IB · HL · Biology

2 hours 18 questions

Structured Questions

# Gas Exchange

Gas Exchange in Organisms / Mammalian Lungs: Adaptations / Mechanism of Ventilation / Measuring Lung Volumes: Skills / Gas Exchange in Plants / Drawing Leaf Structure: Skills / Determining Stomatal Density: Skills / Haemoglobin & Oxygen (HL) / The Bohr Shift (HL) / The Oxygen Dissociation Curve (HL)

| | |
|---|---|
| Easy (5 questions) | /35 |
| Medium (6 questions) | /48 |
| Hard (7 questions) | /65 |
| **Total Marks** | **/148** |

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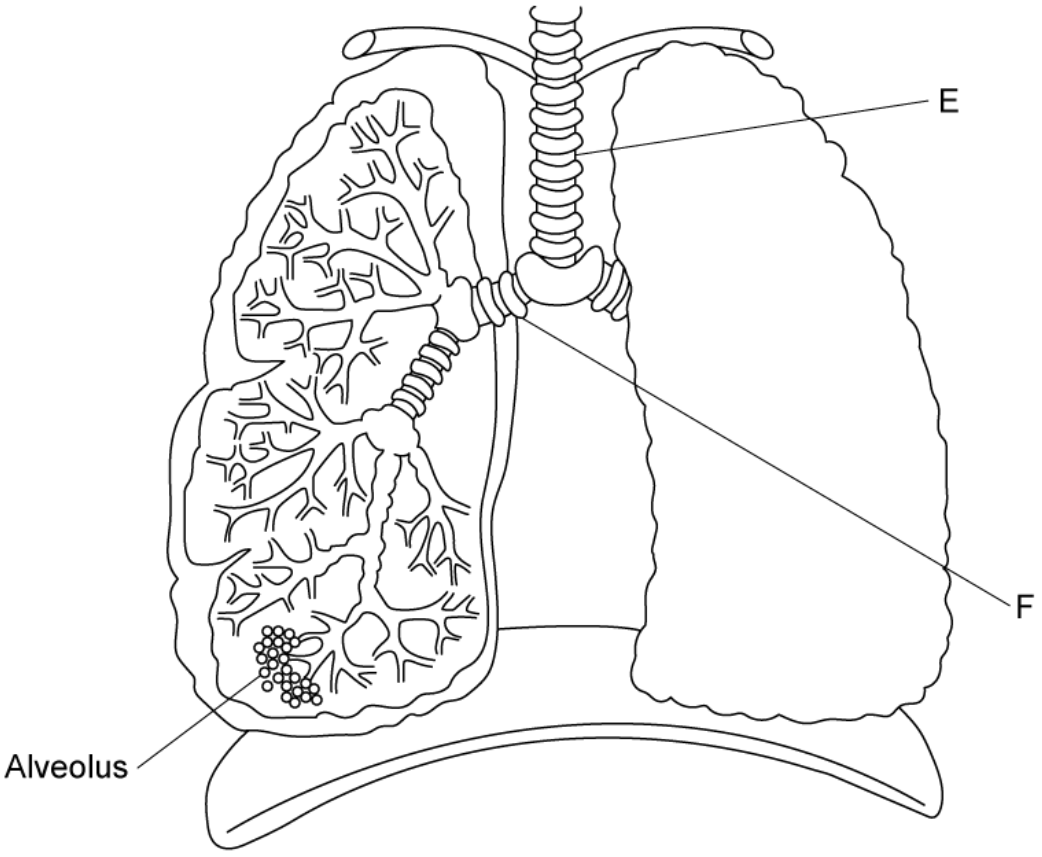
# Easy Questions

**1 (a)** Some of the structures involved with the movement of air into the lungs are shown in the diagram below.




Identify structures **E** and **F**.

.....

.....

**(2 marks)**

**(b)** Both structures **E** and **F** contain cartilage.

State the role of cartilage in structures **E** and **F**.

.....

**(1 mark)**

**(c)** The alveolus in the diagram in part a) is lined with cells known as Type I pneumocytes.

Explain how Type I pneumocytes are adapted to their function.

.....

.....

**(2 marks)**

**(d)** In amongst the Type I pneumocytes described in part c) are cells known as Type II pneumocytes. Type II pneumocytes secrete a solution which covers the lining of the alveolus.

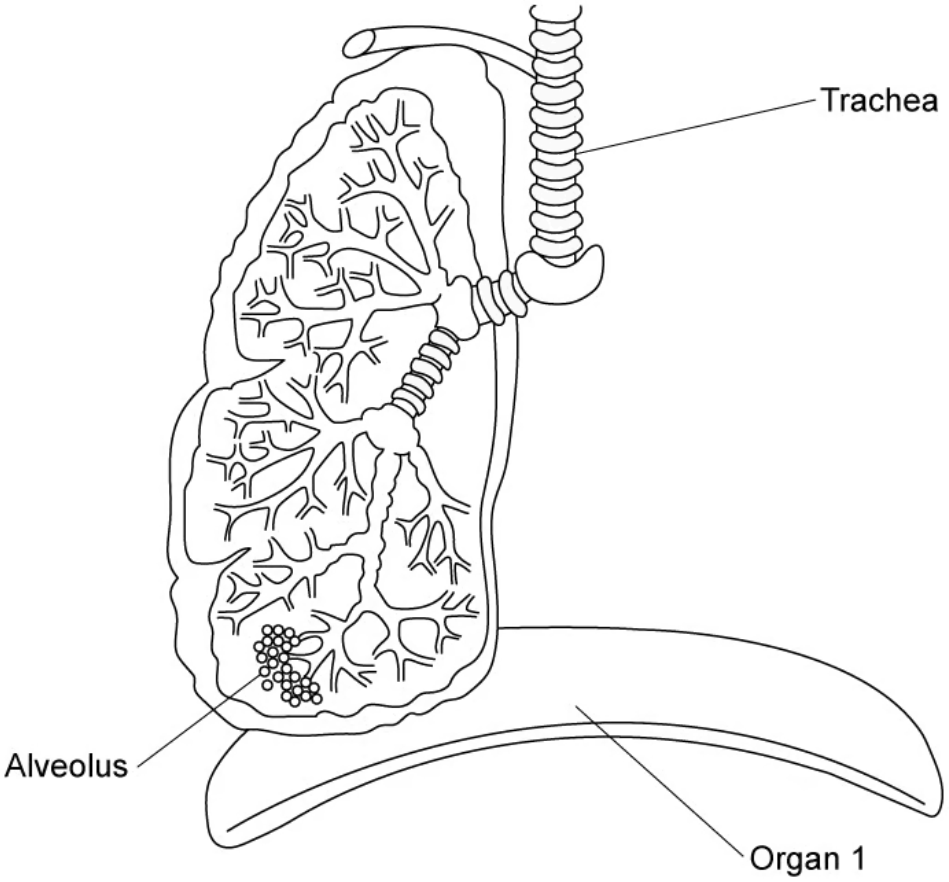
State **two** ways in which the solution secreted by Type II pneumocytes aids alveolar function.

.....

.....

**(2 marks)**

**2 (a)** The diagram below shows some of the structures in the human body involved with the ventilation process.




Identify **Organ 1** in the diagram above.

