Helicate

HELICATE · AS AND A-LEVEL BIOLOGY · TOPIC BANK

3.3.2 Gas exchange

Topic question bank

Version 1 · 1 October 2026

Name

Date

QUESTIONS	TOTAL MARKS	TIME	YOUR SCORE
8	57	No time limit	/ 57

Contents

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Total		**57**

Instructions

- Answer the questions in the spaces provided. Show all your working.
- The marks for each question are shown in brackets. Use them to judge how much detail to give.
- Work through a subtopic at a time, then mark your answers with the matching mark scheme.

Original questions by Helicate for AQA AS and A-level Biology (7401/7402), specification section 3.3.2. Not affiliated with or endorsed by AQA.

Do not write outside the box

Single-celled organisms and insects 3.3.2

0 1 . 1 Which statement explains how a single-celled organism obtains enough oxygen without a specialised gas exchange system?
Tick (✓) one box.

[1 mark]

Oxygen is actively transported across its cell-surface membrane. ☐

Oxygen diffuses across its cell-surface membrane; the cell has a large surface area to volume ratio and a short diffusion distance. ☐

Oxygen diffuses across its cell-surface membrane, and its small surface area to volume ratio means that it needs very little oxygen. ☐

Oxygen enters by facilitated diffusion through carrier proteins in its cell-surface membrane. ☐

0 1 . 2 Some single-celled organisms that live on the sea floor grow to several millimetres across. Many of these large single-celled organisms are very thin and flat.
Suggest how a thin, flat shape allows these large cells to obtain enough oxygen by diffusion alone.

[2 marks]

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Turn over for the next question

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Do not write outside the box

Scientists investigated water loss in a species of beetle that lives in deserts. When the beetle is at rest, its spiracles open only for short periods.

The scientists divided the beetles into three groups of 10. They kept each beetle at rest in dry air at 30 °C and measured its rate of water loss.

- Group **A** received no treatment.
- Group **B** was kept in air containing 4% carbon dioxide. This concentration of carbon dioxide keeps the spiracles open all the time.
- Group **C** had the thin layer of wax that covers the beetle's body surface removed by gently rubbing it with a fine powder.

Table 1 shows the results.

Table 1

Group	Treatment	Time spiracles open / %	Mean rate of water loss / mg per g of body mass per hour
A	None	8	0.48
B	Kept in air containing 4% carbon dioxide	100	1.32
C	Wax removed from body surface	8	2.10

0 2 . 1 Which shows the route taken by oxygen from the air to a muscle cell in the beetle?
Tick (✓) one box.

[1 mark]

spiracle → tracheole → trachea → muscle cell ☐

spiracle → trachea → tracheole → muscle cell ☐

trachea → spiracle → tracheole → muscle cell ☐

tracheole → trachea → spiracle → muscle cell ☐

Question 2 continues on the next page

Do not write outside the box

0 2 . 2 Keeping the spiracles open all the time raised the rate of water loss.
Calculate this change as a percentage of the rate in untreated beetles.

[2 marks]

Answer ..... **%**

0 2 . 3 A student concluded that most of the water lost by untreated beetles is lost through the spiracles.
Use Table 1 to evaluate this conclusion.

[3 marks]

0 2 . 4 Suggest the advantage to this beetle of opening its spiracles for only short periods when it is at rest.

[2 marks]

8

Turn over for the next question

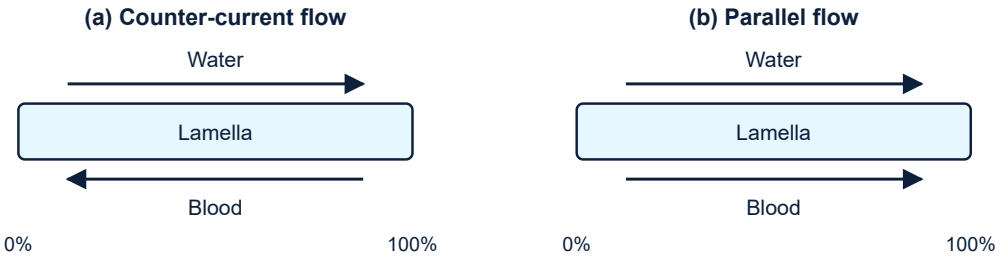
Do not write outside the box

Gas exchange in fish 3.3.2

In the gills of a fish, oxygen diffuses from water into blood across the lamellae.

