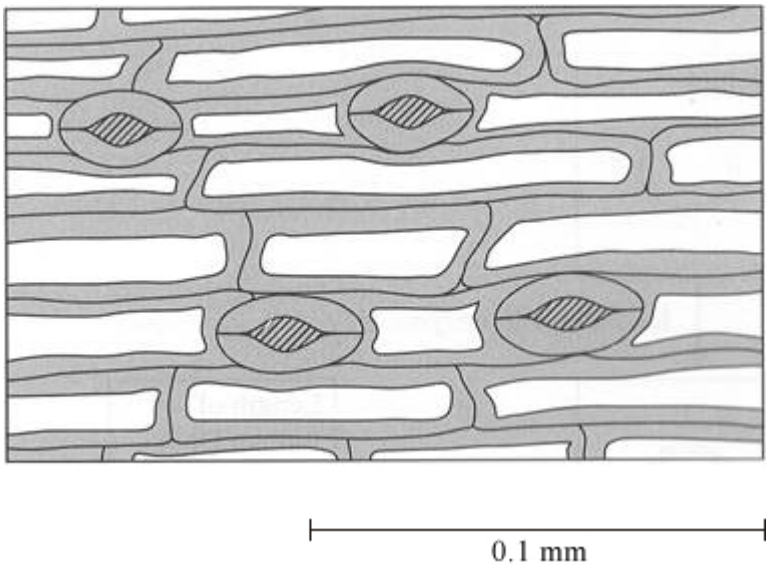
3.2 ORGANISMS AND SUBSTANCE EXCHANGE – GAS EXCHANGE (2) – QUESTIONS

Q1. The drawing shows part of the lower leaf epidermis of sorghum.



(a) Calculate the number of stomata per mm^2 of the leaf surface. Show your working.

Answer _____ stomata per mm^2

(2)

(b) Sorghum has few stomata per mm^2 of leaf surface area. Explain how this is an adaptation to the conditions in which sorghum grows.

_____

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(3)

(Total 5 marks)

Q2. (a) Describe **two** differences between active transport and facilitated diffusion.

1. _____

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2. _____

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(2)

(b) Explain why molecules of oxygen and carbon dioxide are able to diffuse across membranes.

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(2)

(c) Explain why ventilation of the lungs increases the efficiency of gas exchange.

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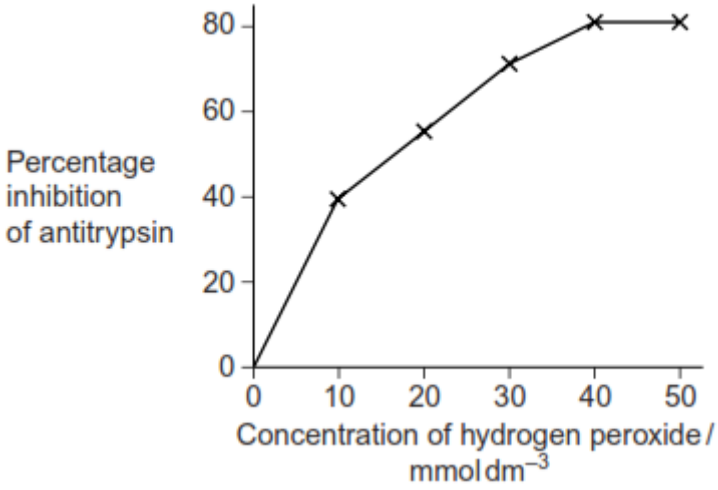
_____ **(2)**

(Total 6 marks)

Q3. Alpha-1-antitrypsin is a protein that reduces the activity of enzymes that can damage lung tissue. Cigarette smoke contains hydrogen peroxide. Hydrogen peroxide reduces the activity of alpha-1-antitrypsin. Scientists investigated the effect of different concentrations of hydrogen peroxide on the activity of alpha-1-antitrypsin. The graph shows their results.



(a) (i) Hydrogen peroxide reacts with two amino acids in alpha-1-antitrypsin. Explain how this reduces activity of the protein.

(2)

(ii) Explain the results shown in the graph.

(2)

(b) Long-term smokers are often short of breath. Use this information to explain why.

(2)

(Total 6 marks)

Q4. (a) When first hatched, the young of some species of fish are less than 2 mm long. Explain how these young fish get enough oxygen to their cells without having gills.

(2)

(b) Mackerel are fast swimming fish whereas toadfish only swim slowly. The table shows some features of the gills of these fish.

	Thickness of lamellae / µm	**Number of lamellae per mm of gill length**
Mackerel	5	32

Toadfish	35	8

Use evidence from the table to explain how mackerel are able to swim faster than toadfish.

(3)

(Total 5 marks)

Q5. This question should be written in continuous prose, where appropriate.
Quality of Written Communication will be assessed in the answer.

(a) Explain how the ventilation mechanism of a fish and the structure of its gills result in the efficient uptake of oxygen from water.

(6)

Table 1 compares some features of water and air.

Feature	Water	Air
Relative density	1000	1
Maximum concentration of oxygen / $cm^3\ dm^{-3}$	9	130

Table 1

Table 2 shows some features of gas exchange in a fish and in a mammal.

