Name:_____ Period:____

AICE Biology Problem Set: The Mammalian Circulatory System and Heart

This problem set is due the day of our test and is worth 30 points. Answer all questions to the best of your abilities and make sure to check your responses on problem set day!

1 Which reactions will be taking place in blood that is passing through active tissues?

1 $HbO_8 \rightarrow Hb + 4O_2$

2 $HbO_8 + H^+ \rightarrow HHb + 4O_2$

3 $HCO_3^- + H^+ \rightarrow H_2CO_3$

4 $H_2O + CO_2 \rightarrow H_2CO_3$

A 1, 2, 3, and 4

B 1, 2 and 4 only

C 1, 3 and 4 only

D 2 and 3 only

2 During a cardiac cycle, the pressure in the right ventricle is lower than that in the right atrium and lower than that in the pulmonary artery.

Which row is correct?

	atrioventricular valve	semilunar valve
A	closed	closed
B	closed	open
C	open	closed
D	open	open

3 What correctly describes an event in the cardiac cycle that follows atrial systole?

A A wave of excitation passes through the sinoatrial node (SAN), before spreading down to the base of the septum.

B Electrical impulses pass from the muscles of the atria to the muscles of the ventricles to cause ventricular systole.

C Electrical impulses pass through conducting fibres, which cause a delay before spreading to Purkyne tissue.

D The opening and closing of the semilunar valves occurs later than the opening and closing of the atrioventricular valves.

4 ‘Heart block’ is a disease which can result in a lower than normal heart rate. A doctor treating a patient suffering from heart block found that electrical impulses were initiated as normal but were not correctly conducted to the ventricles, so the rate of ventricular contraction was slowed.

Which may be functioning incorrectly in the patient?

1 atrioventricular node (AVN)

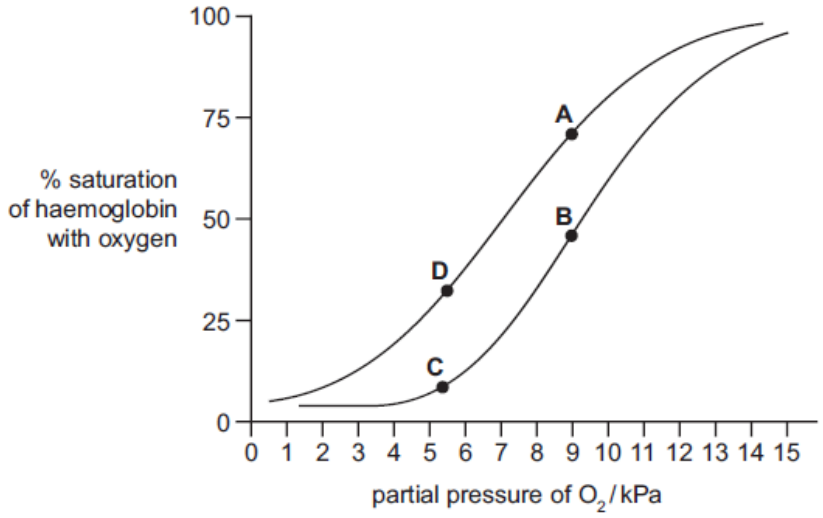
2 Purkyne tissue

3 sinoatrial node (SAN)

A 1 and 2 only **B** 1 and 3 only **C** 2 and 3 only **D** 3 only

5 The graph shows the dissociation curves for adult haemoglobin at two different (unidentified) concentrations of carbon dioxide.

Which point represents the oxygen concentration in red cells as they leave a resting muscle?



6 Which chamber of the heart shows the greatest pressure changes during one cardiac cycle?

A left atrium

B left ventricle

C right atrium

D right ventricle

7 What happens to the blood flow in the cardiac cycle?

A Blood flows into the aorta through the semilunar valve due to contraction of the right ventricle.

B Blood flows into the left atrium through the pulmonary artery when the walls of the left atrium relax.

C Blood flows into the right atrium through the vena cava when the walls of the right atrium relax.

D Blood flows into the right ventricle through the semilunar valve when the walls of the right atrium contract.

8 Which row is correct for the pulmonary vein?

	blood carried	muscle in walls	lumen size
A	deoxygenated	thick	small
B	deoxygenated	thin	large
C	oxygenated	thick	small
D	oxygenated	thin	large

9 Which statement describes the Bohr effect?

A In high partial pressure of oxygen and high partial pressure of carbon dioxide, the affinity of haemoglobin for oxygen increases.

B In high partial pressure of oxygen and low partial pressure of carbon dioxide, the affinity of haemoglobin for oxygen decreases.

C In low partial pressure of oxygen and high partial pressure of carbon dioxide, the affinity of haemoglobin for oxygen decreases.