.....

**(1 mark)**

**(b)** Describe how the contraction of **Organ 1** in part a) aids the inspiration process.

.....

.....

**(2 marks)**

**(c)** Organ 1 is part of an antagonistic pair of muscles.

Explain what is meant by the term **antagonistic pair**.

.....

.....

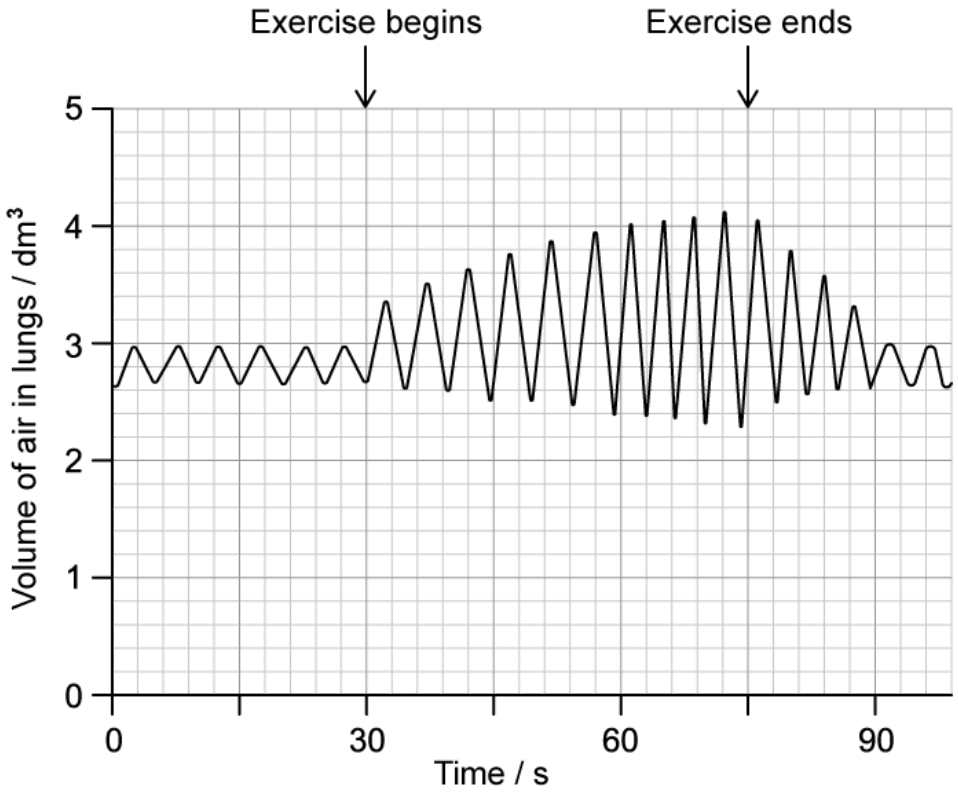
**(2 marks)**

**(d)** Aside from the antagonistic pair that includes Organ 1, identify **one other** antagonistic pair of muscles involved with inspiration and expiration.

.....

**(1 mark)**

**3 (a)** A group of students investigated the effect of physical activity on ventilation. The graph below shows the results of their investigation.




Calculate the ventilation rate while at rest.

.....

**(1 mark)**

**(b)** Describe the effects of exercise on ventilation shown in the graph in part a).

.....

.....

**(2 marks)**

**4 (a)** Outline the process of forced, or active, expiration.

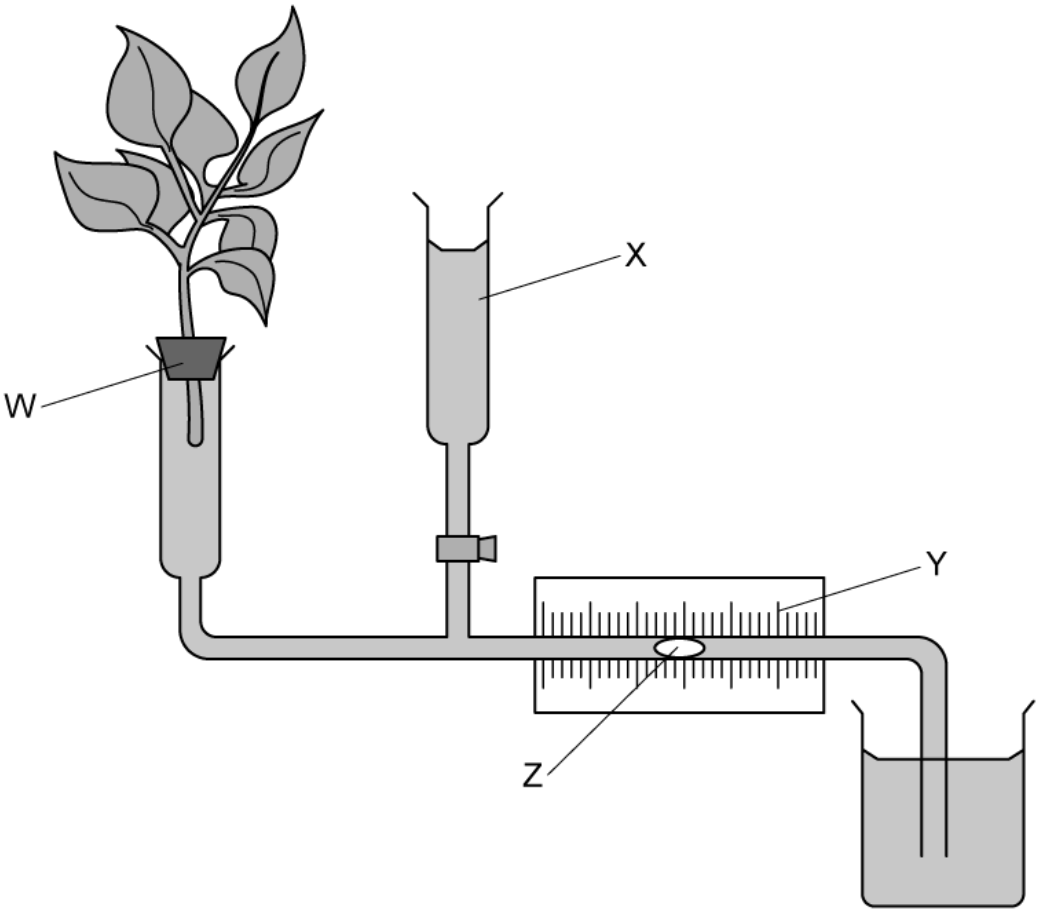
**(4 marks)**

**(b)** Describe how the effect of mild and vigorous exercise on ventilation can be monitored.

**(4 marks)**

**5 (a)** A bubble potometer can be used to investigate the rate of transpiration.

The diagram shows the apparatus required in a bubble potometer.




The table shows some of the functions of this apparatus.

| Function | Letter |
|---|---|
| Used to measure the distance moved by the bubble in cm | |
| Prevents evaporation of water from the equipment | |
| Adds water to the equipment to reset the bubble | |
| Indicates the volume of water used in transpiration | |

Complete the table with the letters which correctly represent the feature described.

