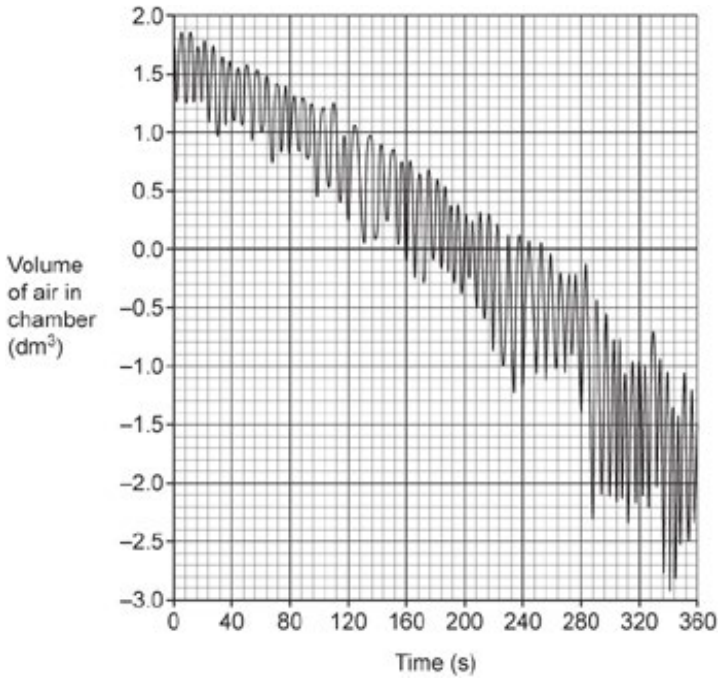
1(a). A student investigated ventilation and heart rate in a resting subject.

The subject breathed in and out through a spirometer.

The spirometer chamber was filled with room air. Soda lime was present to absorb carbon dioxide.

The results are shown in this graph



i. The downward slope of the spirometer trace in the graph is due to oxygen consumption.

The subject exhales the same volume of air as they inhale.

State why the trace slopes downwards.

_____

_____

_____ **[1]**

ii. The subject had a mass of 75 kg.

Calculate the subject's oxygen consumption in $cm^3\ kg^{-1}$ during the first 2 minutes of the experiment.

Give your answer to **2** significant figures.

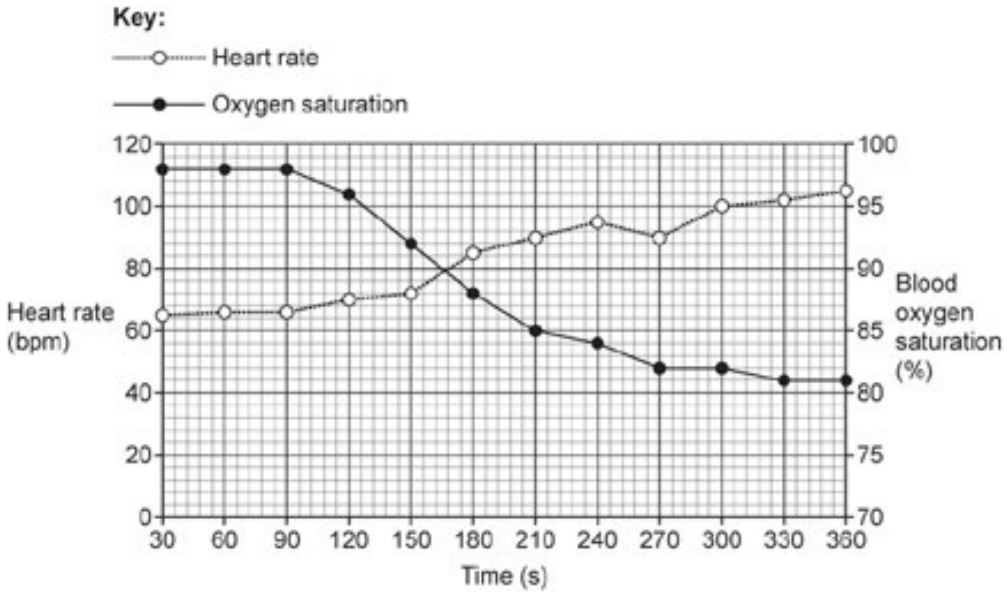
Oxygen consumption = ... $cm^3\ kg^{-1}$ **[2]**

iii. Using the graph compare the breathing pattern between 0-120 s and 120-240 s.