D In low partial pressure of oxygen and low partial pressure of carbon dioxide, the affinity of haemoglobin for oxygen is unchanged.

10 What is produced by the action of carbonic anhydrase?

A carbaminohaemoglobin

B haemoglobinic acid

C hydrogencarbonate ions

D oxyhaemoglobin

11 During the cardiac cycle, the movement of the valves causes sounds that can be heard using a stethoscope.

What causes the first sound after atrial systole in the cardiac cycle?

1 closing of the atrioventricular valves

2 opening of the semilunar valves

3 closing of the semilunar valves

A 1 and 2 **B** 1 and 3 **C** 1 only **D** 3 only

12 What happens during ventricular systole in a mammalian heart?

A aortic pressure increases

B atrioventricular valves open

C semilunar valves close

D ventricular pressure decreases

13 Which two statements about the Bohr effect are correct?

1 Increasing the partial pressure of oxygen increases the percentage of oxyhaemoglobin.

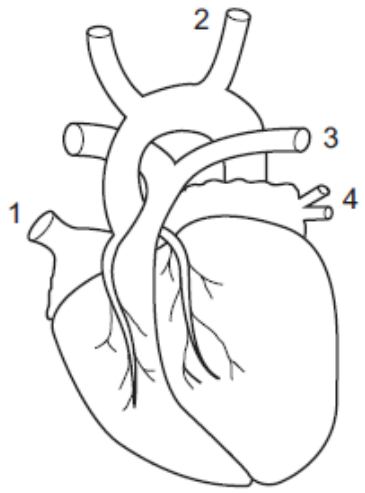
2 Decreasing the partial pressure of carbon dioxide decreases the percentage of oxyhaemoglobin.

3 Increasing the partial pressure of carbon dioxide shifts the dissociation curve of haemoglobin to the left.

4 In low concentrations of carbon dioxide haemoglobin has a high affinity for oxygen.

A 1 and 2 **B** 1 and 4 **C** 2 and 3 **D** 3 and 4

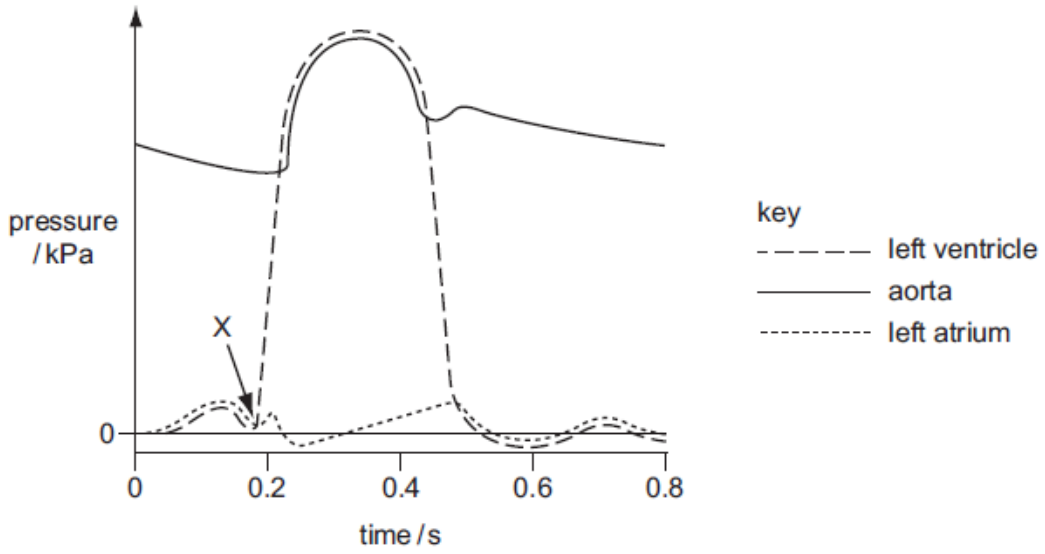
14 The diagram shows the heart and some of its blood vessels.



Which combination of numbers correctly identifies the blood vessels that supply blood to the heart and carry blood from the heart?

	to the heart	from the heart
A	1 and 2	3 and 4
B	2 and 3	1 and 4
C	3 and 4	1 and 2
D	4 and 1	2 and 3

15 The diagram shows pressure changes in the left side of the heart during the cardiac cycle.



What happens at X?

A atrioventricular valves close

B atrioventricular valves open

C semilunar valves close

D semilunar valves open

In the following space, draw a DETAILED diagram of the human heart. Color code to show oxygenated/deoxygenated blood and include arrows to indicate direction of blood flow.

16 What correctly describes the effect of carcinogens on lung tissue?

A Cells of the alveoli walls divide more rapidly than normal by reduction division causing a tumour to develop.