Feature	Fish	Mammal
Percentage of oxygen extracted from water or air	80	25
Oxygen consumption at rest / $cm^3\ kg^{-1}\ hour^{-1}$	100	200

Table 2

(b) (i) The fish has a body mass of 0.2 kg. Calculate the volume of water it will need to pass over its gills each hour to supply the oxygen required when resting. Show your working.

Answer _____ dm^3 / $hour^{-1}$

(2)

(ii) Ventilation in mammals involves movement of air to and from the gas exchange surface in a tidal pattern. Using information in the tables, explain why it is easier to move water over the gas exchange surface of a fish in one direction rather than in a tidal pattern.

_____

_____

_____

_____

(2)

(c) A rise in the temperature of water decreases the amount of oxygen dissolved in the water. As the water temperature rises, the rate of ventilation in a fish also rises. Explain the advantage of this.

_____

_____

(2)
(Total 12 marks)

Q6. (a) Describe and explain how fish maintain a flow of water over their gills.

(4)

(b) Describe and explain how the structure of the mammalian breathing system enables efficient uptake of oxygen into the blood.

(6)
(Total 10 marks)

Q7. (a) Describe how air is taken into the lungs.

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_____

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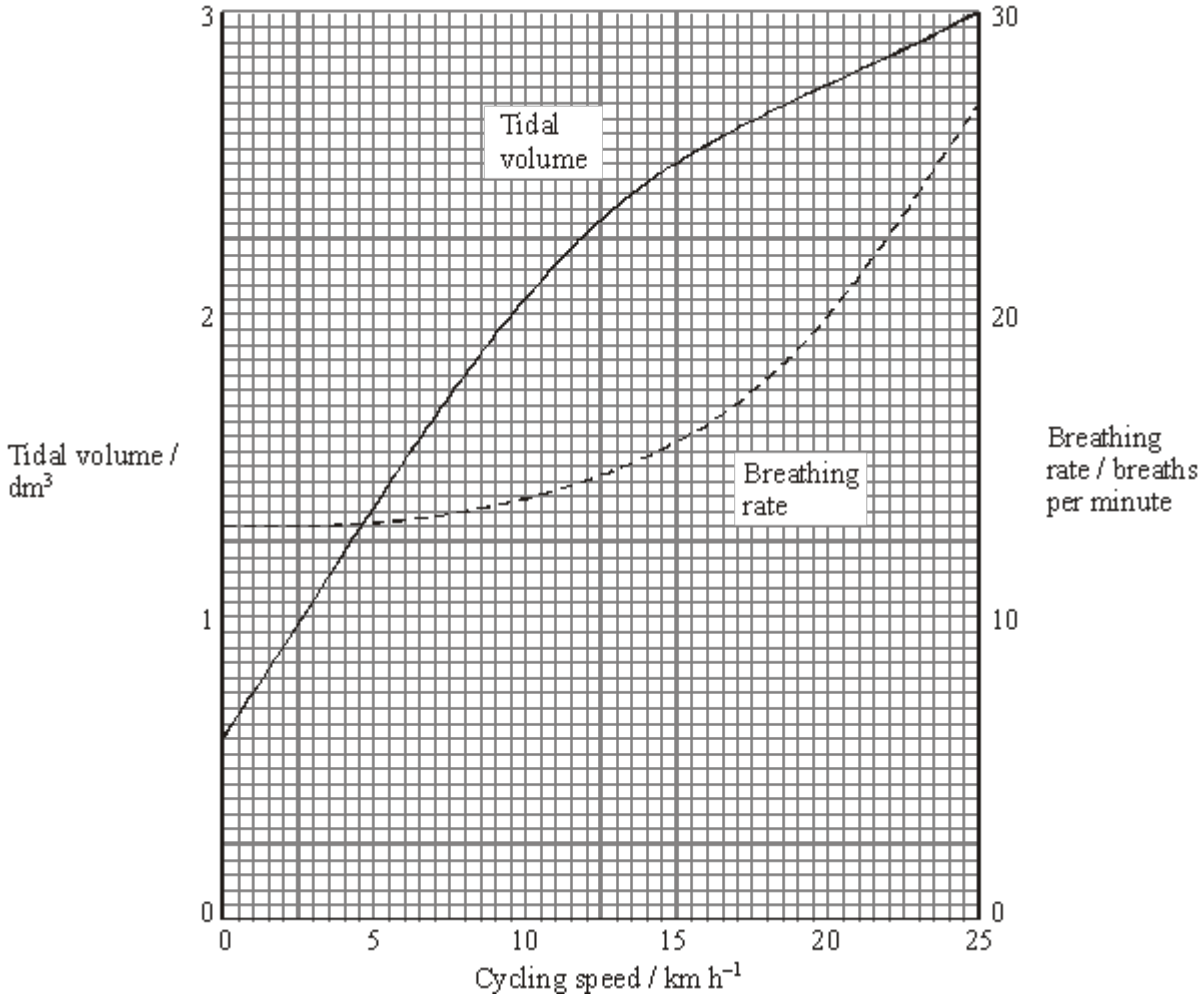
_____

_____

(3)

The volume of air breathed in and out of the lungs during each breath is called the tidal volume. The breathing rate and tidal volume were measured for a cyclist pedalling at different speeds. The graph shows the results.



(b) Describe the **two** curves.