[2]

iv. The student measured the subject's heart rate and blood oxygen saturation every 30 seconds.

The results are shown in the second graph.



Use the data in both graphs and your own knowledge of homeostatic control to explain the changes in breathing rate and heart rate during the experiment.

[4]

(b). Blood oxygen saturation of less than 90% can be dangerous.

Explain **one** modification that you could make to the experiment to safely study the effect of extended periods of exercise.

[2]

2. Bumblebees are large insects that have a high demand for oxygen during flight.

What adaptation enables bumblebees to obtain sufficient oxygen during flight?

A Accumulation of lactate in muscles during flight increases the amount of tracheal fluid which increases the surface area for gas exchange.
B Muscle contraction before or during flight increases ventilation of the tracheal system.
C Spiracles take air directly to the respiring tissues.
D Tracheoles can open and close to allow gas exchange and minimise water loss.

Your answer ☐ **[1]**

3. Which option is **not** an adaptation that helps fish increase the efficiency of gas exchange?

A Blood capillaries lie close to the surface of the lamellae to minimise the diffusion distance.
B Blood flows in the capillaries in the same direction as the flow of water over the lamellae to maximise gas exchange.
C Gill filaments have many lamellae that increase the surface area for gas exchange.
D Raising and lowering of the floor of the buccal cavity helps maintain a flow of water over the gills.

Your answer ☐ **[1]**

4. Which process occurs during ventilation in bony fish?

A During expiration, the operculum opens
B During expiration, the volume in the buccal cavity increases and the pressure decreases
C During inspiration, the mouth opens causing the operculum to open
D During inspiration, the volume in the buccal cavity decreases and the pressure decreases

Your answer ☐ **[1]**

5. Which change in the mammalian gas exchange system takes place only during forced expiration?

A Abdominal muscles relax
B Diaphragm contracts to become dome-shaped
C External intercostal muscles contract
D Internal intercostal muscles contract

Your answer ☐ **[1]**

6. The blue whale can grow up to 30 m long and can weigh up to 200 000 kg.

Whales have specialised surfaces for gas exchange.

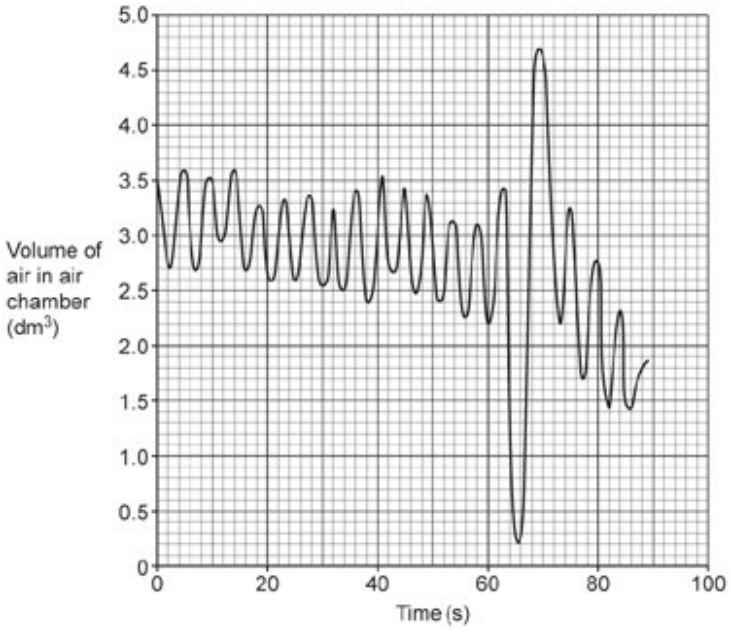
Which option is **not** a reason why blue whales need a specialised surface for gas exchange?

A Transport of gases by diffusion is too slow
B Whales are multicellular organisms
C Whales have a high metabolic demand
D Whales have a large surface area to volume ratio

Your answer ☐ **[1]**

7. The graph shows a trace recorded by a spirometer.

The trace shows a period of normal breathing whilst at rest, followed by a maximum inhalation and maximum exhalation.