B Cilia are paralysed and mucus accumulates in the lungs, causing DNA to change and a tumour to develop.

C DNA changes, causing bronchial epithelial cells to divide by mitosis in an uncontrolled way, causing a tumour to develop.

D Haemoglobin carries less oxygen, causing bronchial cells to divide by mitosis in an uncontrolled way, causing a tumour to develop.

17 A disease damages alveoli walls.

What effect does this have on the gas exchange surface area and on the volume of the lungs?

	surface area	volume
A	decreased	decreased
B	decreased	increased
C	decreased	no change
D	no change	no change

18 Which is a correct description of part of the gas exchange system?

	part of gas exchange system	cartilage	ciliated epithelium	goblet cells	smooth muscle
A	alveolus	✗	✓	✗	✗
B	bronchus	✓	✓	✓	✓
C	bronchiole	✗	✓	✓	✗
D	trachea	✓	✓	✓	✗

key
✓ present
✗ absent

19 The squamous epithelial cells of the alveoli form part of the gas exchange system.

How do these cells assist gas exchange?

1 They contain many mitochondria.
2 They have a large surface area.
3 They provide a short diffusion path.

A 1 and 2 only

B 1 and 3 only

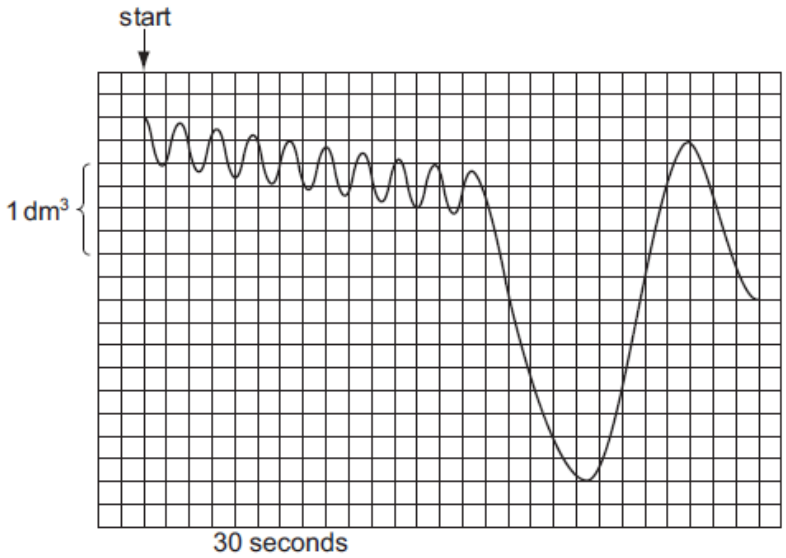
C 2 and 3 only

D 1, 2 and 3

20 Which statements are correct effects of tar in tobacco smoke on the human gas exchange system?

	goblet cells are stimulated to secrete more mucus	mucus glands in the trachea are enlarged	mutations may occur in epithelial cells forming tumors	the activity of cilia in the airays is inhibited
A	✓	✓	✗	✗
B	✗	✓	✓	✓
C	✓	✓	✓	✓
D	✓	✗	✓	✓

21 The diagram shows a record of a person's breathing. The person breathed normally at the start, breathed in as deeply as possible and then breathed out as much as possible.



What is a valid conclusion from the graph?

A The person breathed in 1000 cm^3 during the first 50 seconds.

B The person was carrying out strenuous exercise for the first 30 seconds.

C The rate of breathing for the first 30 seconds was 18 breaths per minute.

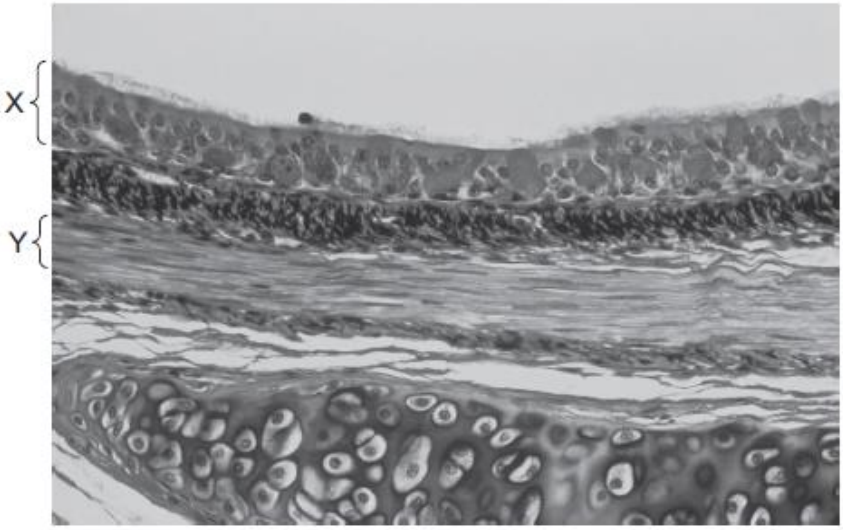
D The tidal volume was 500 cm^3, the vital capacity was 3750 cm^3.