**(3 marks)**

**(b)** Some students set up a potometer similar to the one in part **a)**, in a classroom at 20 °C with no air movement. Over the course of 25 minutes, they calculated that 7.5 $mm^3$ of water was lost through transpiration.

Calculate the rate of transpiration shown by the shoot, in **$mm^3$ $hr^{-1}$.**

**(2 marks)**

**(c)** To see the effect of different environmental factors on the rate of transpiration, the students adjusted the temperature, air movement, humidity and light intensity in the room.

Identify what the students would expect to happen to the rate of transpiration in the following scenarios, by completing the table below:

| Scenario | Effect on transpiration (increase/decrease/no effect) |
|---|---|
| Increased the room temperature | |
| Turned on a fan | |
| Turned on a humidifier | |
| Surrounded the plant by lamps | |

**(4 marks)**

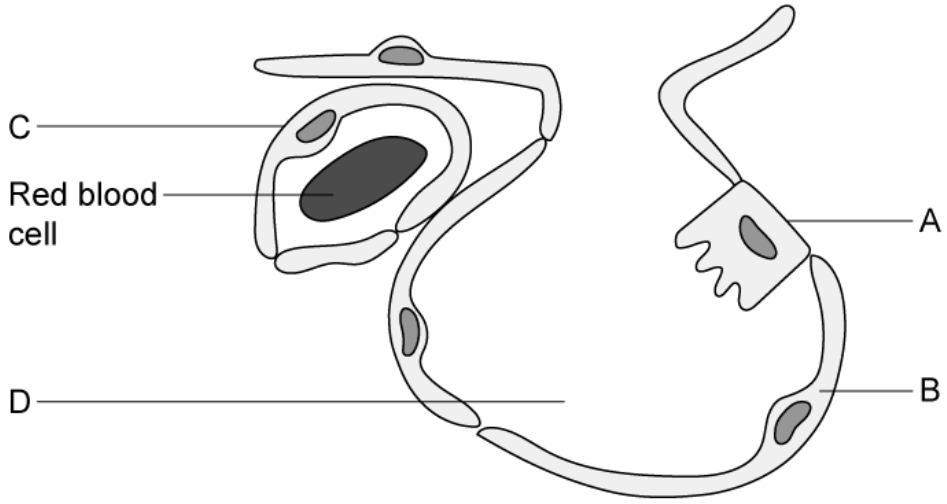
**(d)** During the set up of the potometer shown in part **a)**, the plant stem was cut underneath water before being positioned in the equipment as shown.

Explain why is it necessary to cut the stem underneath the water for this investigation.

**(2 marks)**

# Medium Questions

**1 (a)** The diagram below shows a cross section of an alveolus and associated structures.




(i) Label the structures **A**- **D**

(ii) Give an adaptation of structures **A** and **B**

.....

.....

**(2 marks)**

**(b)** Describe the route taken by an oxygen molecule from an alveolus to the blood.

.....

.....

**(2 marks)**

**(c)** Explain how the fluid secreted by the epithelial cells of the alveolus helps to reduce surface tension and prevent adhesion of the alveolar surface.

.....

**(4 marks)**

**(d)** State the mode of molecular transport by which oxygen from air in the alveoli enters the blood in capillaries.

**(1 mark)**

**2 (a)** Explain how the volume of the thorax increases during inspiration.

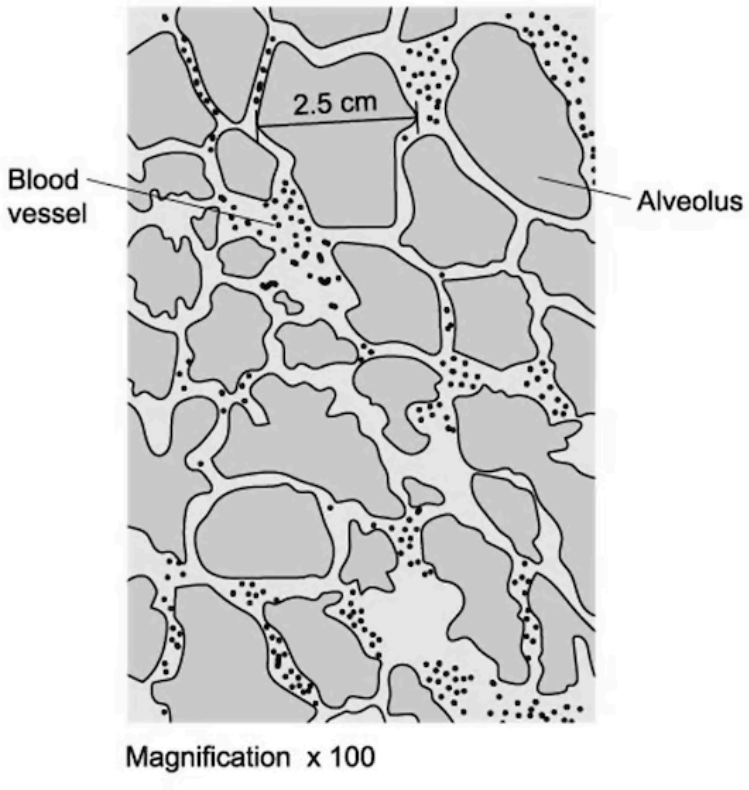
.....

.....

