

11.1.1 Ventilation, air composition, exercise and keeping the airways clean

Name: _____ Class: _____ Date: _____

Total: 35 marks

KEY WORDS gas exchange 气体交换 • diaphragm 膈 • thorax 胸腔 • trachea 气管
• carbon dioxide 二氧化碳

Objective

Sheet 11.1 covered the alveoli and one breathing question. This sheet is the rest of 11.1, and it is nearly all of the unit's exam marks: naming the parts of the breathing system, the **cartilage** 软骨 in the trachea, how the ribs, **intercostal muscles** 肋间肌 and **diaphragm** 膈 change the volume and pressure of the **thorax** 胸腔, what makes **expired air** 呼出气体 different from inspired air, why exercise changes your breathing, and how **goblet cells** 杯状细胞 and **ciliated cells** 纤毛细胞 keep the lungs clean. This sheet covers syllabus 11.1.

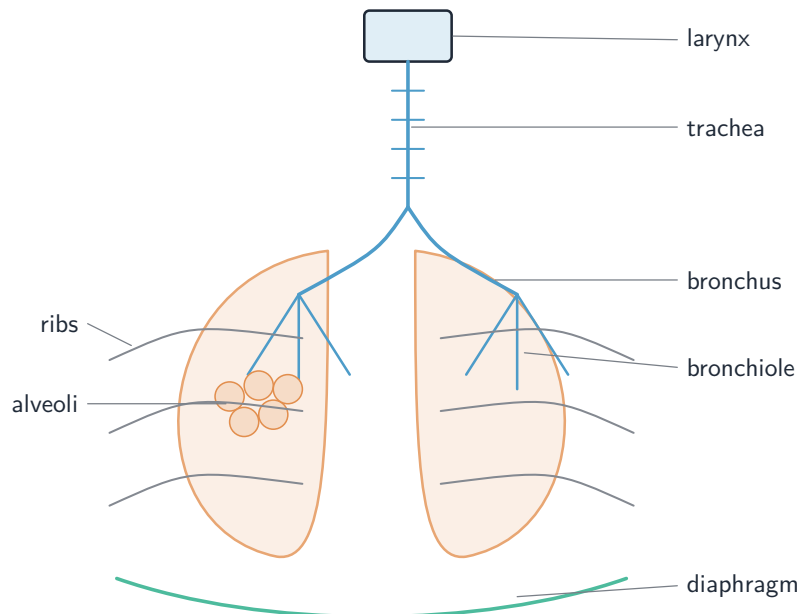
You must be able to:

- describe the features of a gas exchange surface: large surface area, thin, good blood supply, good **ventilation** 通气
- identify the lungs, diaphragm, ribs, intercostal muscles, **larynx** 喉, **trachea** 气管, **bronchi** 支气管, **bronchioles** 细支气管, **alveoli** 肺泡 and their capillaries, including the internal and external intercostal muscles
- state the function of the cartilage in the trachea
- explain how the ribs, the internal and external intercostal muscles and the diaphragm produce the volume and pressure changes that ventilate the lungs
- investigate and describe the differences between inspired and expired air, using **lime-water** 石灰水 as a test for carbon dioxide, and explain those differences
- investigate, describe and explain the effect of physical activity on the rate and depth of breathing
- explain the role of goblet cells, **mucus** 黏液 and ciliated cells in protecting the breathing system

1 Worked examples

Study these first. Each one shows a **method** that a question later on this sheet needs.

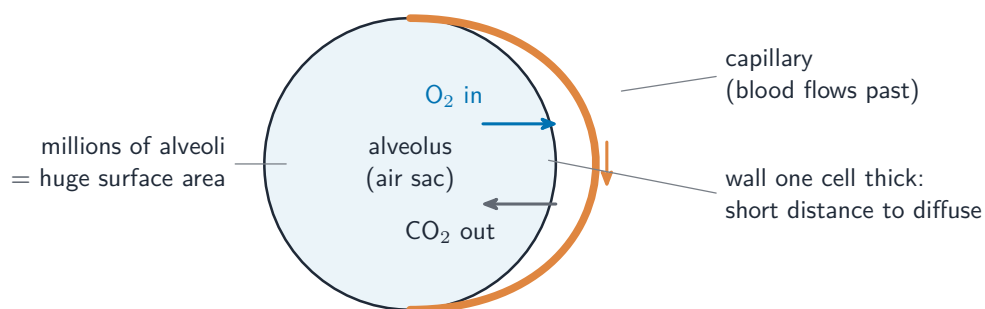
■ The parts, and the one function you are asked for



Air travels: **larynx** → **trachea** → **bronchi** → **bronchioles** → **alveoli**, where the exchange happens.

- The **cartilage** in the trachea wall is the only part whose *function* is examined: it holds the trachea **open**, so that air can always pass even when the pressure inside drops.
- The **intercostal muscles** lie between the ribs. The **external** ones pull the ribs **up and out**; the **internal** ones pull them **down and in**.