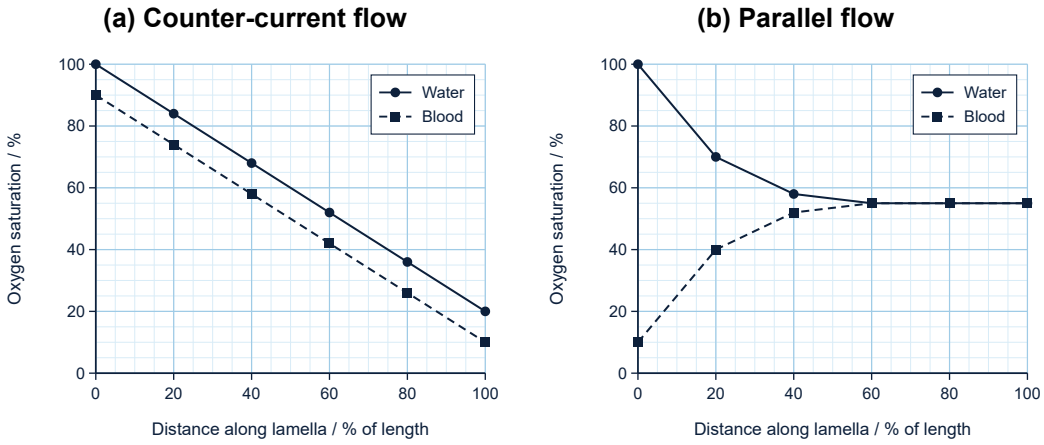
Figure 1 shows two possible directions of blood flow through a lamella: counter-current flow, which occurs in fish, and parallel flow. The distance along the lamella is measured from the point where water enters.

Figure 1



Scientists used a model to predict the oxygen saturation of the water and of the blood along a lamella for each type of flow. In both models, blood entered the lamella with an oxygen saturation of 10%. Figure 2 shows their predictions.

Figure 2



Question 3 continues on the next page

Do not write outside the box

0 3 . 1 In parallel flow, at what distance along the lamella does net diffusion of oxygen into the blood stop?
Tick (✓) one box.

[1 mark]

20% of the length ☐

40% of the length ☐

60% of the length ☐

100% of the length ☐

0 3 . 2 Use Figure 2 to calculate how many times greater the increase in oxygen saturation of the blood is in counter-current flow than in parallel flow.
Give your answer to **two** significant figures.

[2 marks]

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Answer .....

0 3 . 3 Use Figure 2 to explain why blood leaving the lamella has a higher oxygen saturation in counter-current flow than in parallel flow.

[3 marks]

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Question 3 continues on the next page

Do not write outside the box

A student dissected a fish to observe its gills. When a gill was placed in a dish of water, its filaments spread apart and the lamellae on them could be seen with a hand lens. When the gill was lifted out of the water, the filaments stuck together in a single mass.

0 3 . 4 Air contains more oxygen than the same volume of water.
Use the student's observations to explain why a fish cannot obtain enough oxygen when it is out of water.

[2 marks]

8

Turn over for the next question

Do not write outside the box

Leaves and xerophytic plants 3.3.2

0 4 . 1 Describe how carbon dioxide from the air reaches the mesophyll cells of a dicotyledonous leaf during the day.

[2 marks]

Oleander is a dicotyledonous xerophyte. A student compared the leaves of oleander with the leaves of a bean plant, which is not a xerophyte.

The student cut thin vertical sections through five leaves of each plant. She used an optical microscope with an eyepiece graticule to measure the thickness of the waxy cuticle on the upper surface of each leaf. At the magnification she used, one eyepiece graticule division was equal to 2.5 μm.

Table 2 shows her results.

Table 2

Plant	Thickness of cuticle / eyepiece graticule divisions					Mean
	Leaf 1	Leaf 2	Leaf 3	Leaf 4	Leaf 5	
Bean	1	0.5	1	0.5	1	0.8
Oleander	6	7	6	6.5	6.5	

0 4 . 2 Calculate the mean thickness of the oleander cuticle in μm.

[2 marks]

Answer _____ **μm**

Question 4 continues on the next page

Do not write outside the box

0 4 . 3 Each reading has an uncertainty of ± 0.5 eyepiece graticule divisions.
Explain why this method is not suitable for measuring the bean cuticle. Suggest how the student could improve her measurement of the bean cuticle.

[2 marks]

In oleander leaves, all of the stomata are on the lower surface, inside deep pits. Each pit is lined with many hairs.