(i) Tidal volume

_____

_____

(ii) Breathing rate

(2)

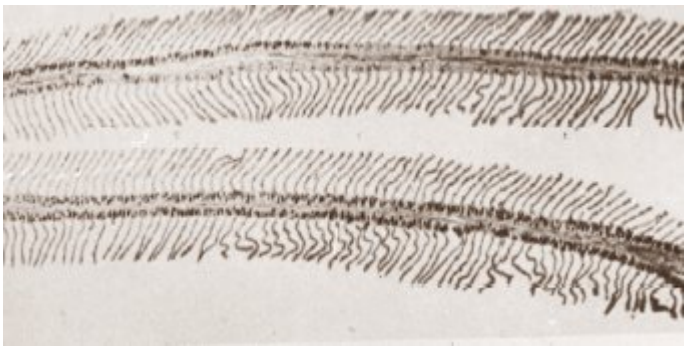
(c) Calculate the total volume of air breathed in and out per minute when the cyclist is cycling at 20 km h^{-1}. Show your working.

_____ dm^3

(2)

(Total 7 marks)

Q8. (a) The photograph shows part of the gill of a fish as seen through a light microscope. It is magnified × 400.



(i) Explain how the structure of the gill makes oxygen uptake efficient.

(2)

(ii) Water containing dissolved oxygen flows over the gill in the opposite direction to the blood flow inside. Explain why this arrangement is important for efficient oxygen uptake.

(2)

(b) There is a one-way flow of water over the gills of a fish whereas there is a two-way flow of air in the lungs of a mammal. Suggest **one** advantage to a fish of this one-way flow of water over its gills.

_____

_____ **(1)**

(Total 5 marks)

Q9. (a) Describe the features of fish gills that give them a large surface area.

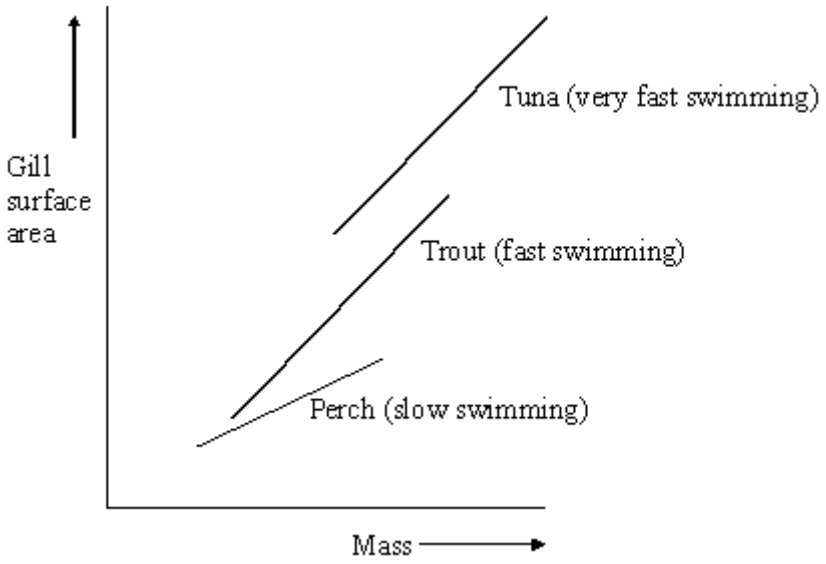
_____

_____

_____

_____ **(2)**

The graph shows the relationship between gill surface area and body mass for three species of fish.



(b) (i) Describe the relationships between gill surface area, mass and swimming speed shown in the diagram.

_____

_____ **(1)**

(ii) Explain the relationship between gill surface area and swimming speed.

_____

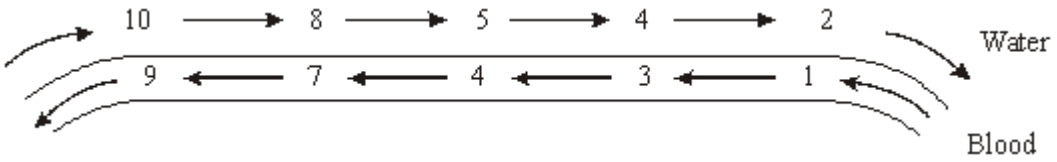
_____

_____

_____ **(2)**

(Total 5 marks)

Q10. (a) The diagram represents the flow of water and blood through the gills of a fish. The figures give relative oxygen concentrations.



Use the information in the diagram to explain the advantage of the countercurrent flow.