22 Ciliated, goblet and squamous epithelial cells are found in various parts of the human lung and associated structures.

Where are these cells located?

	ciliated	goblet	squamous epithelial
A	bronchiole	trachea	alveolus
B	bronchus	bronchiole	pulmonary vein
C	trachea	pulmonary vein	alveolus
D	trachea	bronchus	bronchiole

23 The photomicrograph shows a cross-section through a bronchus.



What is the function of the tissues X and Y?

	X	Y
A	secrete mucus	prevent collapse of the airway
B	support the airway	dilate airway
C	trap dust and dirt	secrete mucus
D	waft dust and dirt upwards	constrict airway

24 Which component(s) of tobacco smoke cause an increase in blood pressure and clot formation?

1 carcinogens

2 nicotine

3 tar

A 1, 2 and 3 **B** 1 and 3 only **C** 2 and 3 only **D** 2 only

25 Peak Flow is used in hospitals to diagnose some lung diseases. It measures the maximum rate at which air can be breathed out from the lungs.

How will the Peak Flow for a person with emphysema differ from that for a healthy person?

A It falls as carbon monoxide reduces oxygen-carrying capacity of the blood.

B It falls as elastic fibres are damaged in the alveoli.

C It remains constant as the damage to the lungs does not affect the lung volume.

D It rises as larger air spaces make it easier for the air to flow.

26 Which symptom is specific to emphysema?

A excess mucus secretion by the goblet cells

B inflammation of the bronchial epithelium

C loss of elasticity of the alveolar walls

D thickening of the smooth muscle of the bronchi

27 Haemoglobin can bind to carbon dioxide, carbon monoxide and oxygen.

1 carbon dioxide

2 carbon monoxide

3 oxygen

Which gases share a binding site?

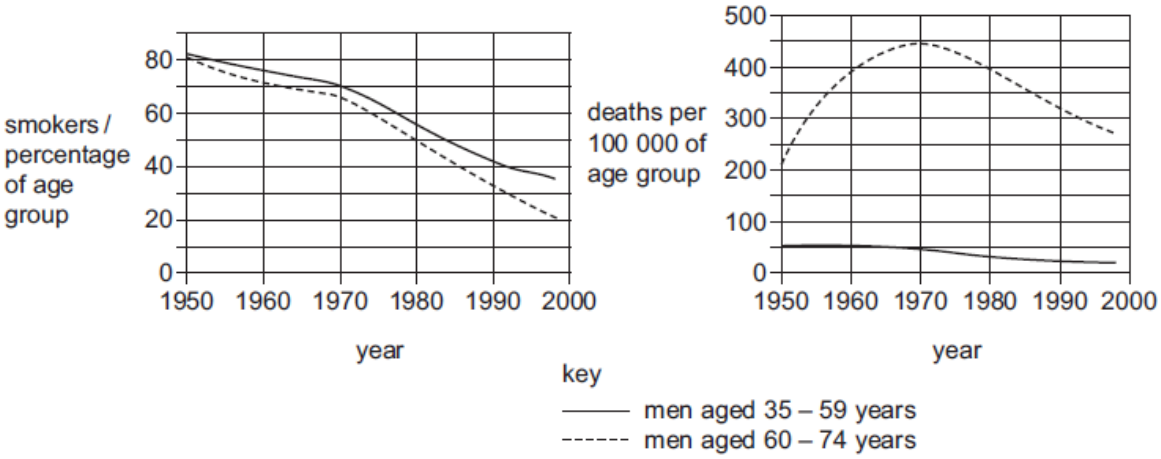
A 1 and 2 only

B 1 and 3 only

C 2 and 3 only

D 1, 2 and 3

28 Some studies suggest that smoking increases the risk of developing lung cancer. The two graphs show the percentage of smokers and the deaths from lung cancer in men of two age groups between 1950 and 1998.



Which statement is **not** supported by the data in the graphs?

A Deaths from lung cancer in men aged 35-59 years decreased by 50 % over the period of the study.

B Deaths from lung cancer in men aged 60-74 years increased up to 1970.

C The data for men aged 60-74 years between 1950 to 1970 suggests that lung cancer takes up to 20 years to develop.

D The number of men aged 35-59 years who were smokers decreased by approximately 60 % over the period of the study.