0 4 . 4 Explain how the features of the oleander leaf described in this question reduce water loss while still allowing gas exchange.

[3 marks]

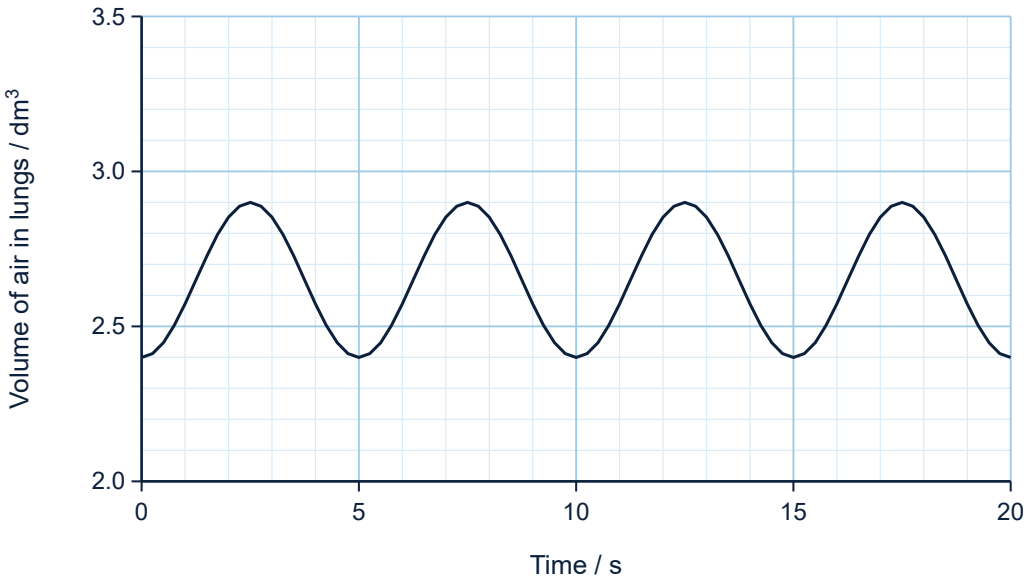
9

Turn over for the next question

The human gas exchange system and ventilation 3.3.2

A person at rest breathed in and out through a spirometer. This device recorded the volume of air in the person's lungs. Figure 3 shows part of the trace.

Figure 3



Tidal volume is the volume of air breathed in during one breath.

pulmonary ventilation rate (PVR) = tidal volume × breathing rate

0 5 . 1 Use Figure 3 and the equation to calculate the person's pulmonary ventilation rate at rest.
Give the correct unit with your answer.

[2 marks]

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Answer .....

Question 5 continues on the next page

Do not write outside the box

0 5 . 2 A trained athlete at rest has a pulmonary ventilation rate of 7.2 dm^3 min^{-1} and a breathing rate of 8 breaths min^{-1}.
What is the athlete's tidal volume?
Tick (✓) one box.

[1 mark]

0.9 dm^3 ☐

1.1 dm^3 ☐

9.0 dm^3 ☐

57.6 dm^3 ☐

0 5 . 3 At rest, breathing out is mainly passive. During exercise, air is forced out of the lungs.
Describe the actions of the muscles during forced breathing out, and explain how these actions move air out of the lungs.

[4 marks]

Question 5 continues on the next page

Do not write outside the box

0 5 . 4 During exercise, the same person's tidal volume was 1.5 dm^3 and their breathing rate was 30 breaths min^{-1}.
A student concluded that the increase in pulmonary ventilation rate during exercise was mainly due to deeper breathing.
Evaluate this conclusion.

[2 marks]

9

Turn over for the next question

Do not write outside the box

Lung disease and risk factors 3.3.2

In a disease called pulmonary oedema, fluid leaks out of the blood capillaries in the lungs. The fluid collects in the tissue between the capillaries and the alveolar epithelium, and then inside the alveoli.

0 6 . 1 Air reaches the alveoli through the smallest airways in the lungs.
Name these airways.

[1 mark]

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0 6 . 2 Explain how pulmonary oedema affects the uptake of oxygen into the blood.

