15.1 Gas exchange: maintaining diffusion gradients

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS ventilation • perfusion

Objective

Gas exchange: maintaining diffusion gradients. Original classroom practice for IB HL; not an official IB paper.

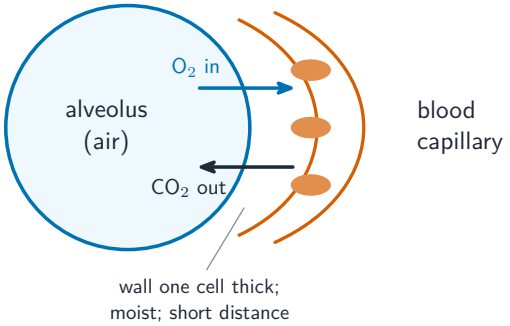
1 Key knowledge and worked examples

What would explain this observation?

- An exchange surface can be very thin yet fail to deliver enough oxygen when **ventilation** or blood flow falls.

Build the model

- Gas exchange occurs by diffusion across a surface.
- Large area, short diffusion distance and maintained concentration gradients support transfer.
- Ventilation refreshes the external medium; **perfusion** carries gases to and from the exchange surface.
- ventilation: Movement of air or water over an exchange surface.
- perfusion: Blood flow through tissue or an exchange surface.



Choose evidence that can test it

- Distinguish movement of the whole medium from diffusion across the membrane.
- Ventilation and perfusion work together, while haemoglobin helps transport oxygen in blood.
- A change in breathing rate alone does not measure oxygen uptake.

In the lab: Use an approved model or published respiratory data. Compare exchange surface area, diffusion path and flow. For human demonstrations use voluntary resting measurements; do not induce breathlessness or hyperventilation.

Work from known quantities

- Known: tidal volume is 0.50 L and breathing rate is 12 breaths/min.
- Minute ventilation = $0.50 \times 12 = 6.0$ L/min.
- This includes dead-space ventilation and is not identical to alveolar ventilation.

Your turn: Tidal volume is 0.60 L and breathing rate is 10 breaths/min. Find minute ventilation.

Check the conclusion and its limits

- Air entering the lungs is not all exchanged with blood.
- Oxygen and carbon dioxide diffuse in opposite net directions because their own gradients differ.

Not true: Minute ventilation directly equals oxygen uptake. Ventilation moves air into the lungs; oxygen uptake is what crosses into the blood. Dead-space air never reaches the exchange surface, and uptake depends on diffusion and blood flow, so the two quantities differ.

Key:

- Gas exchange occurs by diffusion across a surface.

- Distinguish movement of the whole medium from diffusion across the membrane.
- Watch for: air entering the lungs is not all exchanged with blood.

■ **Write from a minute ventilation of 12 litres per minute**

- Tidal volume is 0.80 L and the breathing rate is 15 breaths per minute.
- Find minute ventilation. It includes dead space.

2 Practice

2.1 What maintains an oxygen gradient across the lung exchange surface? Choose one answer.

- **A** Ventilation and blood flow
- **B** Making the diffusion path longer
- **C** Stopping all blood flow [1]

2.2 Tidal volume is 0.60 L and breathing rate is 10 breaths/min. Find minute ventilation. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Ventilation moves air into the lungs; oxygen uptake is what crosses into the blood. [2]

2.4 Movement of air or water over an exchange surface: write the technical term. [1]

3 Exam-style questions

3.1 Fictional patterns use 0.50 L×12/min and 0.30 L×20/min. Given dead space 0.15 L per breath, compare minute and alveolar ventilation in this simplified model. [4]

Solutions

2.1 A Ventilation refreshes alveolar air and blood flow carries oxygen away, so both sides of the surface keep the partial-pressure gradient steep. Stopping blood flow would let equilibration flatten it, and a longer path would slow diffusion.

2.2 minute ventilation=0.60 L/breath×10 breaths/min=6.0 L/min.

2.3 True. True. Ventilation moves air into the lungs; oxygen uptake is what crosses into the blood. Dead-space air never reaches the exchange surface, and uptake depends on diffusion and blood flow, so the two quantities differ.

2.4 ventilation. ventilation means Movement of air or water over an exchange surface.

3.1 Both minute ventilations 6 L/min. Alveolar values=(0.50−0.15)×12=4.2 and(0.30−0.15)×20=3.0 L/min. This model illustrates the distinction and is not a clinical judgement.