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**

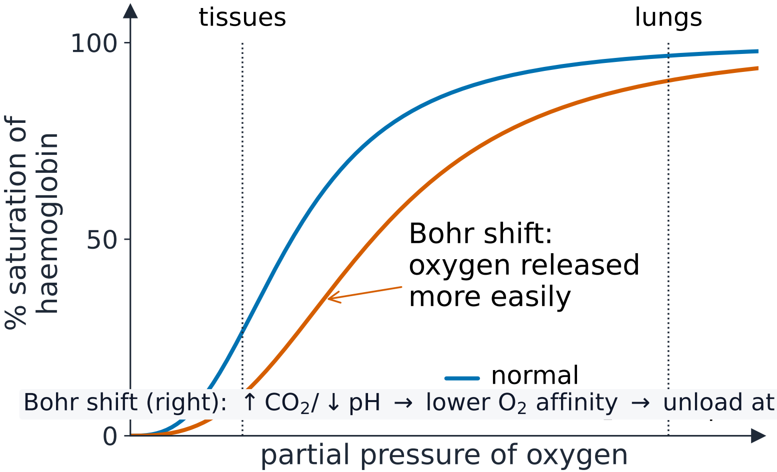
Method — The oxygen dissociation curve

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

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

Reading the curve: O 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): ↑ CO_2/ ↓ pH → lower O_2 affinity → unload at tissues

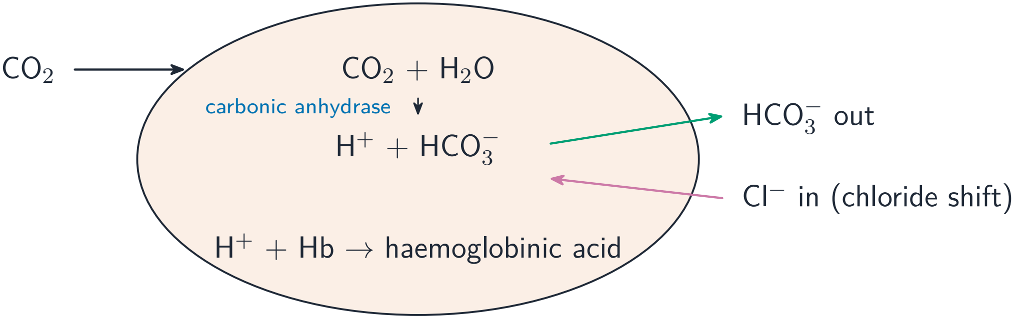
Method — The Bohr shift

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

Method — Carbon dioxide transport

Most CO is carried as **hydrogencarbonate ions 碳酸氢根离子**: **carbonic anhydrase 碳酸酐酶** catalyses CO $+$ water $\rightarrow$ carbonic acid $\rightarrow$ H $+$ HCO . HCO 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



inside the red blood cell

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 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 , lowering pH **M1**; this shifts the curve right, so at the same pO 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 leaves the red cell, chloride ions move in **M1** to keep the charge balanced inside the cell **A1**.