29 An oxygen molecule diffuses directly from the air in an alveolus to haemoglobin in a red blood cell.

What is the minimum number of cell surface membranes through which this molecule must pass?

A 2 **B** 3 **C** 4 **D** 5

A disease damages alveoli.

30 Which effect does this have on the gas exchange surface area and volume of the lungs?

	surface area	volume
A	decreased	decreased
B	decreased	no change
C	increased	increased
D	increased	no change

31 Fig. 6.1 is a section through lung tissue showing an alveolus and its blood supply.

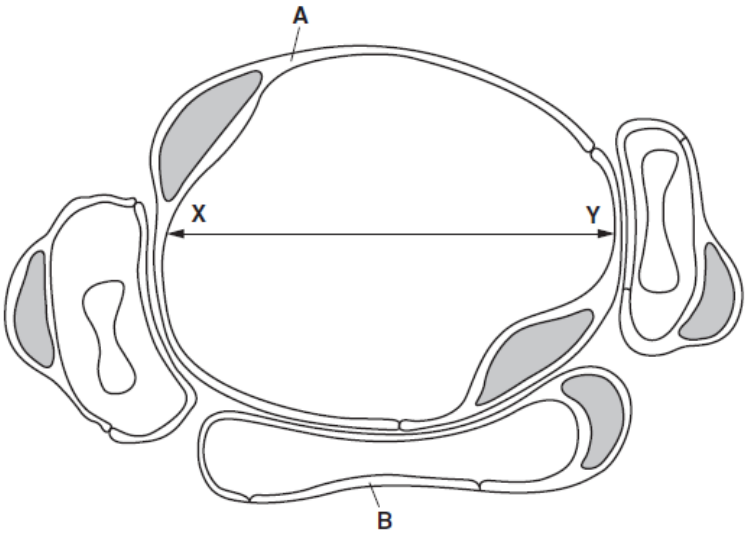


Fig. 6.1

(a) **(i)** Name the type of epithelial cell shown by label lines **A** and **B**.

..... [1]

(ii) Describe how the elastic fibres of the alveoli contribute to the healthy functioning of the lungs.

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..... [2]

(b) The actual diameter of the alveolus along the line **X–Y** is 220 micrometres (μm). Calculate the magnification of Fig. 6.1.

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

answer × ..... [2]

(c) Outline two features of a gas exchange surface **that are shown on Fig. 6.1**.

1. .....

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2. .....

..... [2]

(d) Fig. 6.2 is a simplified diagram of the circulatory system of a human, showing exchange in the lungs and in respiring tissue. The partial pressures of oxygen (pO_2) carbon dioxide (pCO_2) at four locations are also shown.

