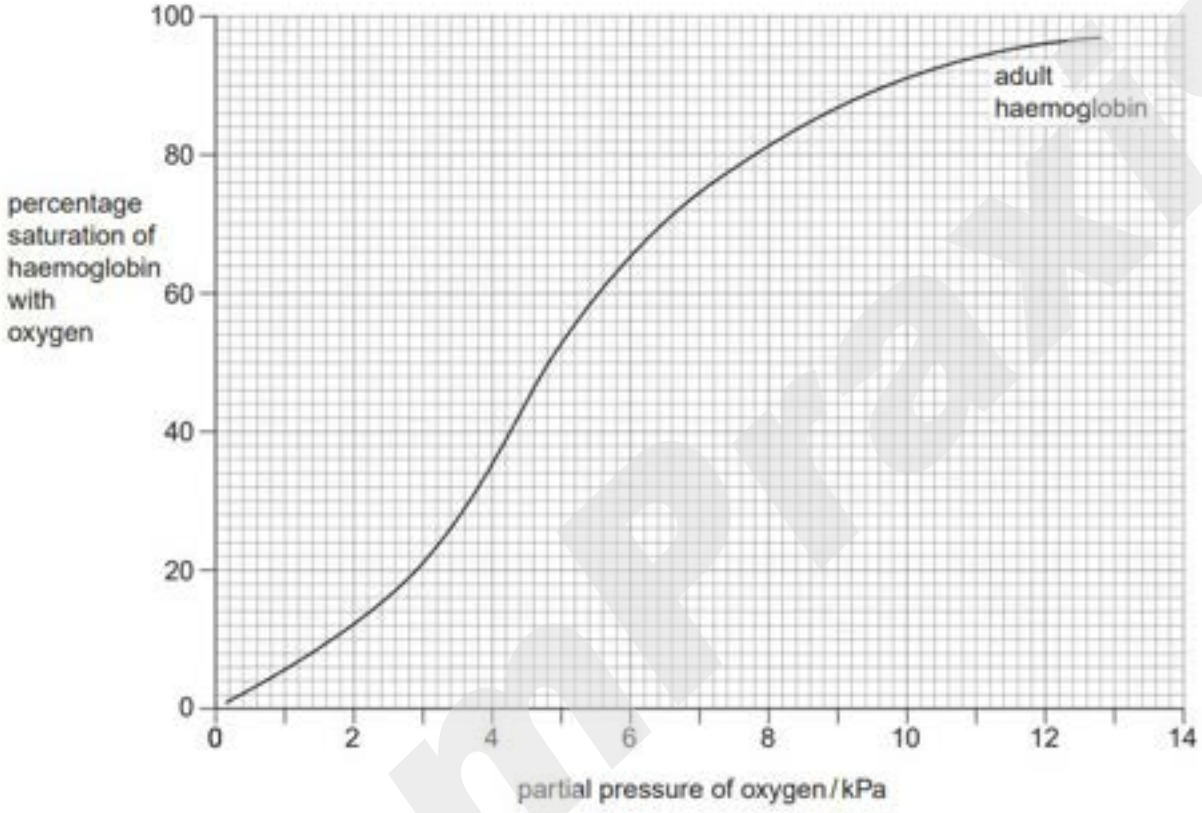

Fig. 4.2

Oct/Nov 2011 (21)/Q3

(c) Collagen is a fibrous protein found in many tissues in animals.

(i) State the function of collagen in the walls of arteries.

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..... [1]

Oct/Nov 2011 (23)

2 (a) Describe the function of each of the following structures in the human heart:

(i) sinoatrial node (SAN)

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..... [2]

(ii) atrioventricular node (AVN)

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..... [2]

(iii) left atrioventricular (bicuspid) valve.

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..... [2]

(b) Fig. 2.1 shows the changes in blood pressure in the left atrium, left ventricle and aorta during one complete cardiac cycle.