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_____

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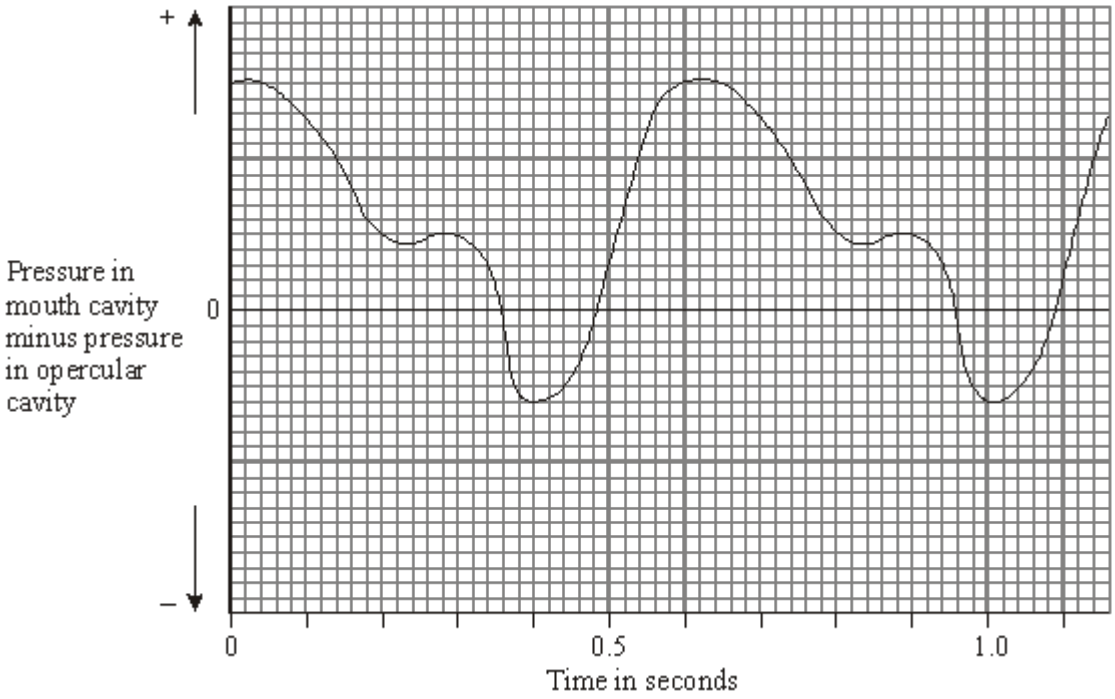
(2)

(b) In the ventilation cycle of a fish, water enters the mouth cavity and then passes through the gills into the opercular cavity. The graph shows the difference in pressure between the mouth cavity and the opercular cavity.



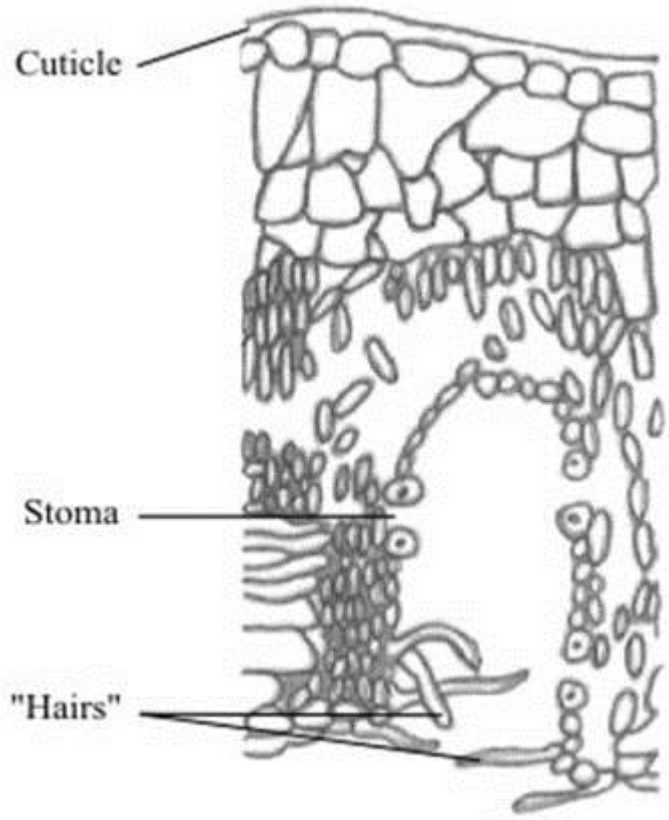
Calculate the number of ventilation cycles per minute of the fish. Show your working.

Answer _____ **(2)**

(Total 4 marks)

Q11. **Figure 1** shows a single stoma and surrounding cells from the leaf of a xerophytic plant.

Figure 1



(i) Explain how the cuticle reduces water loss.

_____

_____

(1)

(ii) Explain how **one** of the other labelled parts reduces water loss.