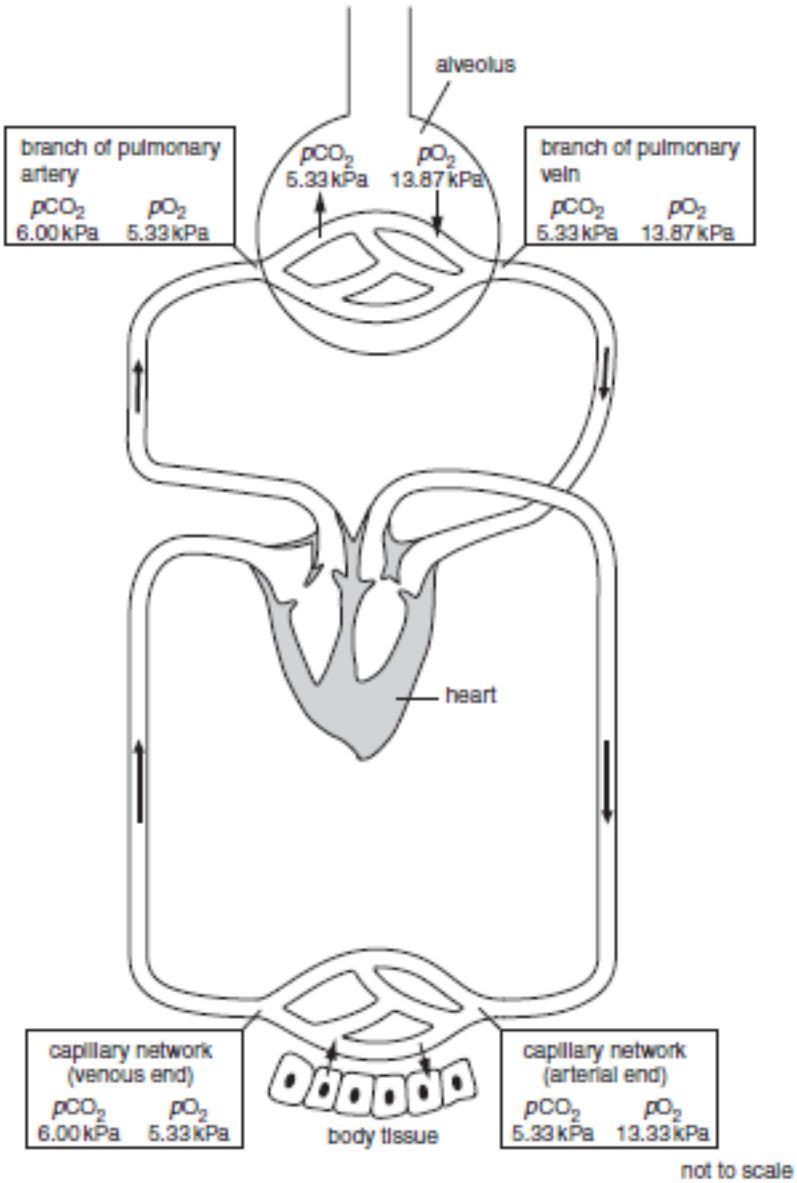

Fig. 6.2

With reference to Fig. 6.2, explain how the differences in $pO2$ and pCO_2 in the alveolus and in blood enable gas exchange in the lungs **and** respiring tissue.

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[Total: 11]

32 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.

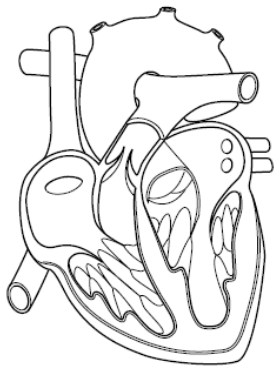

Fig. 5.1

(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

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.

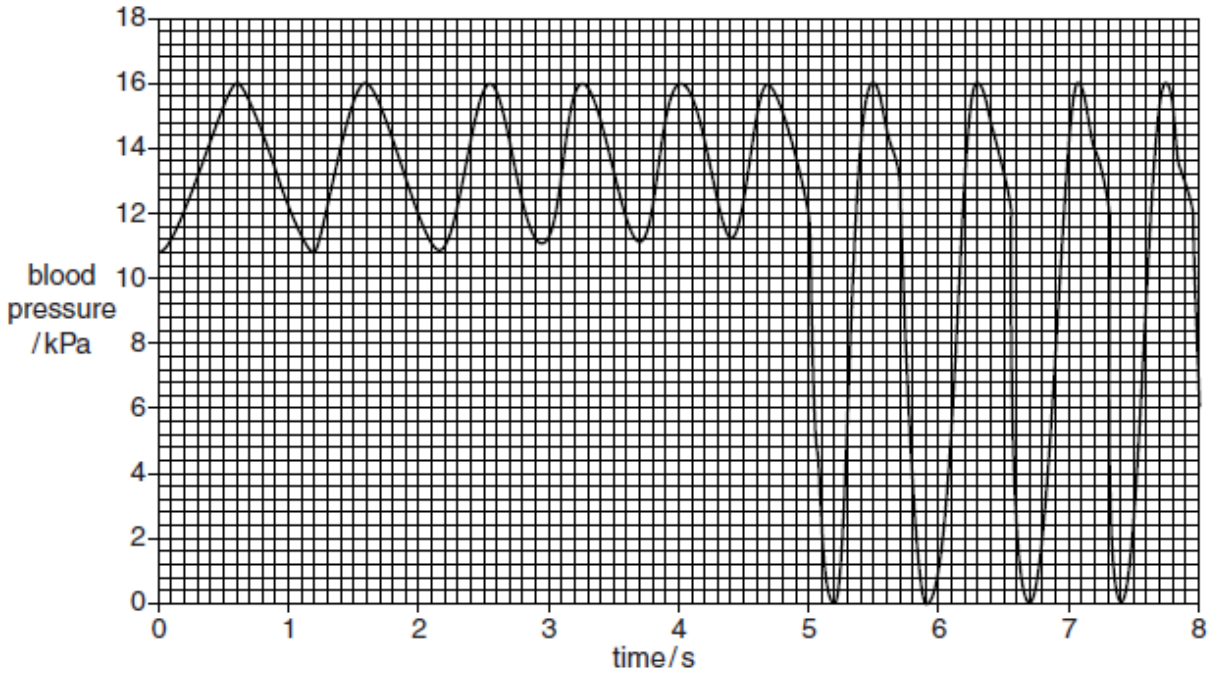

Fig. 5.2

(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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Fig. 5.3 is an X-ray showing narrowing in the blood vessels supplying muscles in the heart. A catheter is used to insert a dye into the blood vessels so that they appear clearly in the X-ray. The arrows indicate where there is narrowing of the blood vessels.