■ Why an alveolus is a good gas exchange surface

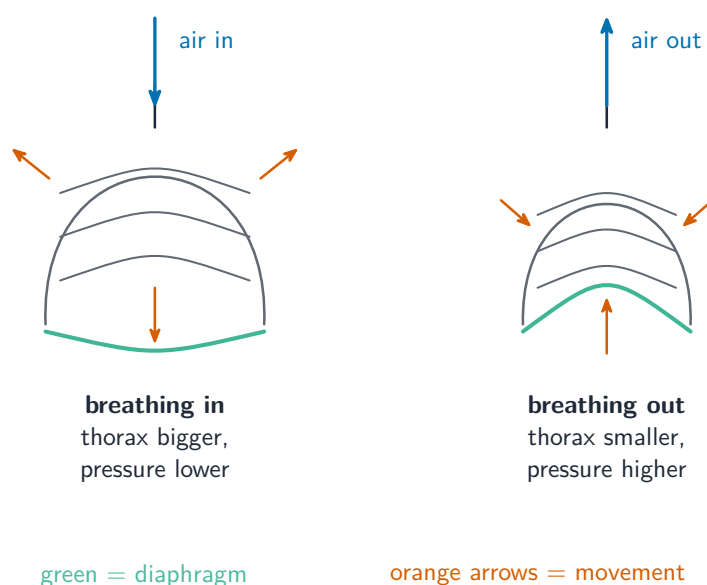


Four features, and each one must be paired with **what it does**:

feature	why it helps
large surface area – millions of alveoli	more gas can diffuse at the same time
thin – the wall is one cell thick	a short diffusion distance 扩散距离
good blood supply – a network of capillaries	keeps a steep concentration gradient 浓度梯度
good ventilation – air is replaced with every breath	also keeps the gradient steep

- Naming a feature alone is half a mark's work. "Large surface area **so more diffusion can happen at once**" is the full answer.

■ **Ventilation:** what moves, what happens to volume, what happens to pressure

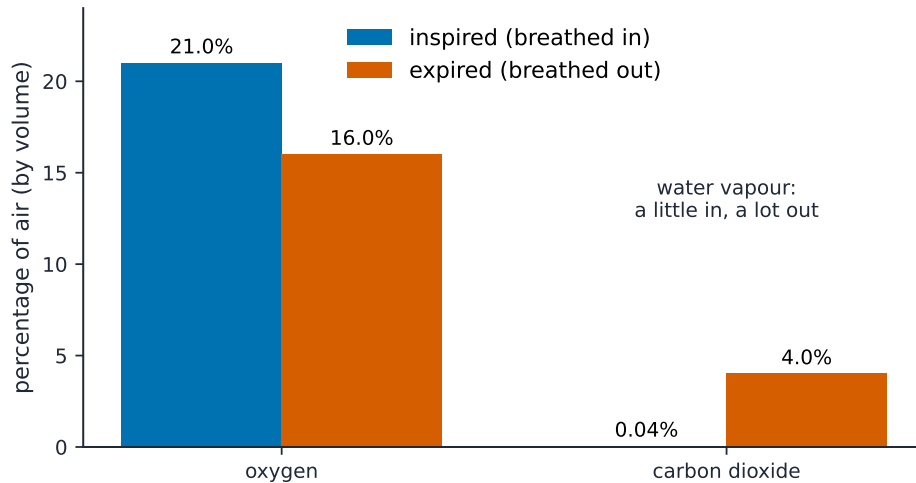


Answer in this order every time: **muscles** → **ribs and diaphragm** → **volume** → **pressure** → **air moves**.

	breathing in	breathing out
external intercostal muscles	contract	relax
internal intercostal muscles	relax	contract
ribs	move up and out	move down and in
diaphragm	contracts and flattens	relaxes and domes up
volume of the thorax	increases	decreases
pressure in the thorax	decreases	increases
air	moves in	moves out

- Air always moves from **higher** pressure to **lower** pressure. Writing “the lungs suck the air in” earns nothing.
- The diaphragm **contracts to flatten**. Saying it “relaxes downwards” is the commonest error on this unit.