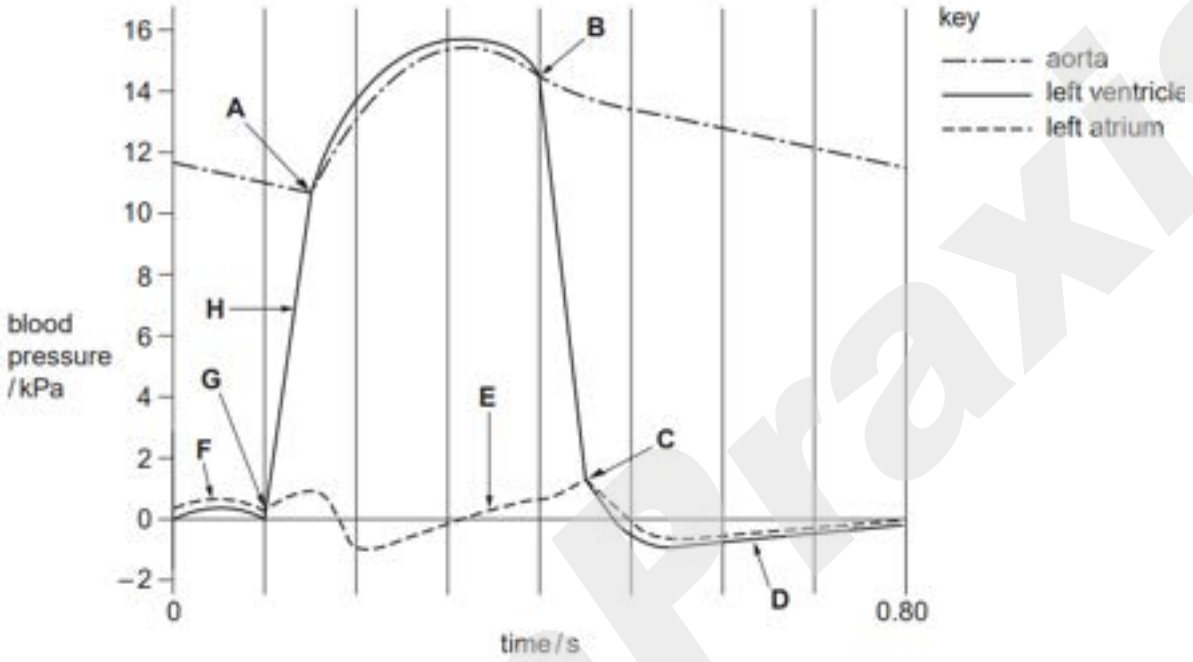

Fig. 2.1

Complete the table below using the appropriate letter, **A** to **H**, to match the points from the graph to the correct statement.

You must only put one letter in each box. You may use each letter once, more than once or not at all.

statement	letter
left atrioventricular (bicuspid) valve starting to open	
left atrioventricular (bicuspid) valve starting to close	
left ventricle starting to contract	
minimum blood remaining in left ventricle	

[4]

May/June 2012 (21)

3 Haemoglobinopathies are inherited conditions linked to the structure and function of haemoglobin. Sickle cell anaemia is one of these conditions in which the transport and delivery of oxygen to tissues is less than normal.

An investigation was carried out to discover the effect of sickle cell anaemia on the ability of blood to carry oxygen. Blood samples were taken from two people:

- person **L** without sickle cell anaemia
- person **M** with sickle cell anaemia.

The percentage saturation of haemoglobin with oxygen was determined over a range of partial pressures of oxygen.

Fig. 3.1 shows oxygen haemoglobin dissociation curves for the two blood samples.

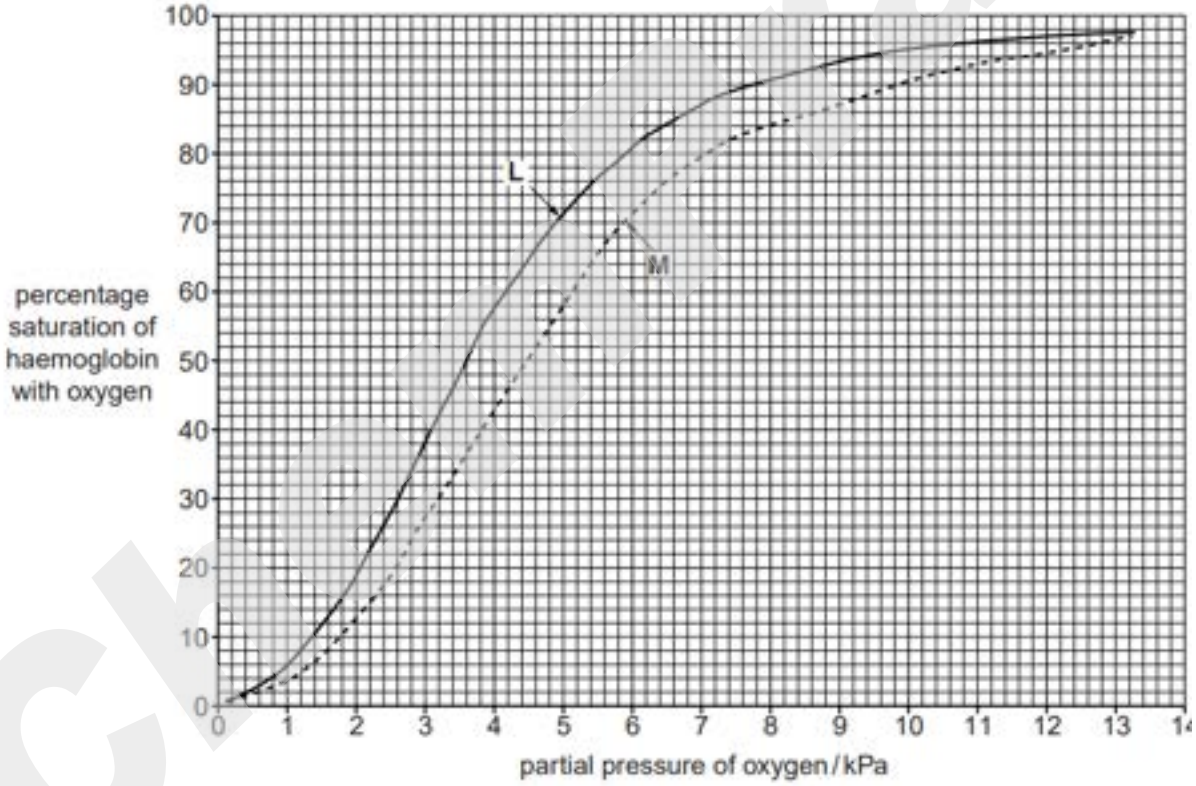

Fig. 3.1

(a) P50 is the partial pressure of oxygen at which haemoglobin is 50% saturated with oxygen. It is taken as a measurement of the affinity of haemoglobin for oxygen.