Fig. 5.3

(d) **(i)** Name the blood vessels shown in Fig. 5.3.

.....[1]

(ii) State the likely effect of narrowing of these blood vessels.

.....[1]

(e) Suggest ways in which the condition shown in Fig. 5.3 may be treated.

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[Total: 16]

33 Fig. 1.1 is a light micrograph of a section through part of the gas exchange system.

A, **B** and **C** are three different types of tissue.

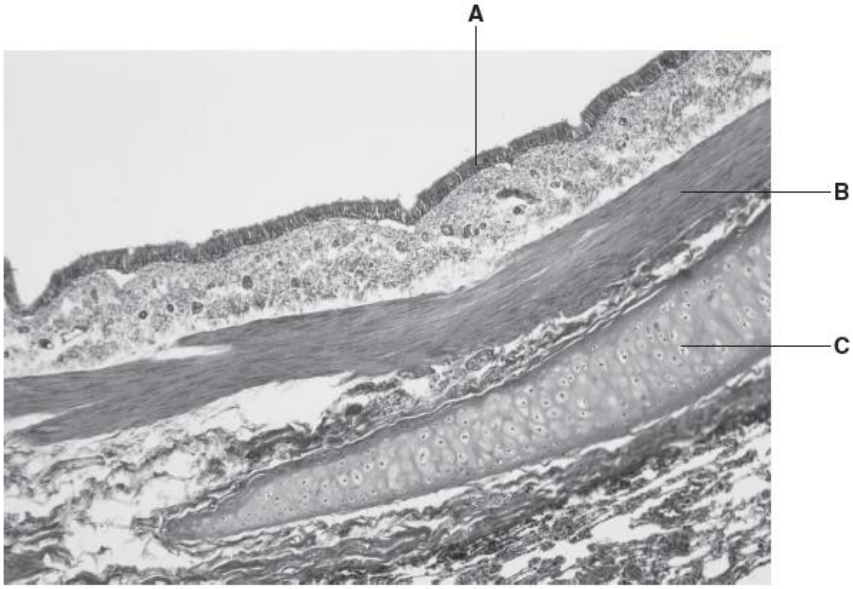

Fig. 1.1

(a) The cell types in tissue **A** have different functions.

Describe how the cell types work together to maintain the health of the gas exchange system.

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.....[3]

(b) Suggest why the cells in tissue **B** have many mitochondria.

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(c) Name the parts of the gas exchange system where tissue **C** is distributed.

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.....[1]

[Total: 5]

34 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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(b) Fig. 3.1 is a diagram that highlights the tertiary and quaternary structure of a haemoglobin molecule.

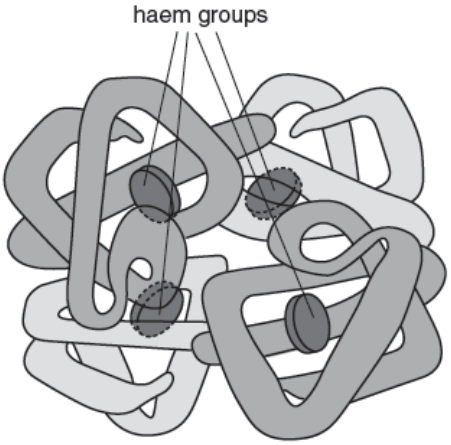

Fig. 3.1

Explain how the tertiary and quaternary levels of protein structure of the haemoglobin molecule contribute to its role in the transport of oxygen.

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(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.