**(2 marks)**

**(b)** The diagram below shows a micrograph of thinly sliced lung tissue.

**Figure 1**



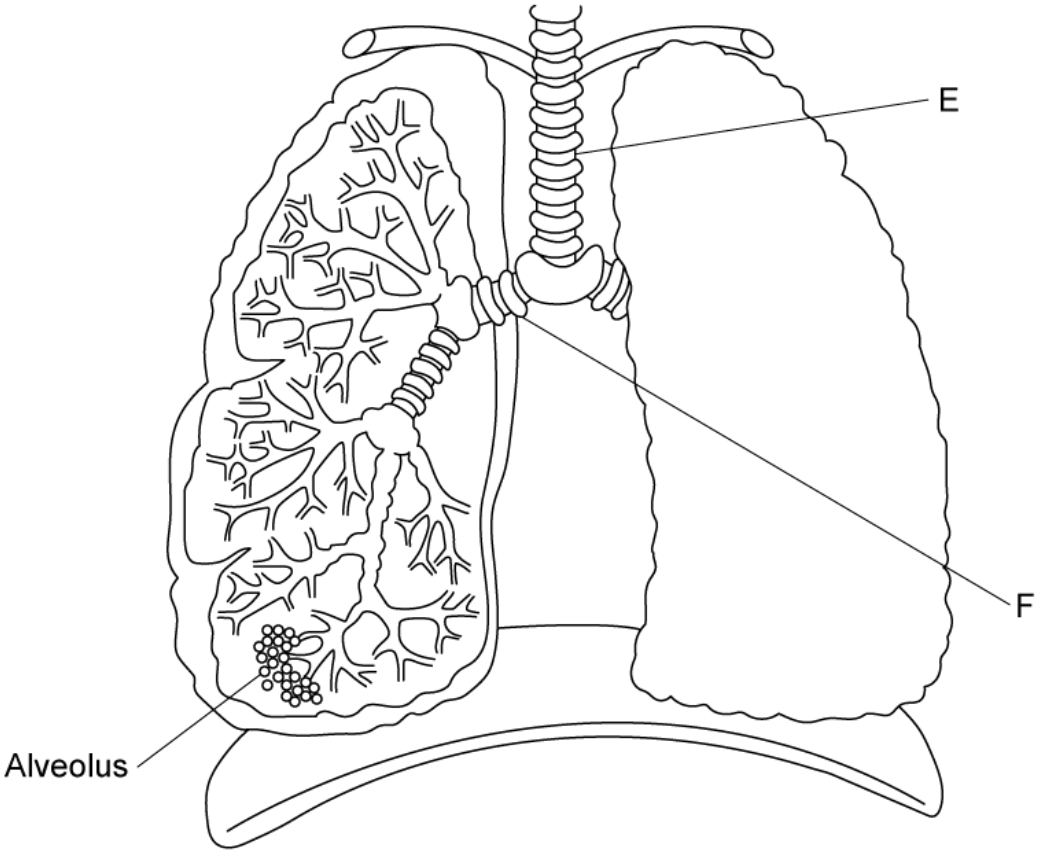

Calculate the actual size, in micrometres, of the alveolus diameter that has been measured in the diagram.

.....

.....

**(2 marks)**

**(c)** The diagram below shows the structure of the human gas exchange system




Identify structures **E** and **F**

.....

**(1 mark)**

**(d)** Explain how the downward movement of the diaphragm leads to air entering the lungs

.....

.....

.....

**(3 marks)**

**3 (a)** Describe and explain **two** adaptations of alveoli that enable rapid gas exchange.

**(2 marks)**

**(b)** Describe the route taken by a carbon dioxide molecule from the blood to the outside air.

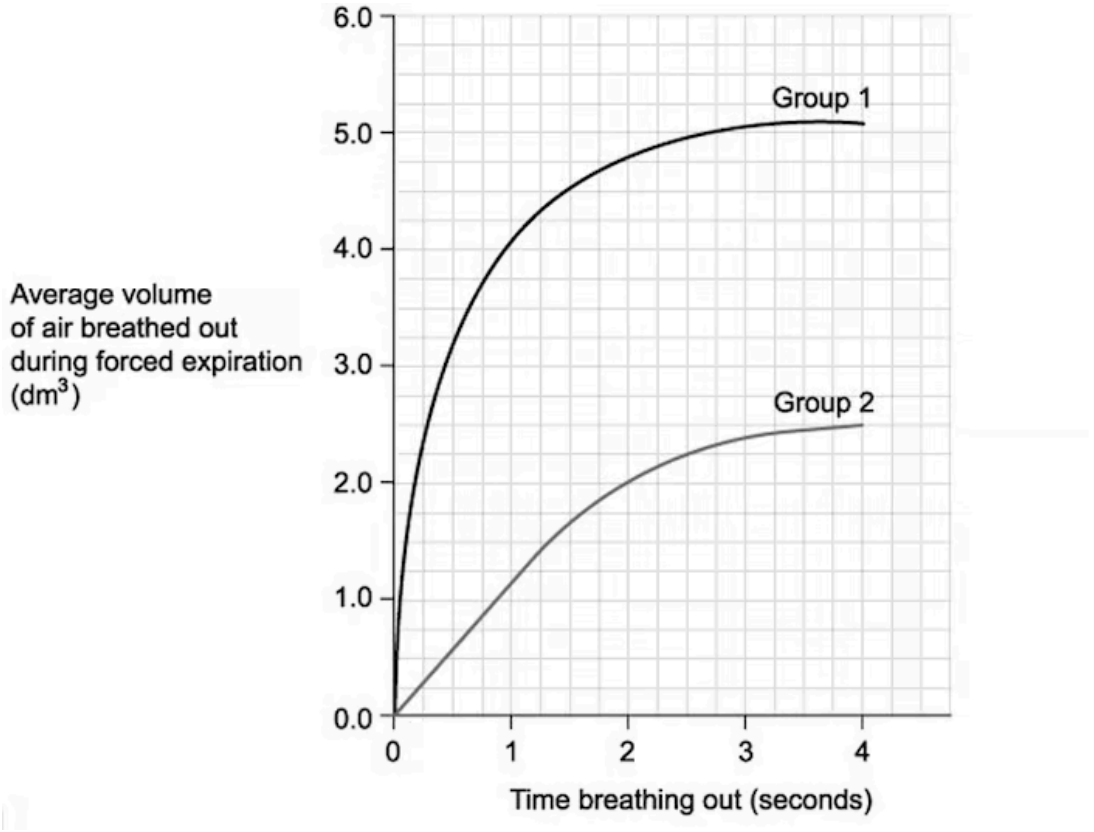
**(4 marks)**

**(c)** Two groups of people were asked to take part in a study. The individuals in group **1** were healthy and the individuals in group **2** had recently recovered from an asthma attack.

In the experiment each individual was asked to breathe in as deeply as they could. They then breathed out via forced expiration.

A study coordinator measured the volume of air that each individual breathed out during forced expiration.

The graph below shows the results.




The FEV (forced expiration volume) is the volume of air that an individual can breathe out within a single second.

Using the graph, calculate the percentage difference in the FEV for group **2** compared with group **1**.

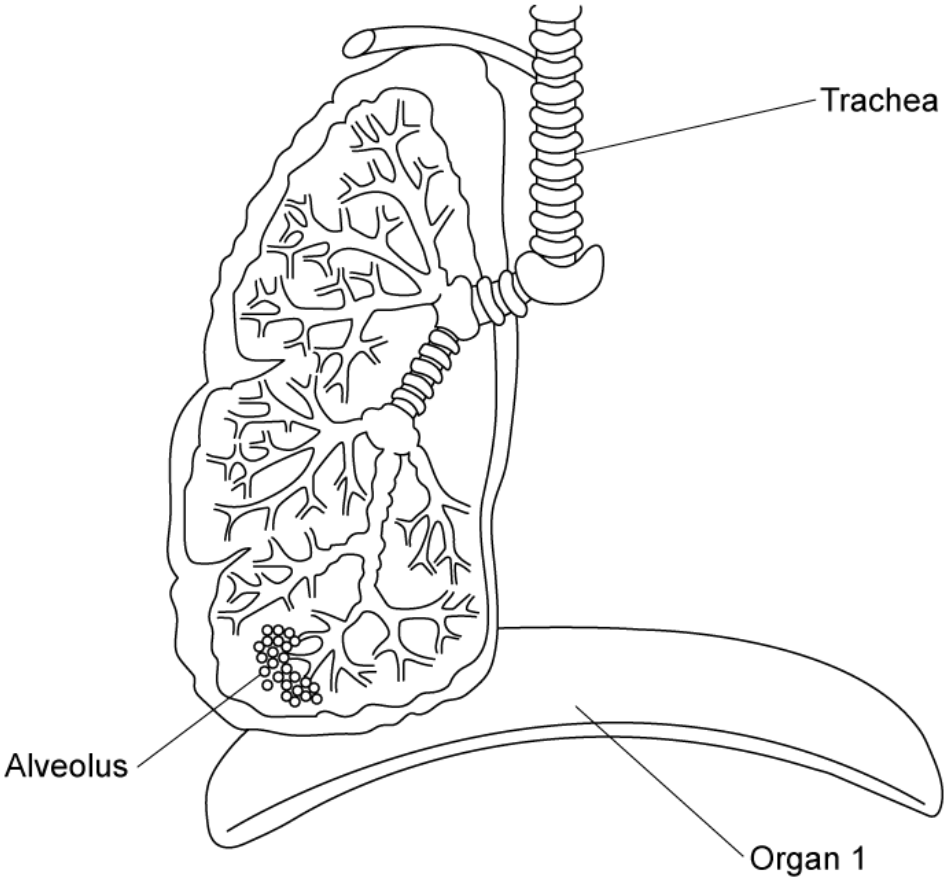
.....