(i) State the P50 for the two blood samples, **L** and **M**.

L .....

M ..... [1]

(ii) With reference to Fig. 3.1, describe how the dissociation curve for person **M** differs from the dissociation curve for person **L**.

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..... [3]

(b) Explain the advantage of the position of the dissociation curve for people with sickle cell anaemia.

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..... [3]

(c) The partial pressure of oxygen in the lungs at sea level is about 13.5 kPa. At an altitude of 3000 metres the partial pressure of oxygen in the lungs is about 7.5 kPa.

When people move from sea level to high altitude they become adapted to the low partial pressure of oxygen.

Describe **and** explain how humans become adapted to the low partial pressure of oxygen at high altitude.

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..... [4]

May/June 2012 (23)

1 Fig. 1.1 is an electron micrograph of a cross section through a blood vessel.

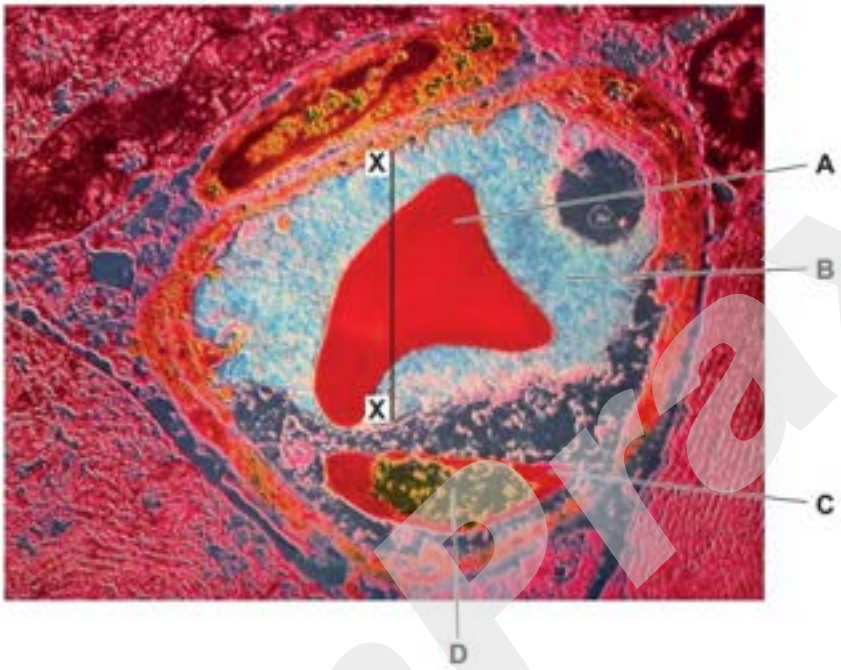

Fig. 1.1

(a) Name the type of blood vessel shown in Fig. 1.1 and describe one **visible** feature which is characteristic of this type of vessel.

type of vessel .....

characteristic feature .....

..... [2]

(b) Name:

(i) structure **A** .....

(ii) the main component of substance **B**. ..... [2]

(iii) Cell **C** in Fig. 1.1 is an endothelial cell.

Name structure **D**.

..... [1]

Oct/Nov 2012 (21)

5 Mammals have closed, double circulatory systems.

(a) Explain what are meant by the terms *closed* and *double* as applied to mammalian circulatory systems.

closed .....

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double .....

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.....[2]

Fig. 5.1 shows a longitudinal section through a mammalian heart.

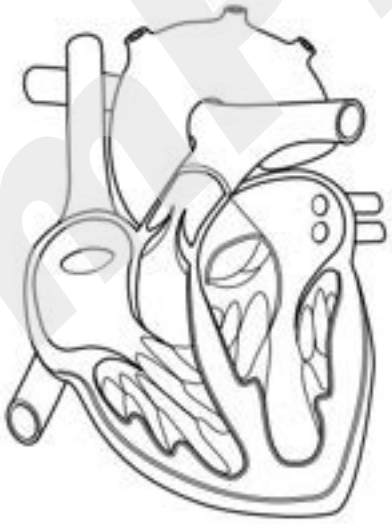

Fig. 5.1

(b) Use label lines and the letters **P**, **Q**, **R** and **S** to label the following on Fig. 5.1:

P the right atrium

Q a semilunar valve

R a blood vessel that carries deoxygenated blood

S the position of Purkyne tissue [4]

Catheters are small tubes that are inserted into blood vessels. A catheter was inserted into an artery in the arm and then moved into the aorta and then into the left ventricle during a diagnostic investigation. The catheter contained a device to measure the blood pressure in the aorta and in the left ventricle. The results are shown in Fig. 5.2.