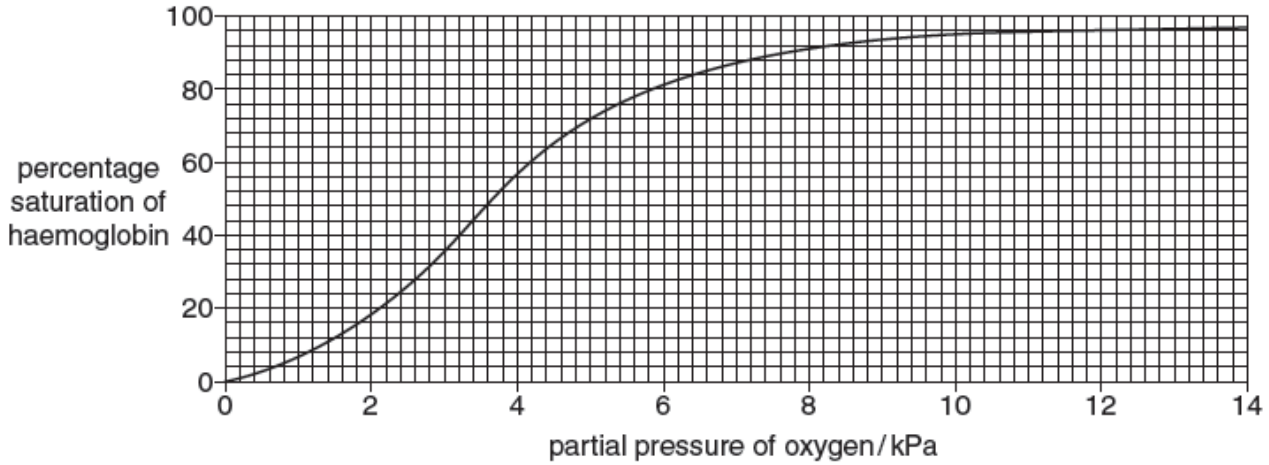

Fig. 3.2

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]

(e) Before acclimatisation can occur, some people develop a condition known as acute mountain sickness when they travel to high altitude areas.
Acetazolamide is a non-competitive enzyme inhibitor that is used as a drug to prevent and treat acute mountain sickness.

Explain the effects of a non-competitive inhibitor on the rate of enzyme activity.

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..... [3]

(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).

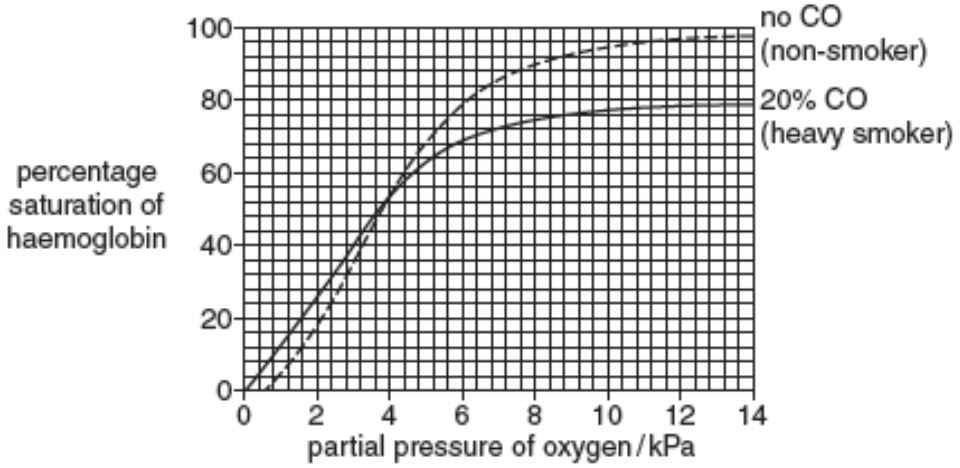

Fig. 3.3

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

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[Total: 16]

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

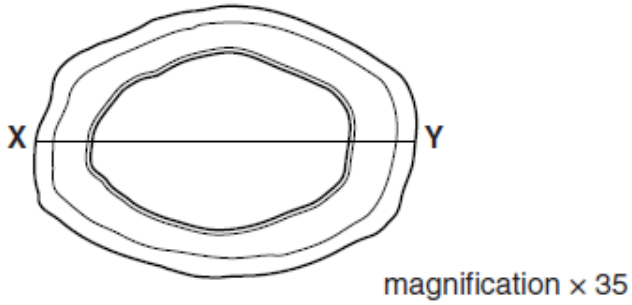

Fig. 1.1

(a) Calculate the actual diameter of the vein marked by the line **X–Y**.

Show your working and give your answer in millimetres (mm).

answer ..... mm [2]

(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]

(d) The inner lining of arteries and veins is composed of a layer of epithelial cells supported by a layer of elastic and connective tissue. The epithelial cells are capable of cell division by mitosis.

(i) State the role of mitosis in cell division of epithelial cells.

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.....[2]

(ii) Explain why the epithelial cells undergo mitosis and **not** meiosis.

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.....[2]

(e) Fig. 1.2 is a diagram of a cell in late prophase of mitosis.

Fig. 1.2

Complete Fig. 1.3 to show the **same cell** in the **anaphase** stage of mitosis.

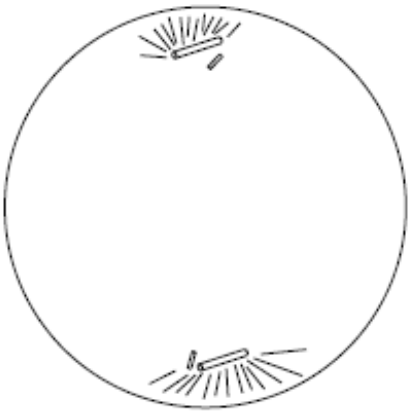

Fig. 1.3

[2]

[Total: 13]