_____

_____

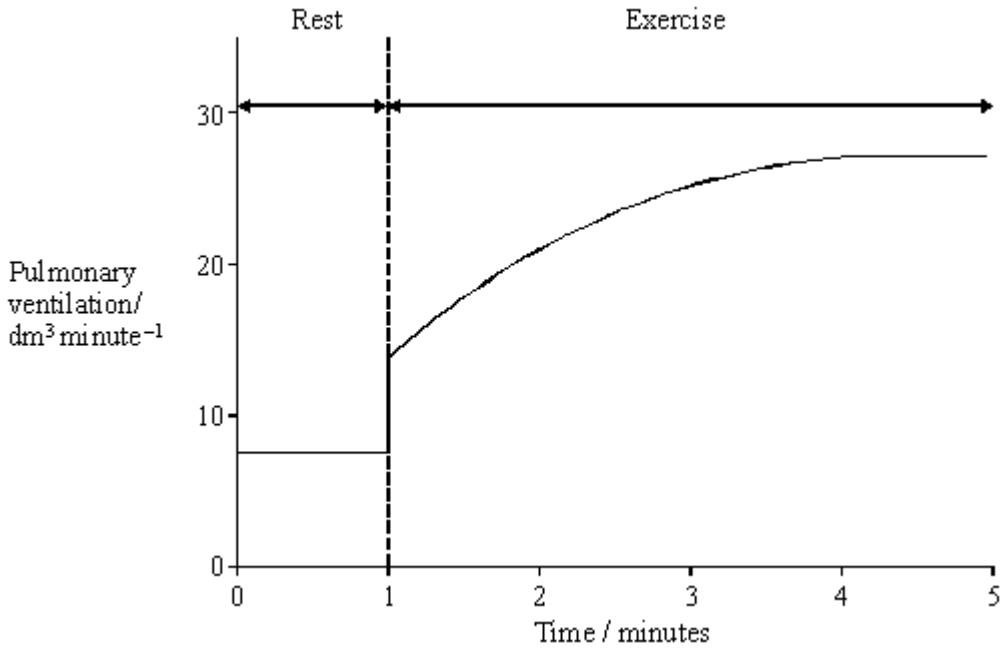
_____

_____

(2)

(Total 3 marks)

Q12. The graph shows how pulmonary ventilation changes during a period of exercise.



(a) Describe how pulmonary ventilation changed during the period of exercise.

_____

_____

_____

(1)

(b) After 4 minutes of exercise, the breathing rate was 20 breaths per minute. Explain how you could use this information and the graph to calculate tidal volume.

_____

_____

_____

_____

(2)

(c) When a person starts to breathe out, the percentage of oxygen in the air first exhaled is the same as the percentage of oxygen in the atmospheric air. Explain why.

_____

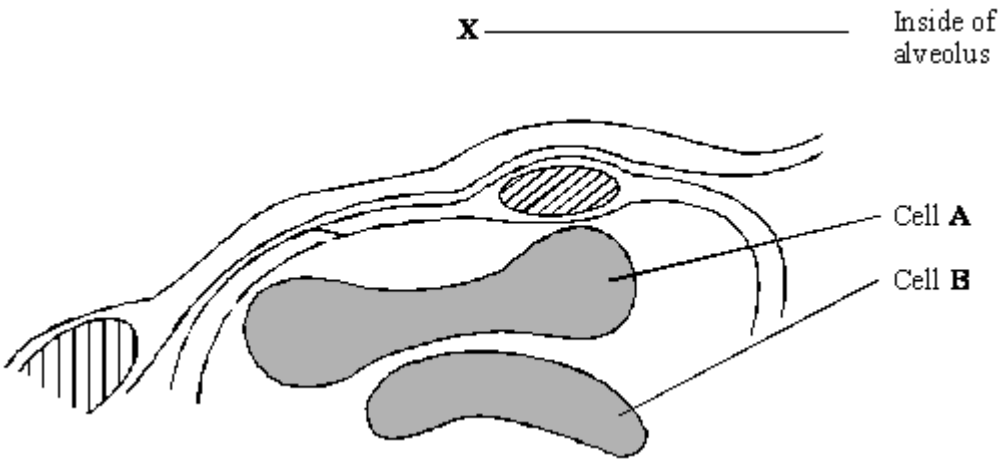
_____

_____

(2)

(Total 5 marks)

Q13. The drawing shows an electron micrograph of a section through part of an alveolus from a lung.



(a) Describe the path of a molecule of oxygen from the air in the alveolus at **X** to the plasma membrane of cell **A**.

_____

_____

(1)

(b) Cell **A** is a eukaryotic cell. Give **two** features that may be found in a prokaryotic cell which are not found in cell **A**.

1. _____

_____

2. _____

_____

(2)

(c) Cells **A** and **B** are biconcave discs. Explain **one** advantage of a biconcave disc over a spherical cell of the same volume in transporting oxygen.

_____

_____

_____

_____

(2)

(d) The diameter of a human red blood cell is 7 μm.

(i) Calculate the magnification of the drawing. Show your working.

Magnification = _____

(2)

(ii) In calculating the magnification, what assumption did you have to make about how the section was cut?

_____

_____

(1)

(Total 8 marks)

Q14. In the lungs, the alveoli are the site of gas exchange.

(a) A large number of small alveoli is more efficient in gas exchange than a smaller number of larger alveoli. Explain why.

_____

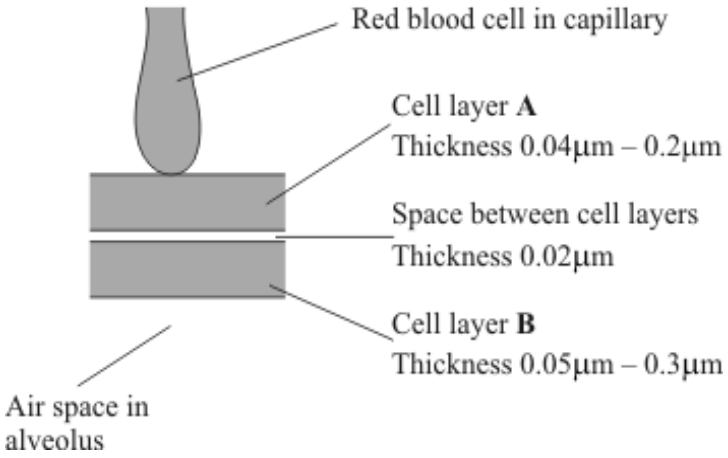
_____

_____

_____

(2)

(b) The diagram shows part of an alveolus and a capillary.