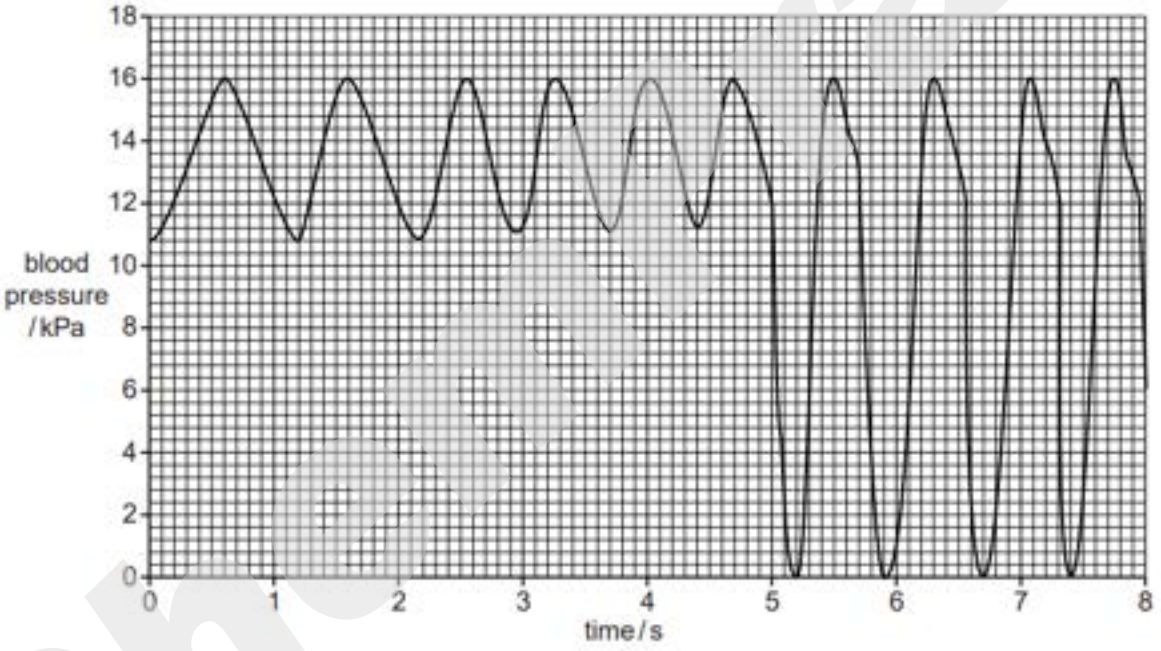

Fig. 5.2

(c) (i) Calculate the heart rate during the period of the investigation.

Show your working.

answer .....[2]

(ii) Describe **and** explain the differences in pressure as the catheter moves from the aorta into the left ventricle.

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.....[4]

May/June 2013 (21)

1 Capillaries are known as exchange vessels. Substances are exchanged between blood and tissue fluid as the blood flows through the capillaries.

Fig. 1.1 is an electron micrograph of a section through a capillary with two red blood cells.

Fig. 1.1

(a) (i) Name the cells labelled **A** and the structure labelled **B**.

A .....

B ..... [2]

(iii) Explain how capillaries are adapted for their function as exchange vessels.

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..... [2]

(b) Table 1.1 shows the composition of blood, tissue fluid and lymph.

Table 1.1

component	blood	tissue fluid	lymph
red blood cells /cells $mm^{-3} \times 10^6$	5.1	0.0	0.0
white blood cells /cells mm^{-3}	9000	75	1000000
glucose/g dm^{-3}	800	800	775
protein/g dm^{-3}	71	1	26

Explain the differences between the composition of blood, tissue fluid and lymph as shown in Table 1.1, for white blood cells, glucose and protein.

Explain the differences between the composition of blood, tissue fluid and lymph as shown in Table 1.1, for white blood cells, glucose and protein.

white blood cells .....

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glucose .....

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protein .....

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..... [5]

(c) Outline how **red blood cells** are involved in the transport of carbon dioxide.

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..... [3]

May/June 2013 (22)

6 **(a)** The statements below are some of the events that occur in the initiation and control of heart action during one cardiac cycle.

Place the events in the correct sequence, using **1** as the first event in the sequence.

event	correct sequence
Purkyne tissue conducts the wave of excitation	
atrioventricular node sends out a wave of excitation	
atria contract	
ventricles contract	
sinoatrial node sends out a wave of excitation	

[3]

(b) The wall of the left ventricle contains more cardiac muscle than the wall of the right ventricle.

Explain the difference in the thickness of the walls of the left and right ventricles of the heart, in terms of their functions.

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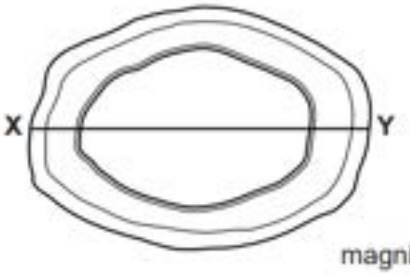
..... [2]

Oct/Nov 2013 (22)

1 Fig. 1.1 is a diagram of a transverse section through a vein.



magnification × 35

Fig. 1.1

(b) The presence of a valve would help to confirm that the blood vessel in Fig. 1.1 is a vein and not an artery.

Describe three structural features of the blood vessel shown in Fig. 1.1 that would help to identify it as a vein and **not** as an artery.

1. .....

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2. .....

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3. .....

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.....[3]

(c) Explain how the following structural features of a capillary are related to its function.