.....

**(2 marks)**

**4 (a)** The diagram below depicts a section of the human gas exchange system.

**Figure 1**




State the name of **Organ 1** and describe its role in breathing out.

.....

.....

.....

**(3 marks)**

**(b)** In normal and healthy lungs, an oxygen concentration gradient is maintained between the alveoli and the lung capillaries. Describe and explain how this is maintained.

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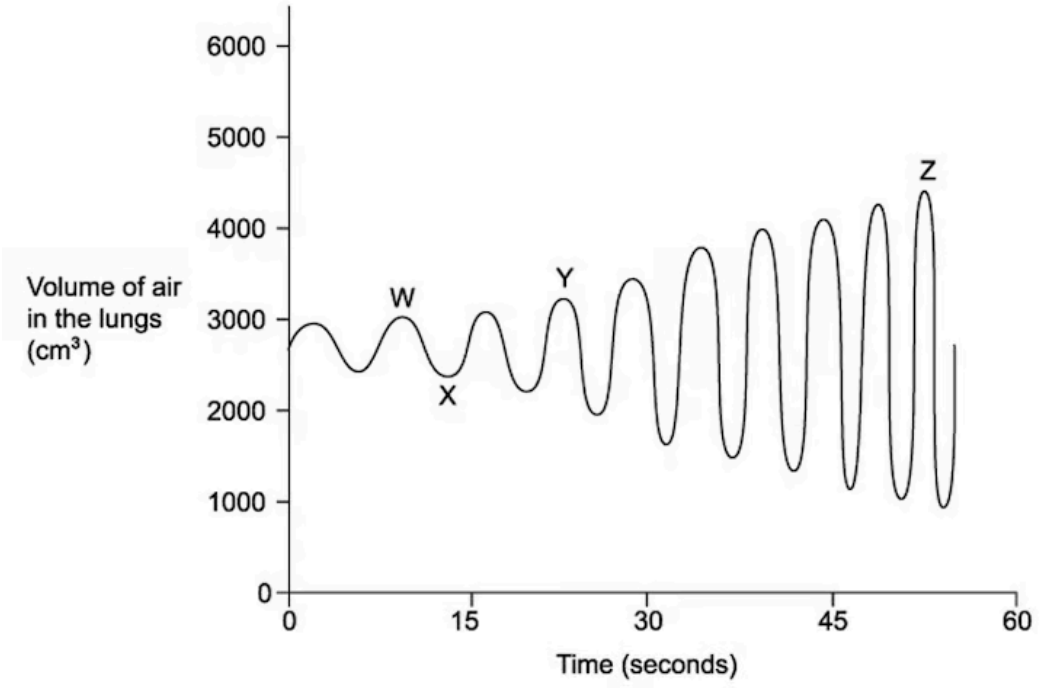
**(4 marks)**

**(c)** The graph below shows the changes in the volume of air in a woman's lungs while breathing.




Explain how the graph shows that the woman was breathing out between times **W** and **X**.

**(1 mark)**

**(d)** Muscle action during ventilation is described as antagonistic.

Outline what this means with reference to **one** example during ventilation.

**(1 mark)**

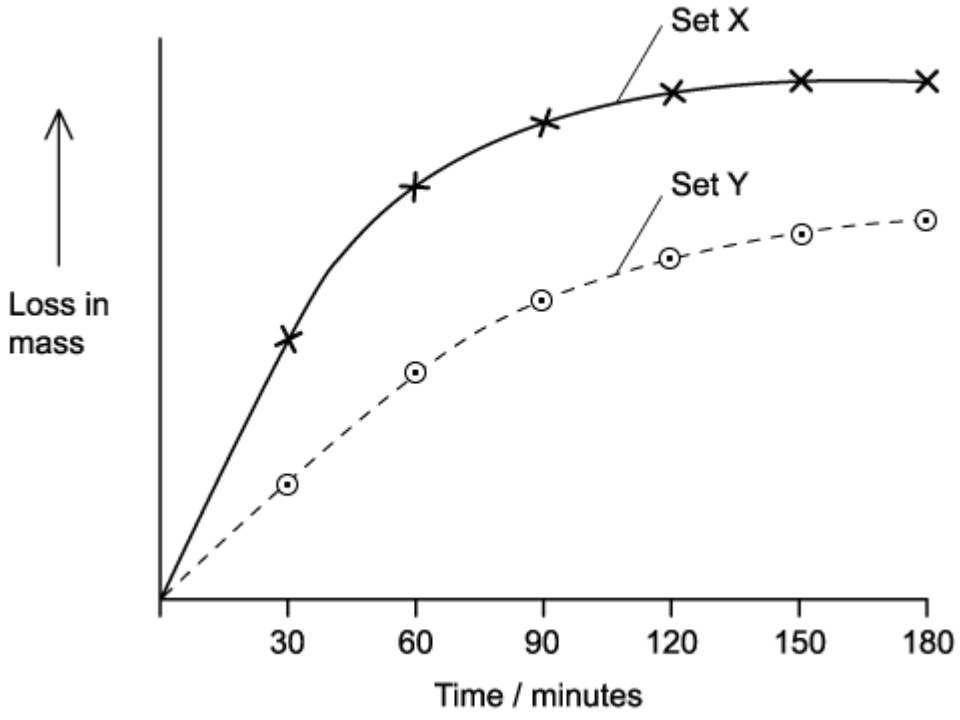
**5 (a)** Define the term *transpiration*.

.....

**(1 mark)**

**(b)** Holly is a common type of evergreen plant that can be found in British gardens. The leaves of holly bushes possess particularly thick waxy cuticles. A student investigated the rate of transpiration in holly leaves. They cut 10 leaves for set **X** and 10 leaves for set **Y**. The student then covered the leaves in set **Y** in petroleum jelly. After weighing each set of leaves, they attached the leaves in each set to a separate wire.The student then weighed each set of leaves at 30-minute intervals for a duration of 3 hours.

Their results are seen in the graph below.




Environmental conditions can affect the rate of transpiration in plants. State **two** environmental variables that should be controlled in this investigation.

.....

.....

**(2 marks)**

**(c)** As seen in the graph in part b), between 90 minutes and 120 minutes the rate of transpiration begins to slow in both sets of leaves.

Explain why this happens.

