

Exercise walk-through

Transport of oxygen and carbon dioxide ■ 8.2

eXercise

You must be able to

- describe and explain the oxygen dissociation curve and its importance in the lungs and tissues
- describe and explain the Bohr shift
- describe carbon dioxide transport, including the **chloride shift** 氯转移

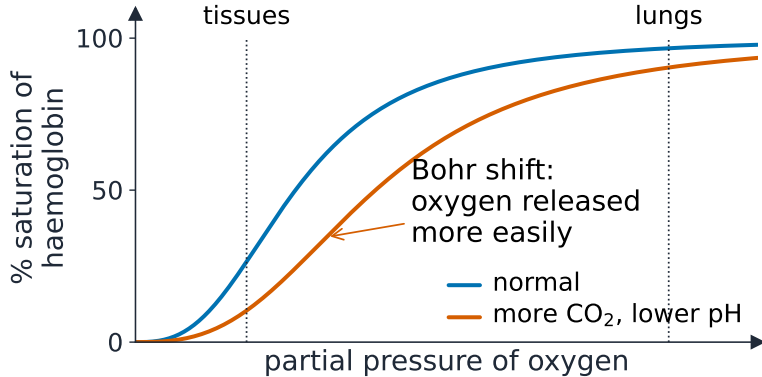
Method — The oxygen dissociation curve

The S-shaped curve plots **saturation** 饱和度 of haemoglobin against the **partial pressure** 分压 of oxygen.

- in the lungs (high pO_2), haemoglobin becomes almost fully saturated (loads O_2).
- in respiring tissues (low pO_2), haemoglobin unloads O_2 for the cells.

Reading the curve: O_2 unloaded = saturation in lungs — saturation in tissues. E.g. 98% → 40% means 58% of the oxygen is released.

Method — The oxygen dissociation curve



Bohr shift (right): $\uparrow \text{CO}_2 / \downarrow \text{pH} \rightarrow$ lower O_2 affinity $\rightarrow$ unload at tissues

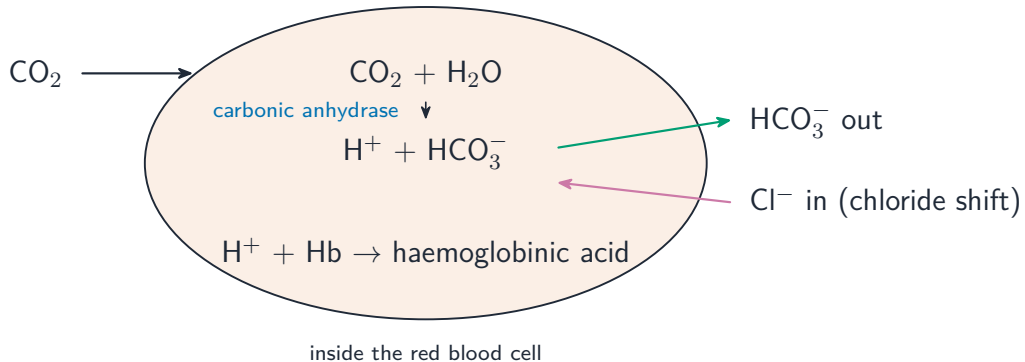
Method — The Bohr shift

Active tissues make more **carbon dioxide** 二氧化碳, lowering pH; this makes haemoglobin release O_2 more easily, so the curve shifts **right** — O_2 is given up where it is most needed.

Method — Carbon dioxide transport

Most CO_2 is carried as **hydrogencarbonate ions** 碳酸氢根离子: **carbonic anhydrase** 碳酸酐酶 catalyses $\text{CO}_2 + \text{water} \rightarrow \text{carbonic acid} \rightarrow \text{H}^+ + \text{HCO}_3^-$. HCO_3^- leaves the red cell and **chloride ions** move in (the chloride shift) to balance the charge; H^+ binds haemoglobin (**haemoglobinic acid** 血红蛋白酸).

Method — Carbon dioxide transport



Practice 2.1 ■ 2 marks

State where on the dissociation curve haemoglobin (a) loads oxygen and (b) unloads oxygen.

Solution 2.1

Method: The oxygen dissociation curve

Worked steps

(a) at high partial pressure of oxygen (in the lungs) **B1**; (b) at low partial pressure of oxygen (in respiring tissues) **B1**.

Practice 2.2 ■ 1 mark

Name the enzyme that catalyses the reaction of carbon dioxide with water.

Solution 2.2

Method: Carbon dioxide transport

Worked steps

carbonic anhydrase **B1**.

Exam-style 3.1 ■ 1 mark

In which form is **most** carbon dioxide carried in the blood?

- A dissolved in plasma
- B as hydrogencarbonate ions
- C as carbaminohaemoglobin
- D as carbonic anhydrase

Solution 3.1

Method: Carbon dioxide transport

- A dissolved in plasma
- B as hydrogencarbonate ions
- C as carbaminohaemoglobin
- D as carbonic anhydrase



Worked steps

B. Most CO_2 is carried as hydrogencarbonate ions.

Exam-style 3.2 ■ 1 mark

The Bohr shift moves the oxygen dissociation curve to the right. This means that, at a given partial pressure of oxygen, haemoglobin:

- A** is more saturated with oxygen
- B** releases oxygen more readily
- C** carries more carbon dioxide directly
- D** has a higher affinity for oxygen

Solution 3.2

Method: The oxygen dissociation curve

- A is more saturated with oxygen
- B releases oxygen more readily
- C carries more carbon dioxide directly
- D has a higher affinity for oxygen



Worked steps

B. Shifting right means lower affinity, so haemoglobin releases oxygen more readily.

Exam-style 3.3 ■ 1 mark

Use the dissociation curve idea: in the lungs haemoglobin is 98% saturated; in an exercising muscle it falls to 25%.

- (a) Calculate the percentage of oxygen unloaded to the muscle.
- (b) Explain how the Bohr shift increases the oxygen delivered to exercising muscle.

Solution 3.3

Method: The oxygen dissociation curve

Worked steps

(a) $98 - 25 = 73\%$ **A1**.

(b) exercising muscle releases more CO_2 , lowering pH **M1**; this shifts the curve right, so at the same pO_2 haemoglobin is less saturated and releases more oxygen **M1**; so more oxygen is delivered exactly where respiration is fastest **A1**.

Exam-style 3.4 ■ 2 marks

Explain the importance of the chloride shift.

Solution 3.4

Method: Carbon dioxide transport

Worked steps

as HCO_3^- leaves the red cell, chloride ions move in **M1** to keep the charge balanced inside the cell **A1**.