(i) The capillary wall is composed of a single layer of squamous epithelial cells.

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.....[1]

(ii) The diameter of the capillary lumen is approximately 8 μm.

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.....[1]

Oct/Nov 2013 (22)/Q3

(c) Complete Table 3.1 to state four differences between transport systems in mammals and in plants.

Table 3.1

transport system in mammals	transport system in plants

[4]

Oct/Nov 2013 (23)

4 Fig. 4.1 is a diagram of a section through a mammalian heart.

Fig. **4.1**

(a) Use a label line and the appropriate letter to label each of the following on Fig. 4.1:

W right atrium

X tricuspid valve

Y aorta.

[3]

(b) Starting from the left ventricle, describe the route taken by the blood as it travels to the lungs.

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..... [3]

May/June 2014 (21)

5 Fig. 5.1 shows a vertical section of the left side of the heart of a mammal.

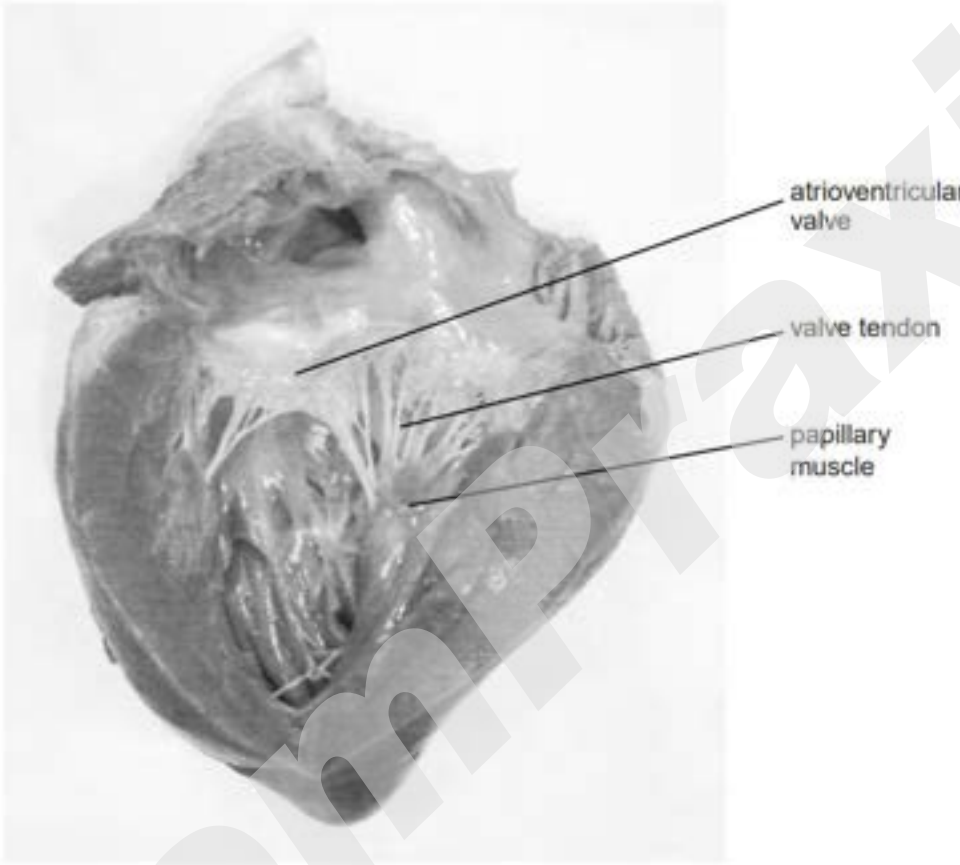

Fig. 5.1

(a) Explain the difference in the thickness of the left ventricle and the left atrium.

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.....[2]

(b) Explain how the structures labelled on Fig. 5.1 ensure that blood flows in the correct direction.

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..... [3]

(c) During one cardiac cycle, blood is pumped from the heart into the pulmonary and systemic circulations.

Explain how the contraction of the four chambers of the heart are coordinated and controlled to enable blood to be pumped simultaneously into both the pulmonary and systemic circulations.

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..... [4]

May/June 2014 (22)/Q3

(b) Fig. 3.1 shows the changes that occur in atmospheric pressure and oxygen partial pressure as altitude changes. The highest altitude at which people live permanently is 5100 m.