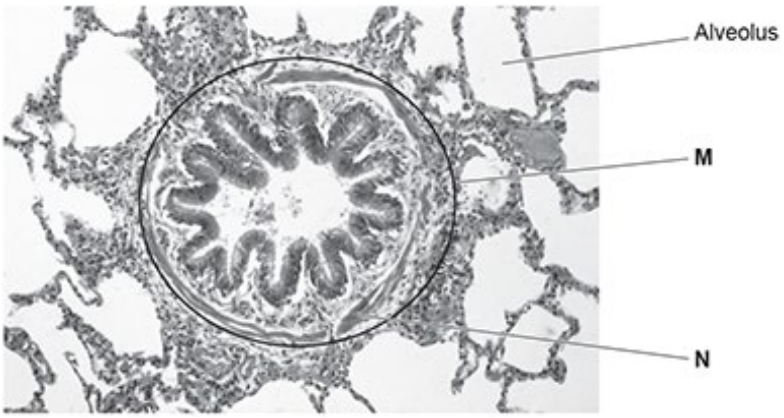


What is the value for vital capacity?

A 0.70 dm^3
B 0.90 dm^3
C 3.15 dm^3
D 4.50 dm^3

Your answer ☐ **[1]**

8(a). The light micrograph shows a transverse section through human lung tissue.



Alveoli provide an efficient gas exchange surface because of their large surface area.

State **one other** feature of alveoli that provides an efficient gas exchange surface.

_____

_____[1]

(b). The human lung is part of the gas exchange system.

Name the component of the gas exchange system in the circle labelled **M** in the light micrograph.

_____[1]

(c). Name the tissue labelled **N** in the light micrograph **and** outline its function in component **M**.

_____

_____

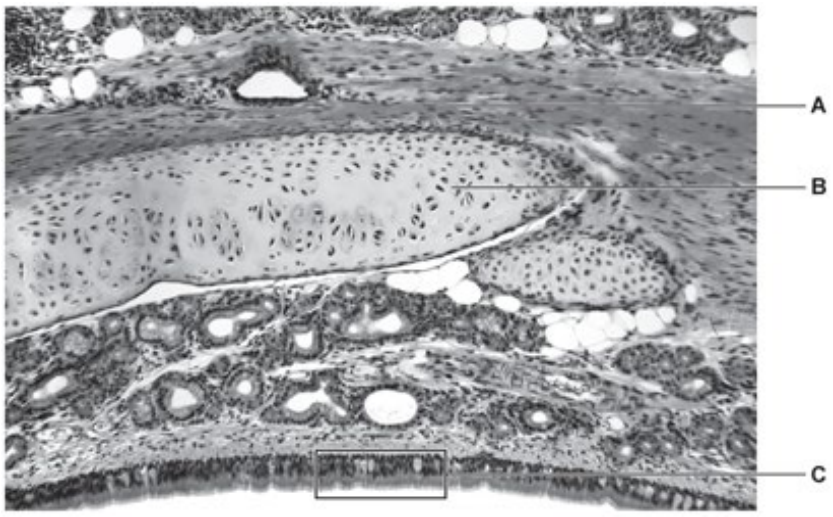
_____

_____

_____[2]

9(a). Cats are mammals.

A light micrograph of a section through the trachea of a cat is shown in the figure below.



i. Name the tissues labelled **A** and **B** in the figure.

A _____

B _____ **[2]**

ii. Name the **two** types of cell in the box labelled **C** in the figure **and** outline their functions.

1 Name _____

Function _____

2 Name _____

Function _____ **[2]**

(b). Alveoli increase the surface area to volume ratio (SA:V) in the lungs of cats and other mammals.

i. An alveolus in the lung of a cat has:

- a spherical shape
- a diameter of 0.13 mm
- a surface area of 0.053 mm^2.

Calculate the SA:V of this alveolus.
Use the formula: volume of sphere = $\frac{4}{3}\pi r^3$

SA:V = ... **[3]**

ii. Explain why the large SA:V of alveoli is an advantage to mammals.

_____

_____

[1]

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10. *A teacher set up the apparatus shown in **Fig. 5.1** to demonstrate ventilation in mammals to a group of students.