(i) Name the type of cells in layer **B**.

_____

(1)

(ii) What is the minimum distance a molecule of carbon dioxide diffuses from the blood plasma to the air space in the alveolus?

_____

(1)

(c) Just before a person starts to exhale, the composition of the air in an alveolus differs from the composition of the air in the trachea.

(i) Give **two** ways in which the composition would differ.

1. _____

2. _____

(1)

(ii) Explain what causes this difference in composition between the air in the alveolus and the air in the trachea.

_____

_____

(1)

(d) The partial pressure of a gas is a measure of the amount of gas that is present.
The partial pressure of carbon dioxide in blood going to the lungs is 6.3 kPa.
The partial pressure of carbon dioxide in an alveolus is 5.3 kPa.

(i) Through which vessel does blood leave the heart to go to the lungs?

_____

(1)

(ii) Suggest why blood returning to the heart from the lungs contains some carbon dioxide.

_____

_____

_____

_____

(2)

(Total 9 marks)

Q15. Lung cancer, chronic bronchitis and coronary heart disease (CHD) are associated with smoking. **Tables 1** and **2** give the total numbers of deaths from these diseases in the UK in 1974.

Table 1 Men

Age/years	Number of deaths (in thousands)		
	lung cancer	chronic bronchitis	coronary heart disease
35 - 64	11.5	4.2	31.7
65 - 74	12.6	8.5	33.3
75+	5.8	8.1	29.1
Total (35 - 75+)	29.9	20.8	94.1

Table 2 Women

Age/years	Number of deaths (in thousands)		
	lung cancer	chronic bronchitis	coronary heart disease
35 – 64	3.2	1.3	8.4
65 – 74	2.6	1.9	18.2
75+	1.8	3.5	42.3
Total (35 – 75+)	7.6	6.7	68.9

(i) Using an example from the tables, explain why it is useful to give data for men and women separately.

_____

_____

_____

(2)

(ii) Data like these are often given as percentages of people dying from each cause.

Explain the advantage of giving these data as percentages.

_____

_____

_____

_____

(2)

(Total 4 marks)

Q16. (a) Describe the part played by the diaphragm in causing air to enter the lungs during breathing.

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_____

(3)

Seals are mammals. They have lungs and must breathe air. They can dive and remain under

water for a long time. The table shows the flow of blood to the lungs and to the diaphragm in a seal when it is on land and when it is under water.

Organ	Blood flow / $cm^3\ min^{-1}\ g^{-1}$	
	On land	**Under water**
Lungs	0.88	0.52
Diaphragm	0.21	0.02

(b) Explain why the figures in the table are given per gram of tissue.

_____

_____

_____

_____

(2)

(c) Calculate the percentage by which blood flow to the lungs is reduced when a seal is swimming under water. Show your working.

Answer _____

(2)

(d) There is a greater percentage reduction in blood flow to the diaphragm than to the lungs during a dive. Explain the advantage to a diving seal of

(i) blood continuing to flow to the lungs;

_____

_____

(1)

(ii) a large reduction in blood flow to the diaphragm.

_____

_____

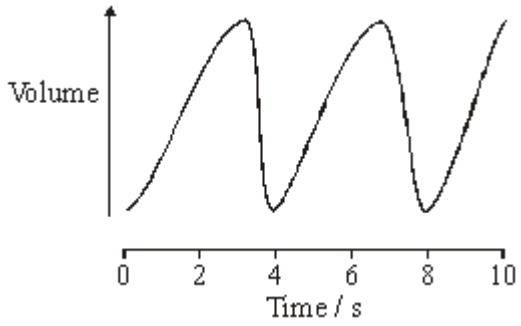
_____

_____

(2)

(Total 10 marks)

Q17. A person was sitting at rest and breathing normally. A recording was made of the changes in the volume of air in his lungs over a ten-second period. The diagram shows this recording.



(a) Describe the part played by muscles in bringing about the change between 3 and 4 seconds.

_____

_____ **(1)**

(b) Describe how an increase in lung volume leads to air entering the lungs.