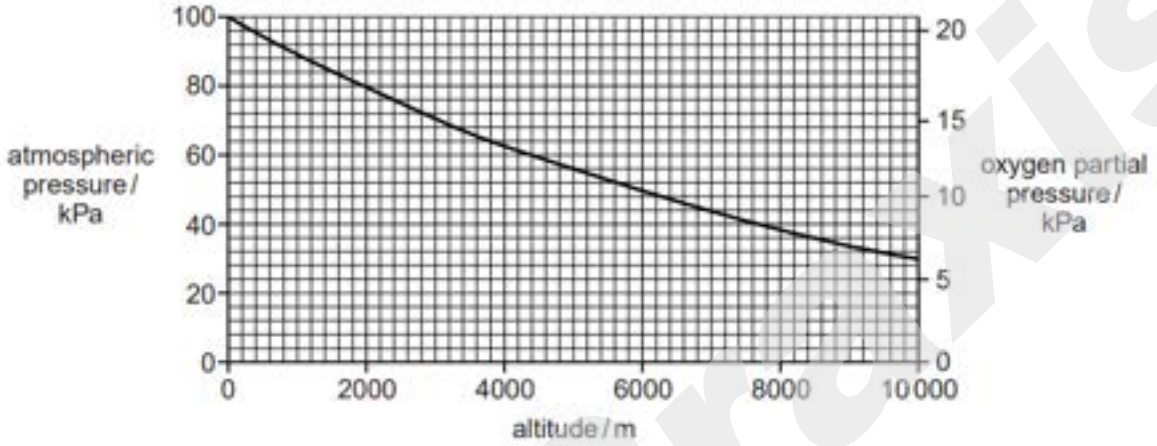

Fig **3.1**

With reference to Fig. 3.1:

(i) describe the effect of increasing altitude on both atmospheric pressure and the partial pressure of oxygen

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.....[2]

(ii) calculate the change in the atmospheric pressure when a person travels from sea level to an altitude of 3500 m.

Show your working.

answer .....[2]

(c) When a person travels from 0 m (sea level) to a high altitude, gas exchange in the lungs is affected. A condition known as hypoxia results, where the body tissues do not receive an adequate oxygen supply.

Explain how hypoxia occurs when a person ascends from sea level to a high altitude.

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.....[4]

(d) At high altitudes, short-term responses by the body to hypoxia include:

- a decrease in the volume of plasma in the blood
- a decrease in the volume of blood pumped out of the heart per heart beat
- an increase in the heart rate
- an increase in the breathing rate.

(i) Suggest why a decrease in the volume of plasma in the blood may reduce the effects of hypoxia.

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.....[1]

(ii) Explain why an increase in the heart rate occurs in response to hypoxia.

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.....[2]

6 **(a)** Explain the need for transport systems in multicellular plants and animals.

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(b) In mammals, the role of the heart is to pump blood around the body. The events that occur during one heart beat are known as the cardiac cycle. The timing for one cardiac cycle is shown in Fig. 6.1.

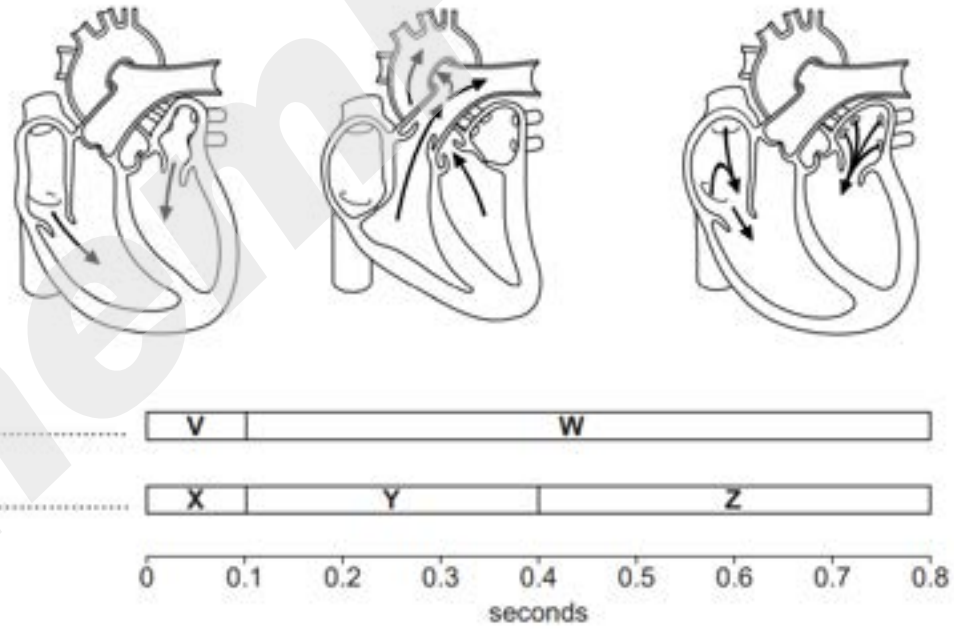

Fig. 6.1

P and **Q** represent the two types of heart chambers.

V, **W**, **X** , **Y** and **Z** represent the systolic (contracted) or diastolic (relaxed) state of the relevant heart chambers.

(i) In the spaces provided on Fig. 6.1, identify chambers **P** and **Q**. [1]

(ii) Complete the table by writing the letters **V**, **W**, **X**, **Y** and **Z** in the appropriate box to indicate the state of the heart chambers during the cardiac cycle as shown in Fig. 6.1.

systole	
diastole	

[2]

May/June 2014 (23)

5 When haemoglobin in red blood cells travels through the capillaries of the lungs it binds with oxygen to form oxyhaemoglobin. When oxyhaemoglobin reaches respiring tissues, it dissociates to release oxygen.

(a) Explain what causes oxyhaemoglobin to dissociate readily in actively respiring tissues.

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.....[3]

(b) When people move to high altitudes there is an increased production of red blood cells. Explain why more red blood cells are produced when people move to higher altitudes.

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.....[3]

6 Fig. 6.1 shows a section of diseased artery from a smoker.

Fig. **6.1**

(a) (i) With reference to Fig. 6.1, describe how this diseased artery differs in appearance from a healthy one.