■ Inspired and expired air

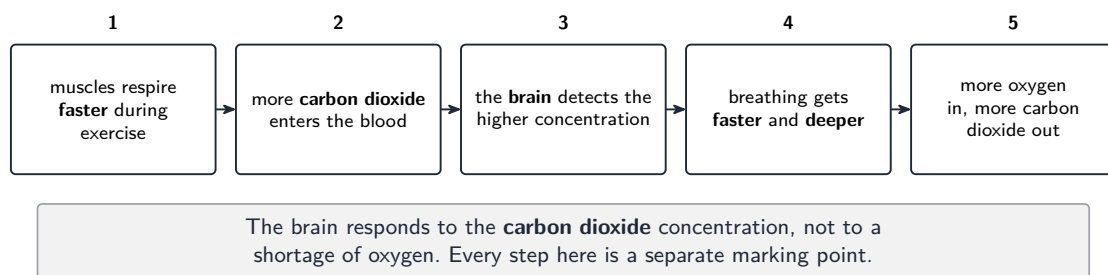


expired air: ↓ O₂, ↑ CO₂, ↑ water vapour (vs inspired)

gas	inspired	expired	why
oxygen	about 21%	about 16%	some diffused into the blood, to be used in respiration 呼吸作用
carbon dioxide	about 0.04%	about 4%	made by respiration in the body cells, and diffused out of the blood
water vapour	little	a lot	the alveoli and airways are moist , and water evaporates from them

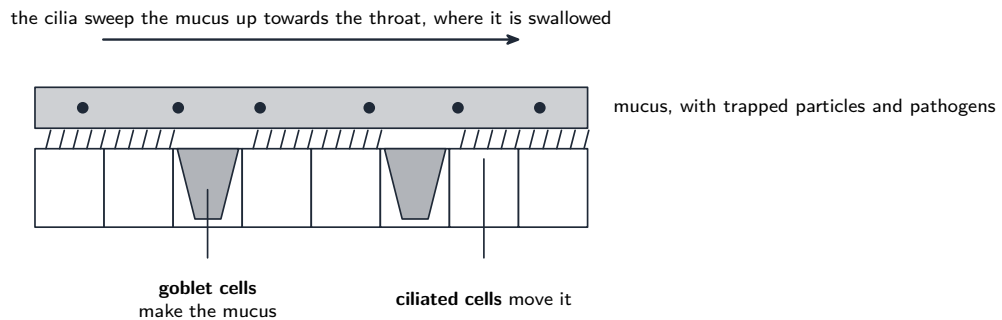
The limewater test. Bubble each sample of air through limewater. **Expired air turns the limewater milky much faster**, because it contains far more carbon dioxide. The inspired-air tube is the **control**: it goes milky only slowly, which shows the difference is real.

■ Exercise and breathing



- Both the **rate** (breaths per minute) and the **depth** (volume of each breath) increase.
- The trigger the exam wants is the **carbon dioxide concentration in the blood**, detected by the **brain**. Answers built on “the body needs more oxygen” miss the marking point.

■ Keeping the airways clean



Two cell types, two jobs. A question that asks about *protection* wants both: the mucus traps the particles, and the cilia carry them away from the lungs.

- **Goblet cells** make the sticky **mucus**, which **traps** particles and pathogens in the air you breathe in.
- **Ciliated cells** carry hair-like **cilia** that beat and **sweep the mucus up** the trachea to the throat, where it is swallowed.
- Two cell types, two jobs. A question about protection wants both.

2 Practice

Now use the methods above.

2.1 Name the tube that carries air from the larynx to the bronchi, and state the function of the cartilage in its wall. [2]

2.2 State **two** features of a gas exchange surface, and explain how each one helps gas exchange. [4]

2.3 Describe what the external intercostal muscles and the diaphragm do when a person breathes in. [3]

2.4 Explain how the volume and the pressure inside the thorax change when a person breathes in, and why this makes air enter the lungs. [3]

2.5 Describe what you would see when expired air is bubbled through limewater, and state what the control should be. [2]

2.6 State the function of goblet cells and the function of ciliated cells. [2]

3 Exam-style questions

3.1 Which row describes the thorax when a person breathes **in**? [1]

	external intercostal muscles	diaphragm	volume of thorax	pressure in thorax
A	contract	contracts and flattens	increases	decreases
B	contract	relaxes and domes up	increases	decreases
C	relax	contracts and flattens	decreases	increases
D	relax	relaxes and domes up	decreases	increases

3.2 The table shows the composition of inspired and expired air.

gas	inspired air / %	expired air / %
oxygen	21	16
carbon dioxide	0.04	4

(a) Explain why expired air contains less oxygen than inspired air. [2]

(b) Expired air also contains much more water vapour. Explain why. [2]

(c) Expired air still contains 16% oxygen. Explain why this makes mouth-to-mouth resuscitation useful. [2]

3.3 A student measured her breathing rate and the volume of each breath before, during and after five minutes of exercise.

when	breathing rate / breaths per minute	volume of each breath / dm ³
at rest	14	0.5
during exercise	30	1.8
5 minutes after exercise	18	0.8

(a) Calculate the volume of air she breathed in one minute at rest, and in one minute during exercise. [2]

(b) Describe the effect of exercise on her breathing. [2]

(c) Explain, in terms of carbon dioxide, why her breathing changed during exercise. [4]

(d) Five minutes after the exercise stopped, her breathing rate was still above its resting value. Explain why. [2]

(e) State **two** variables she should keep the same if she repeats the investigation with a friend. [2]