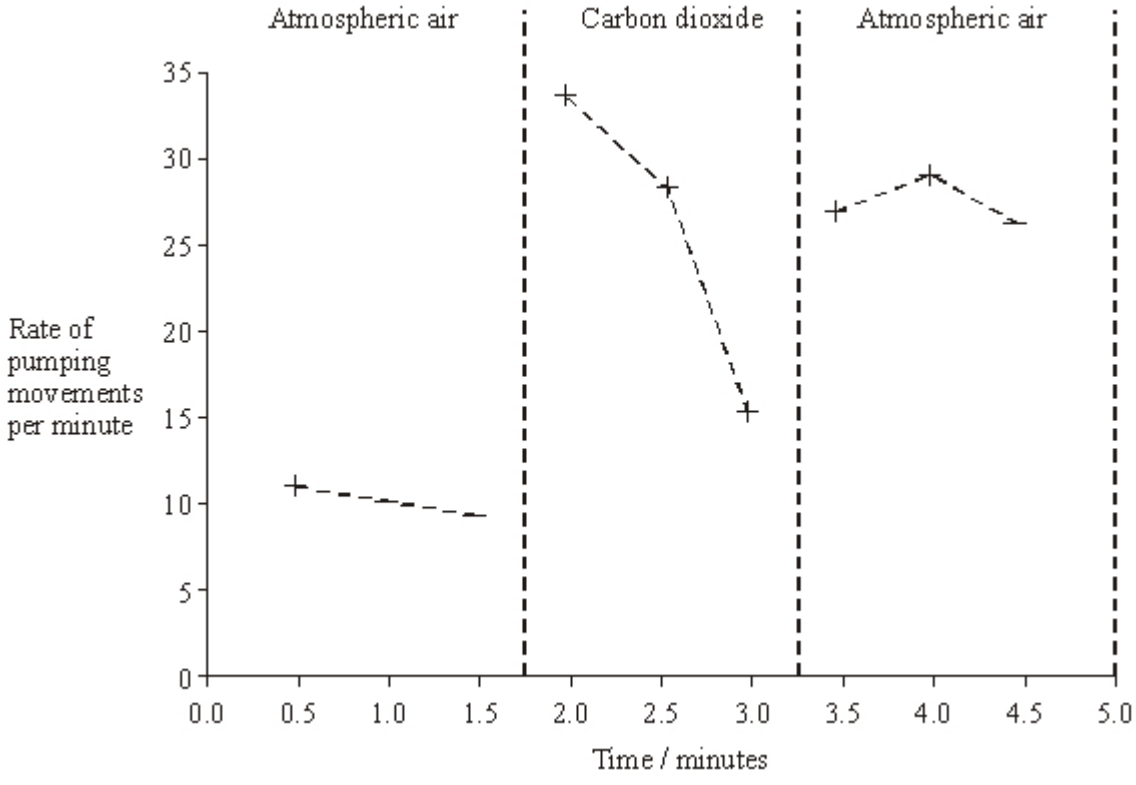
_____

_____ **(1)**

(Total 2 marks)

Q18. In an investigation, a locust was given alternating supplies of atmospheric air and pure carbon dioxide. The rate of pumping movements of the insect's abdomen was measured.

The graph shows the results.



(a) Explain what caused

(i) the rise in the rate of abdominal pumping movements between 1.5 and 2.0 minutes,

_____

_____

(1)

(ii) the fall in the rate of abdominal pumping movements between 2.0 and 3.0 minutes.

_____

_____

_____

_____

(2)

(b) The rate of abdominal pumping movements increases between 3.0 and 3.5 minutes. Suggest the advantage of this change to the locust.

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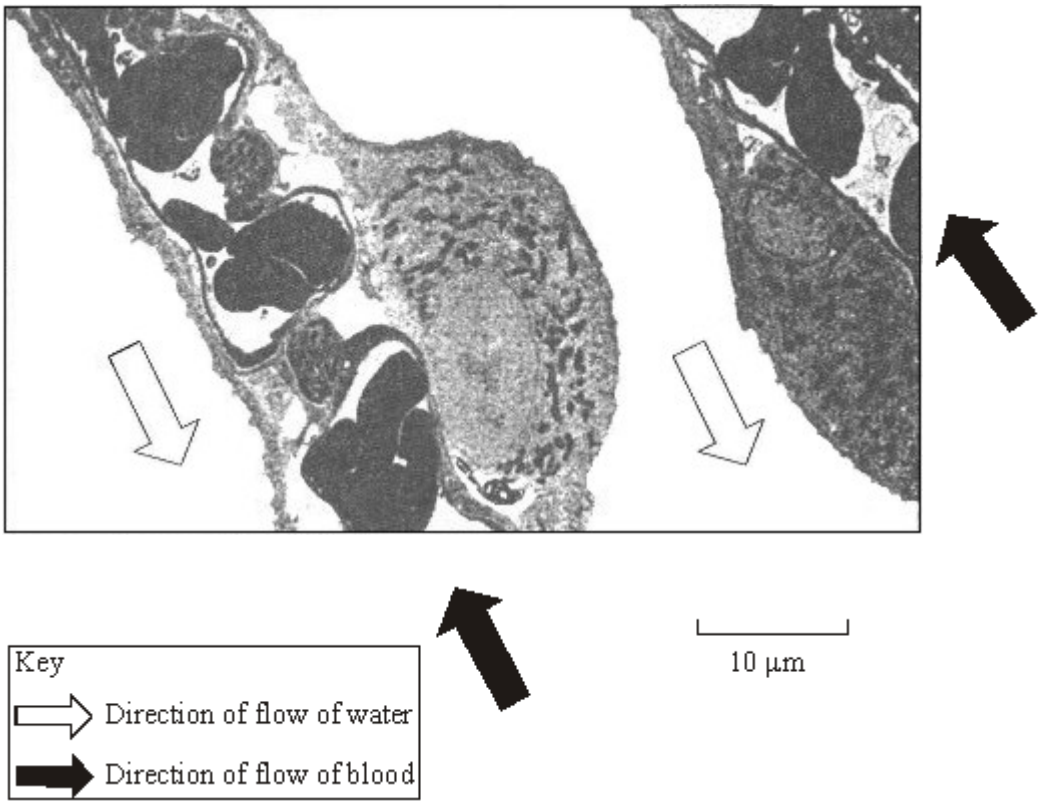
_____

(1)

(Total 4 marks)

Q19. The electron micrograph shows a section through a fish gill. The directions of flow of water and of blood are indicated by arrows.