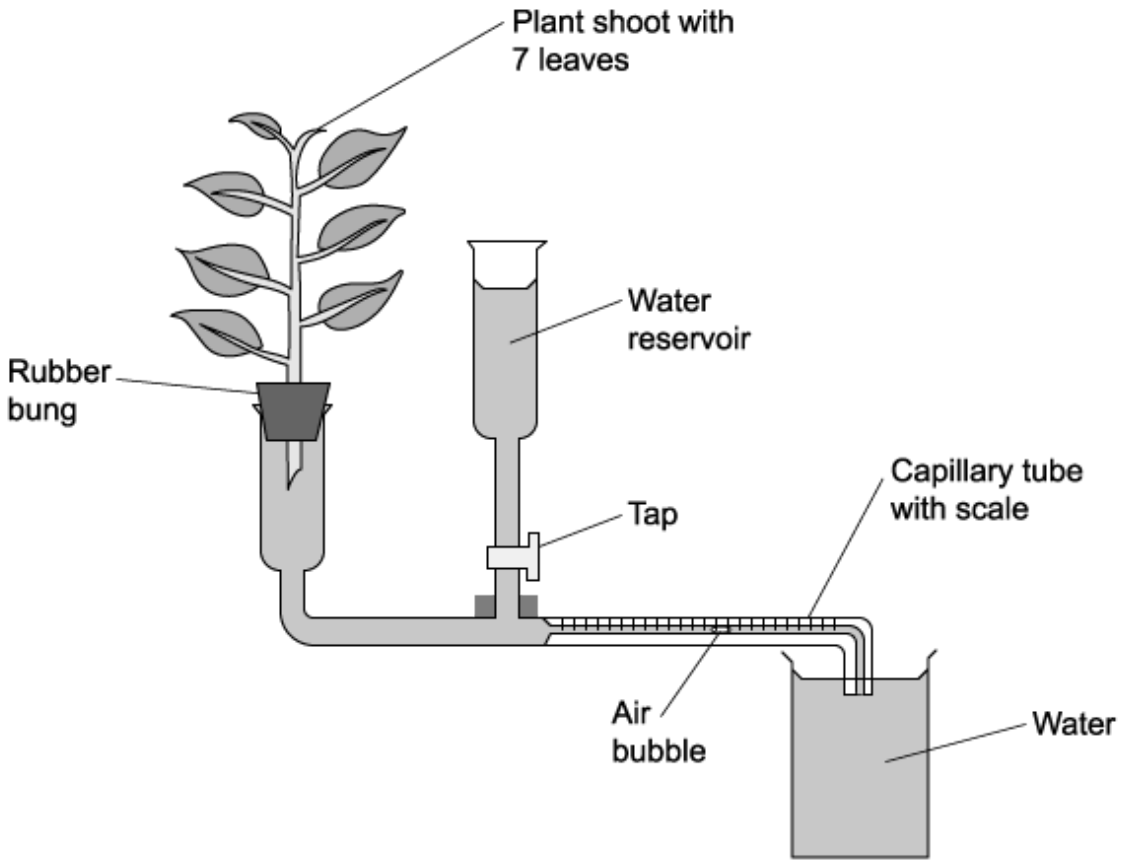
**(3 marks)**

**(d)** The results for the leaves in set **X** are different from the leaves in set **Y**.

Suggest an explanation for this.

**(2 marks)**

**6 (a)** A potometer can be used to investigate the water uptake of plants under different conditions. The diagram below shows how a student set up a potometer to investigate the rate of water uptake in a plant shoot.




When setting up the potometer one of the precautions the student took to ensure reliable measurements of water uptake was to dry off the leaves before taking any measurements.

Suggest a reason for this.

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**(1 mark)**

**(b)** Identify **two** other precautions the student should take when setting up the potometer apparatus to ensure they obtain reliable results.

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**(2 marks)**

**(c)** A potometer measures the water uptake of a plant in a given time.

Suggest **three** reasons why the measurements taken from a potometer do not represent the true rate of transpiration in a plant.

**(3 marks)**

# Hard Questions

**1 (a)** Describe the pathway taken by a molecule of oxygen from the outside air to the blood of a human.

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**(3 marks)**

**(b)** Premature babies can suffer from a deficiency of a substance referred to here as substance **X**. This can lead to a condition known as respiratory distress syndrome (RDS). The image below shows the possible appearance of the lung tissue of an RDS patient (left) and the appearance of normal lung tissue (right).

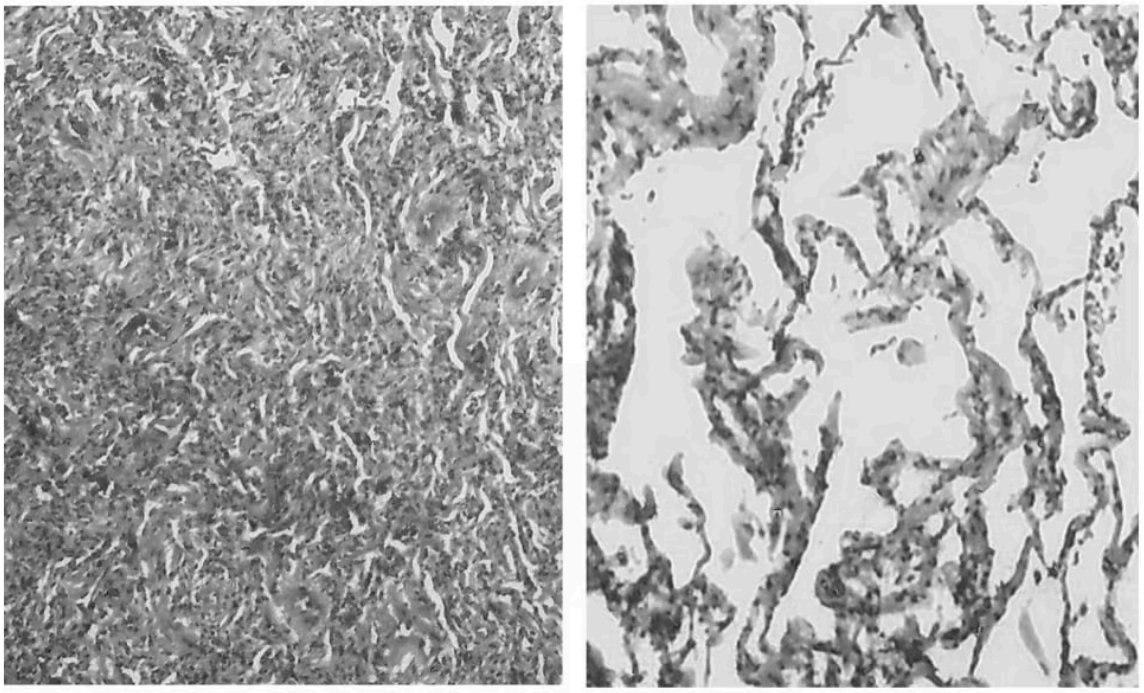

Image courtesy of Atlas of Pulmonary Pathology, licensed under the Creative Commons Attribution-ShareAlike 2.0 Generic license, and adapted and redistributed under conditions found at https://creativecommons.org/licenses/by-sa/2.0/

(i) Suggest the identity of substance **X**.

[1]

(ii) Explain the appearance of the RDS lung tissue in the image above.