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.....[2]

(b) Arteries and capillaries have different structures related to their different functions.

For each type of blood vessel, give **one** structural feature and the function that it provides.

(i) artery:

structural feature .....

function .....

.....

[2]

(ii) capillary:

structural feature .....

function .....

.....

[2]

Oct/Nov 2014 (21)/Q3

Table 3.1 shows the blood pressure in the right ventricle and in the pulmonary artery of a person who is in good health.

Table 3.1

phase of cardiac cycle	blood pressure / kPa	
	right ventricle	pulmonary artery
Ventricular systole	3.33	3.33
Ventricular diastole	0.67	1.33

(d) Use the information in Table 3.1 to explain why the blood pressure in the pulmonary artery is the same as the pressure in the right ventricle during systole, but higher during diastole.

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..... [3]

Oct/Nov 2014 (22)

3 In mammals, oxygen is transported by red blood cells in a system that is described as a closed double circulation. The majority of oxygen molecules are transported as oxyhaemoglobin. At the respiring tissues, oxygen dissociates from haemoglobin and diffuses to the surrounding cells.

(a) Explain what is meant by a *closed double circulation*.

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..... [2]

(c) At high altitudes, the partial pressure of inspired oxygen is considerably lower than at sea level. This means that the partial pressure of oxygen in the blood is also much lower at high altitudes than at sea level.

Fig. 3.2 is an oxygen dissociation curve of adult oxyhaemoglobin.

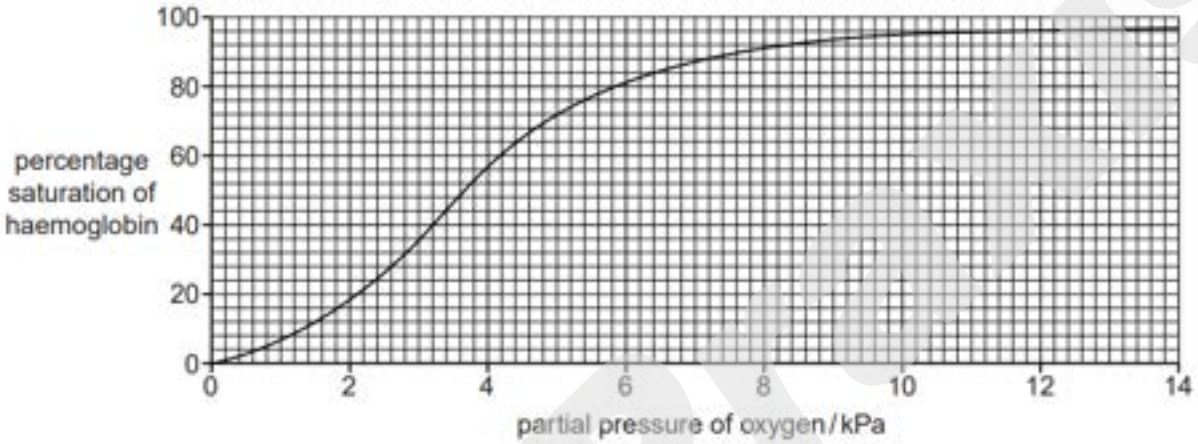

Fig. 3.2

With reference to Fig. 3.2, calculate the difference in percentage saturation of haemoglobin at sea level, where the partial pressure of oxygen is 13.0 kPa, and at a higher altitude, where the partial pressure of oxygen is 6.2 kPa.

Show your working.

answer ..... % [2]

(d) After spending time at altitude, a person can become acclimatised. One feature of acclimatisation is an increase in the red blood cell count.

Explain the importance of the increase in the red blood cell count.

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..... [2]

(f) Tobacco smoking can have an effect on the transport of oxygen by haemoglobin.
Fig. 3.3 shows oxygen dissociation curves with and without the presence of carbon monoxide (CO).

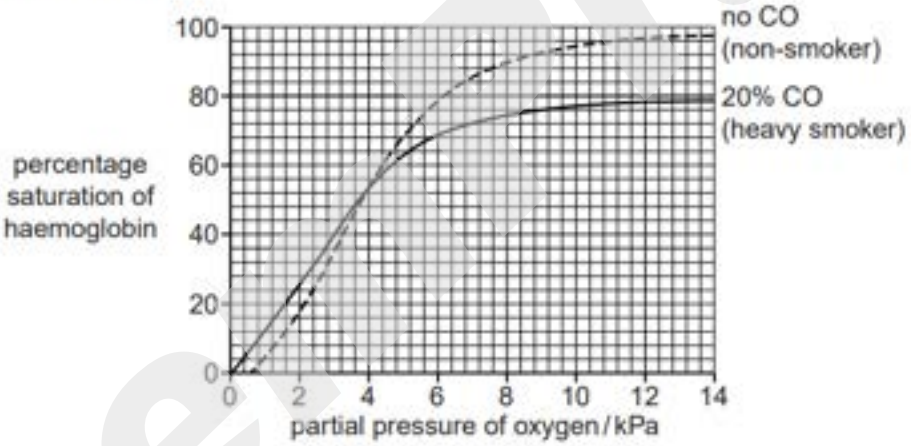

Fig. 3.3

With reference to Fig. 3.3, describe the effect of carbon monoxide on the cardiovascular system.