[3 marks]

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Turn over for the next question

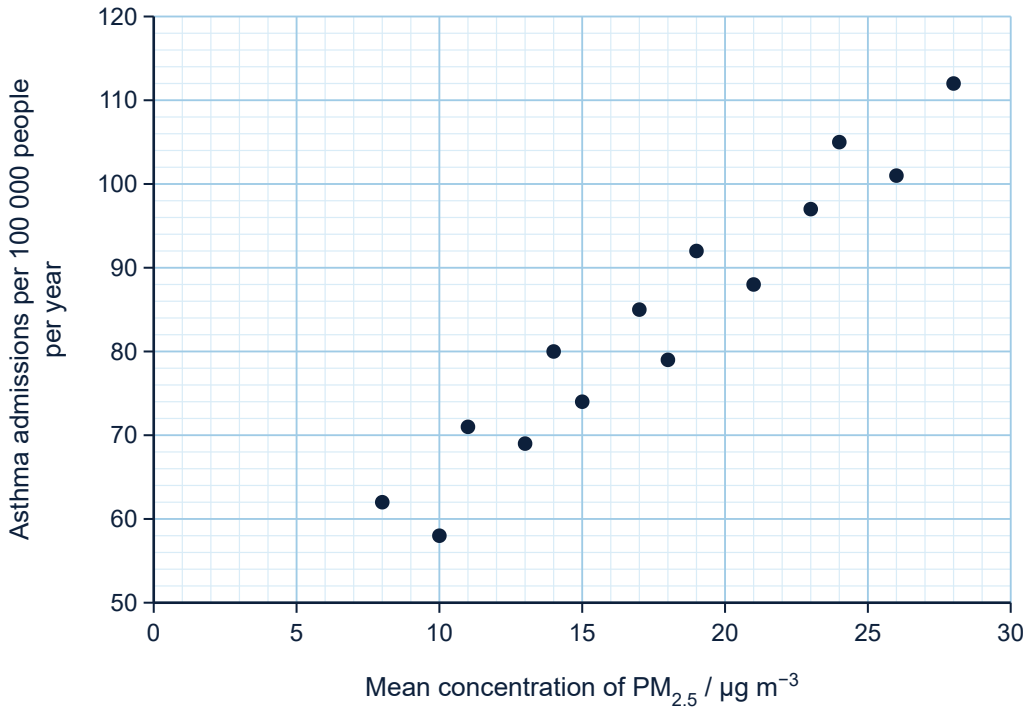
Do not write outside the box

Asthma is a lung disease in which the airways narrow, so less air reaches the alveoli. During an asthma attack, the narrowing becomes severe.

$PM_{2.5}$ is air pollution made of very small particles. In cities, much of it comes from vehicle exhausts.

Scientists recorded the mean concentration of $PM_{2.5}$ in the air of 14 cities in one country. They also recorded the number of emergency hospital admissions for asthma in each city. Figure 4 shows their results.

Figure 4



0 7 . 1 Describe the relationship shown in Figure 4.

[1 mark]

Question 7 continues on the next page

Do not write outside the box

0 7 . 2 A newspaper used Figure 4 to claim that $PM_{2.5}$ causes asthma attacks.
Give **two** reasons why Figure 4 does **not** show this.

[2 marks]

Question 7 continues on the next page

Do not write outside the box

City **P** introduced a law at the start of Year 4. The law banned older diesel vehicles from the city centre. City **Q** did not introduce a law.

Table 3 shows the mean concentration of $PM_{2.5}$ and the number of emergency hospital admissions for asthma in each city for six years.

Table 3

Year	City P (law from start of Year 4)		City Q (no law)	
	Mean $PM_{2.5}$ / µg m^{-3}	Asthma admissions per 100 000 people	Mean $PM_{2.5}$ / µg m^{-3}	Asthma admissions per 100 000 people
1	24	104	21	95
2	23	101	22	97
3	24	103	21	94
4	20	95	21	93
5	19	91	20	92
6	18	88	20	90

0 7 . 3 Calculate the percentage decrease in the mean number of asthma admissions in city **P** between Years 1–3 and Years 4–6.
Give your answer to **one** decimal place.

[2 marks]

Answer ..... **%**

Question 7 continues on the next page

Do not write outside the box

0 7 . 4 The government of this country is deciding whether to make the law used in city **P** apply to all cities.
Evaluate whether Figure 4 and Table 3 provide evidence to support this decision.

[5 marks]

10

Turn over for the next question

Do not write outside the box

Extended response: comparing gas exchange systems 3.3.2

0 8 Compare how the gas exchange systems of a bony fish and of an insect are adapted to supply oxygen to respiring cells.
In your answer, refer to features that increase the rate of diffusion.

[6 marks]

6

END OF QUESTIONS

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