Source: www.ucdavis.edu/mjguinan

(a) Calculate the minimum distance that a molecule of oxygen would have to travel from the water to a red blood cell. Give your answer in micrometres and show your working.

Answer _____ μm. **(2)**

(b) Explain how the relationship between the direction of flow of water and of blood shown in the micrograph is useful to a fish.

_____

_____

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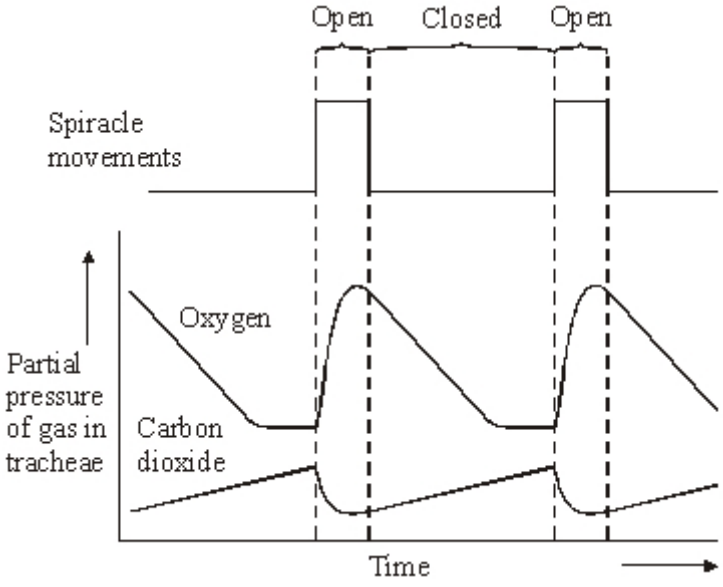
_____ **(3)**

(Total 5 marks)

Q20. Many insects release carbon dioxide in short bursts even though they produce it at a constant rate. The diagram shows how this is achieved in one particular insect.



(a) Using information from the diagram, suggest what stimulates the spiracles to open.

_____

_____ **(1)**

(b) Explain what causes the oxygen concentration in the tracheae to fall when the spiracles are closed.

_____

_____

_____

_____

(2)

(c) The insect lives in dry conditions. Suggest an advantage of the pattern of spiracle movements shown in the diagram.

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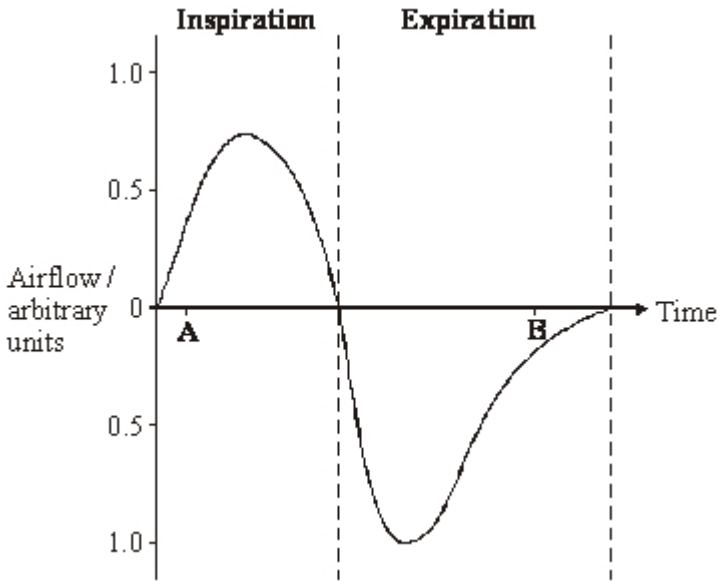
_____

(2)

(Total 5 marks)

Q21. The graph shows airflow into and out of the lungs during a normal breath.



(a) (i) How will the concentration of carbon dioxide in the airflow differ at times **A** and **B**?

_____

_____

(1)

(ii) Describe the role of diffusion in producing this difference.

_____

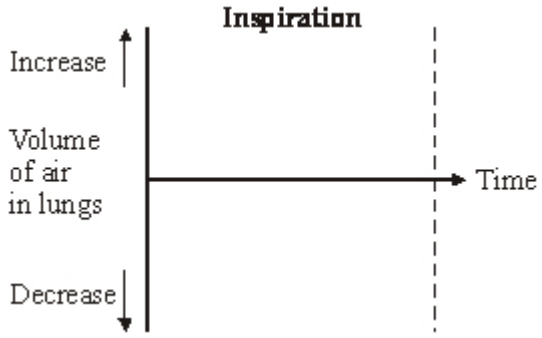
_____

_____

_____

(2)

(b) Use information from the graph to sketch a curve on the axes below to show how the volume of air in the lungs changes during inspiration.



(2)

(c) The intercostal muscles are between the ribs. In normal breathing, describe the part played by the intercostal muscles

(i) during inspiration;

_____

_____

_____

_____

_____

_____

(3)

(ii) during expiration.

_____

_____

(1)

(Total 9 marks)