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5 **(a)** Complete Table 5.1 by numbering each event to show the sequence occurring in the initiation and control of one heart beat.

Use **1** as the first event in the sequence.

Table 5.1

event	sequence
impulses pass down septum through conducting fibres known as the bundle of His	
atrioventricular node sends out impulses	
impulses travel across atrial walls	
impulses reach base of ventricles (apex of heart)	
impulses pass up through Purkyne fibres in ventricle walls	
sinoatrial node sends out impulses	

[3]

(b) Explain the circumstances that cause the closing of the semi-lunar valves during the cardiac cycle.

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.....[2]

(c) At the arterial end of a capillary bed in muscle tissue, the hydrostatic pressure is high enough to cause the formation of tissue fluid.

Explain the differences between the composition of blood and the composition of tissue fluid at the arterial end of a capillary bed.

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.....[2]

May/June 2015 (22)

1 Each of statements **A to E** describe a structure associated with the mammalian heart.

For each statement, identify the structure that is being described.

A The chamber that pumps blood into the pulmonary artery.

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B A blood vessel that transports deoxygenated blood into the right atrium.

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C The specialised tissue responsible for delaying the conduction of impulses from the atria to the ventricles.

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D The blood vessels that supply cardiac muscle with oxygenated blood.

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E The valve that prevents the backflow of blood from the ventricle that contains oxygenated blood.

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[5]

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Fig. 3.2 shows red blood cells within a capillary. The capillary shown in Fig. 3.2 allows the rapid exchange of substances between the blood, tissue fluid and body cells.

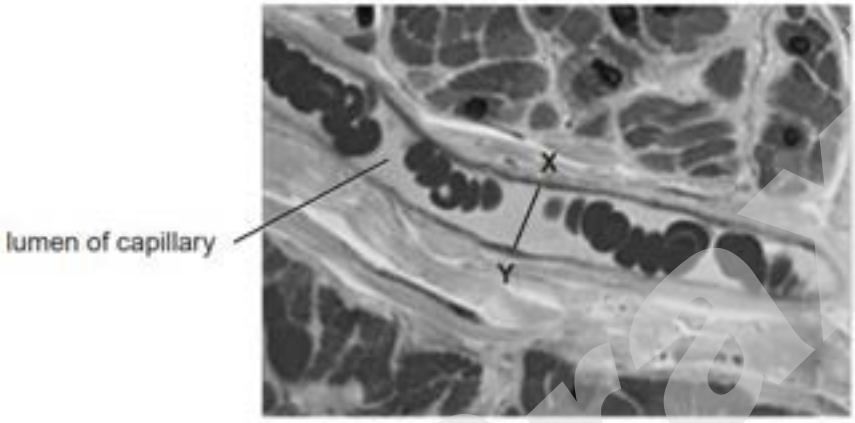

Fig. 3.2

(d) With reference to Fig. 3.2, explain one feature that enables the surrounding body cells to receive an adequate supply of oxygen from the blood supplied by the capillary.

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.....[2]

(e) Some areas of the brain, known as blood-brain barriers, have a type of capillary that is relatively impermeable to substances.

Suggest one way in which the structure of a capillary in the blood-brain barrier differs from the structure of the capillary shown in Fig. 3.2.

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.....[1]

May/June 2015 (23)

4 Fig. 4.1 shows how blood pressure changes in the human systemic circulation.

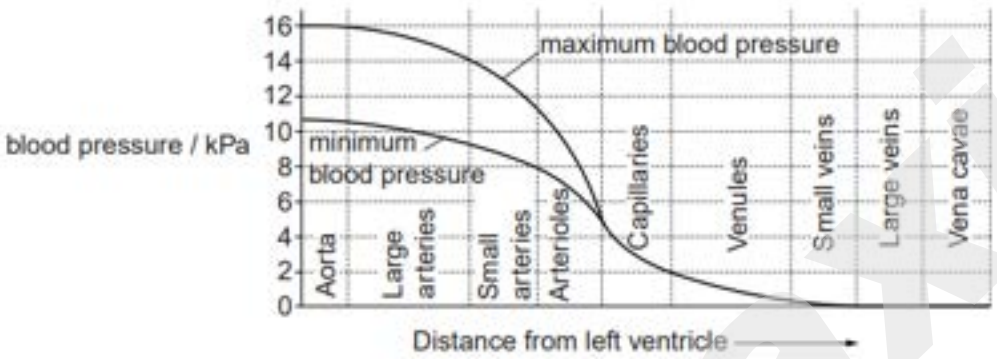

Fig. 4.1

(a) (i) Describe the changes in blood pressure shown in Fig. 4.1.

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.....[3]

(ii) Explain how the structure of veins is related to their function in returning blood to the heart.

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Oct/Nov 2015 (22)

6 **(a)** The thickness of the different chambers of the mammalian heart is due to the amount of cardiac muscle present. The atria have less cardiac muscle than the ventricles, and hence thinner walls.

In terms of their functions, explain why the atria have thinner walls than the ventricles.

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..... [2]

(b) Name the dividing wall separating the right and left sides of the mammalian heart.

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