[2]

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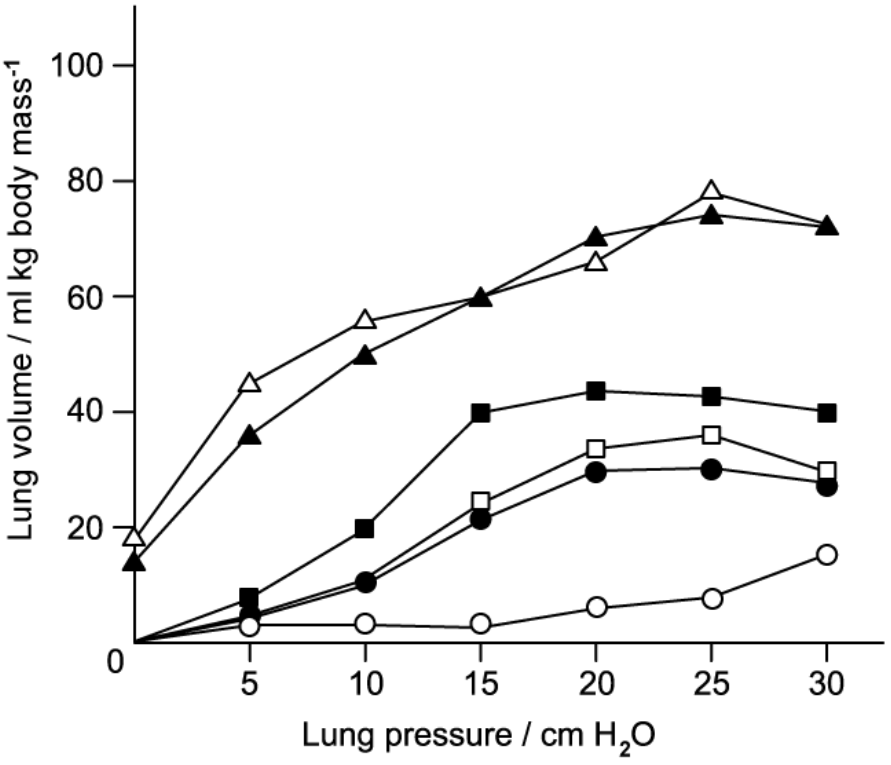
**(3 marks)**

**(c)** RDS can be treated by the administration of an alternative form of substance **X** to the lungs. The graph below shows the effect of different variations of substance **X** on the lung volume of rabbits at different pressures. The variations include substance **X** isolated from sheep lungs, as well as synthetic versions of substance **X** that contain its separate lipid and protein components. Note that cm $H_2O$ is a unit of pressure.




**Key:** △ = Substance X from sheep lungs
▲ = SP-B protein
■ = SP-C protein
□ = Solution containing phospholipids
● = SP-A protein
○ = No treatment

Use the information provided to explain why each of the following statements is incorrect:

(i) Substance **X** is essential for lung expansion.

[1]

(ii) Phospholipids are the active component of substance **X**.

[1]

(iii) Substance **X** from sheep is the most effective treatment for RDS in premature babies.

[2]

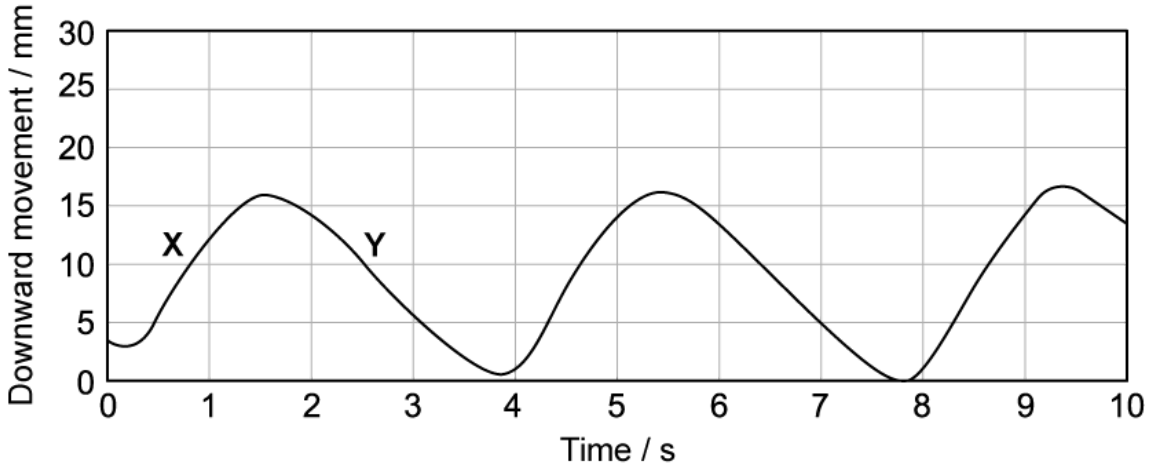
**(4 marks)**

**(d)** The form of substance **X** produced in mammalian lungs contains proteins known as SP-A and SP-D, which are known to be involved with the activation of phagocytes.

Suggest, with a reason, a symptom that would result from a deficiency of SP-A and SP-D proteins.

**(2 marks)**

**2 (a)** A study was carried out that looked at the movement of the diaphragm during normal breathing. The graph below shows the diaphragm movement in a healthy 55-year-old male.




Calculate the breathing rate of the individual shown in the graph.

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.....

**(2 marks)**

**(b)** (i) Identify the ventilation processes occurring at the stages marked **X** and **Y**.

[1]

(ii) For the stage marked **Y** on the graph, name a muscle **other than** the diaphragm involved at this stage **and** identify its state.

[2]

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.....

.....

**(3 marks)**

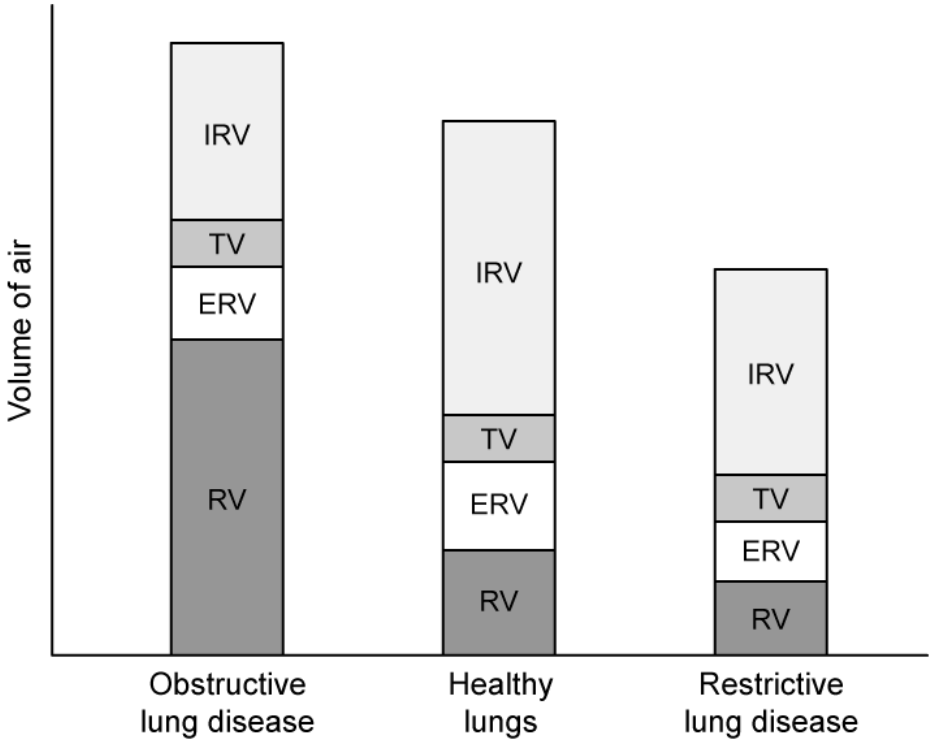
**(c)** Events such as surgical trauma or nerve degeneration can lead to weakness or even paralysis of the diaphragm.