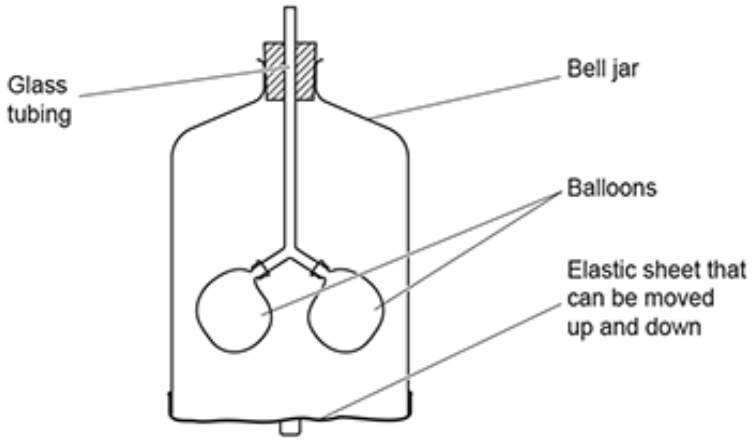

Fig. 5.1

Describe how the apparatus in **Fig. 5.1** can be used to model the changes that take place during inspiration in mammals.

In your answer comment on how appropriate the apparatus is in demonstrating inspiration.

_____

_____

_____

[6]

Additional answer space if required.

11. A mycorrhiza is mutualistic association between a fungus and a plant. The fungus penetrates root cells and assists with uptake of water and nutrients.

A group of scientists investigated the role of mycorrhiza in the uptake of phosphates by plants.

Wild type barley plants produce root hairs. Mutant (*brb*) barley plants do not produce root hairs.

brb mutant and wild type plants were grown in pots and half of each group had mycorrhiza fungus added. After 28 days, the dry mass and phosphate content of the plants was measured.

The results are shown in the table.

Plant type	Mycorrhiza fungus added	Dry mass (g pot^{-1})	Phosphate content (mg plant^{-1})
brb mutant	no	0.84 ± 0.10	1.22 ± 0.13
brb mutant	yes	1.23 ± 0.16	2.15 ± 0.25
Wild type	no	3.57 ± 0.16	4.72 ± 0.23
Wild type	yes	2.97 ± 0.36	3.91 ± 0.52

The scientists concluded that the mycorrhiza compensated for the absence of root hairs in the mutant (*brb*) barley plants.

Evaluate this conclusion.

[3]

12. Ventilation of the lungs involves muscles working together.

Which option describes expiration?

A In expiration at rest, the external intercostal muscles and the diaphragm relax and the rib cage moves down and in.

B In expiration at rest, the internal intercostal muscles and the diaphragm contract pulling the rib cage down and in.

C In forced expiration, the diaphragm relaxes and the external intercostal muscles contract pulling the rib cage down and in.

D In forced expiration, the internal intercostal muscles and the diaphragm contract pulling the rib cage down and in.

Your answer ☐ **[1]**

13. The table shows the dimensions of a dividing ball of cells and their surface area to volume ratios.

Number of divisions	Number of cells	Radius (mm)	Surface area (mm^2)	Volume (mm^3)	Surface area to volume ratio
0	1	0.5	3.14	0.52	6 : 1
3	8	1.0	12.57	4.19	3 : 1
5	32	1.5	28.27	14.14	2 : 1
6	64	2.0	50.27	33.51	

What is the best estimate of the surface area to volume ratio after the cell has divided six times?

A 7 : 4
B 3 : 2
C 5 : 4
D 1 : 1

Your answer ☐ **[1]**

14. Fick's Law describes the relationship between the rate of diffusion and factors that affect this rate.

This can be simplified as the equation:

$$\text{Rate of diffusion } \alpha \frac{\text{surface area} \times \text{concentration gradient}}{\text{thickness of surface}}$$

Inhalation of asbestos dust can cause a thickening of the alveolus wall.

Which option shows the change in the rate of diffusion if the alveolus wall increases from a thickness of 2.0 μm to 2.5 μm?

A Decreases by 20%
B Decreases by 50%
C Increases by 20%
D Increases by 50%

Your answer ☐ **[1]**

END OF QUESTION PAPER