Suggest the effect that this would have on ventilation.

**(2 marks)**

**3 (a)** Certain types of lung disease can be categorised as either obstructive or restrictive. The effect of obstructive and restrictive lung diseases on ventilation can be seen in the graph below, where:

- Tidal volume (TV) = the volume of air breathed in and out with each normal breath
- Inspiratory reserve volume (IRV) = the additional volume of air that can be drawn into the lungs during a large inward breath
- Expiratory reserve volume (ERV) = the additional volume of air that can be expelled from the lungs during forced expiration
- Residual volume (RV) = the volume of air that remains in the lungs after forced expiration




Compare and contrast the effects of obstructive and restrictive lung disease.

**(3 marks)**

**(b)** Explain why sufferers of both obstructive and restrictive lung disease find exercise difficult.

**(3 marks)**

**(c)** Use the graph in part a) to suggest what might be happening to the lungs in a restrictive lung disease.

**(2 marks)**

**4 (a)** Outline the need for a ventilation system in mammals.

**(3 marks)**

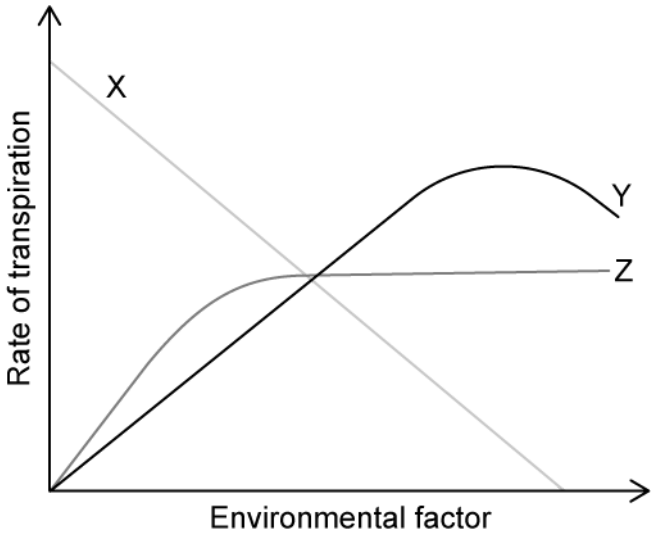
**(b)** Draw an annotated diagram to explain the process of inspiration.

**(6 marks)**

**(c)** Explain how the lungs are adapted to their function.

**(6 marks)**

**5 (a)** The graph shows the effect of three different environmental factors on the rate of transpiration in a terrestrial plant.




(i) Identify which environmental conditions may be represented by the lines **X, Y** and **Z**.

| | |
|---|---|
| X | |
| Y | |
| Z | |

[3]

(ii) Explain the reasons for your choice.

[3]

.....

.....

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.....

**(6 marks)**

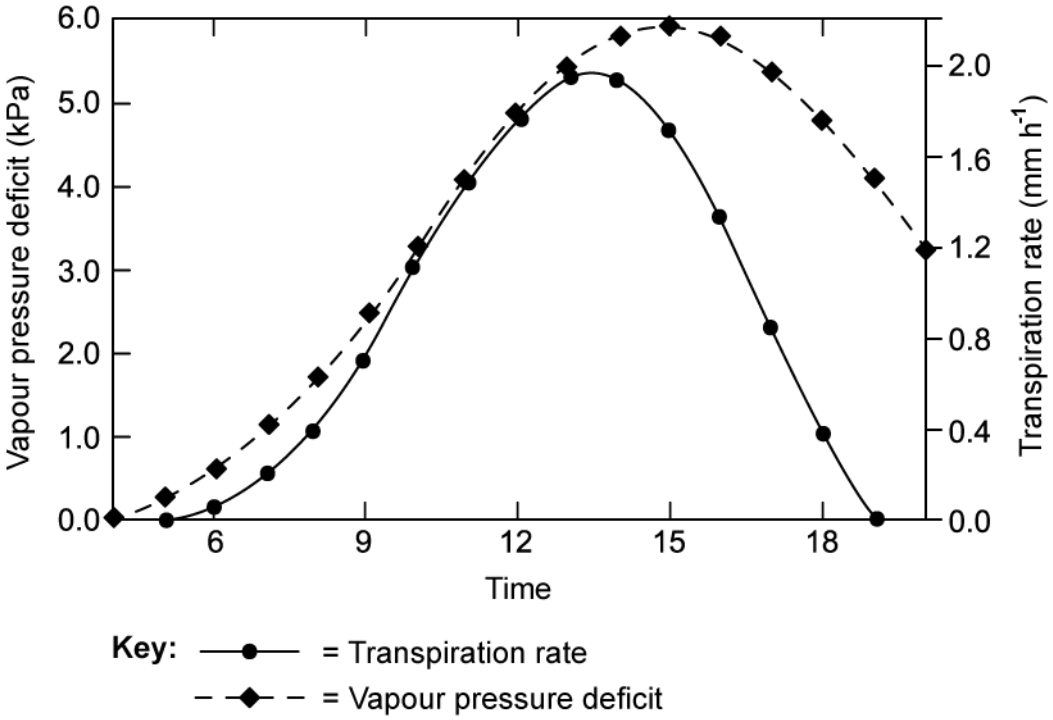
**(b)** Explain why the trend shown by line **Y** in the graph at part **a)**, could result in decreased growth of a terrestrial plant.

**(3 marks)**

**(c)** Suggest what effect flooding may have on the rate of transpiration in crop plants.

**(2 marks)**

**6 (a)** The graph shows the relationship between vapour pressure deficit and the rate of transpiration in wheat plants.




Vapour pressure deficit (VPD) is the difference between the amount of moisture in the air and how much moisture the air can hold when its saturated.

Using this information, state whether a high vapour pressure deficit would indicate that air humidity was high or low.

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**(1 mark)**

**(b)** With reference to the data shown in the graph from part **a),** explain the effect that VPD has on transpiration of wheat between 6:00 and 12:00.

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.....

.....

**(3 marks)**

**(c)** Explain the pattern seen in the results from part **a)** between 13:00 and 18:00.

**(2 marks)**

**(d)** Suggest how information about vapour pressure deficit may be useful for growers of wheat plants.

**(3 marks)**

**7** Students set up a potometer with a 0.8 mm diameter capillary tube to measure the rate of transpiration in a branch removed from a tree. Over a period of 30 minutes, the students noted that the bubble moved 13.7 cm.

Calculate the rate of transpiration shown by the leaf in $mm^3hr^{-1}$. Use the equation $\pi r^2$ to calculate the area of a circle.

**(3 marks)**