A-LEVEL BIOLOGY • EXERCISE SHEET

8.2 Transport of oxygen and carbon dioxide

Name: _____ Class: _____ Date: _____ **Total: 23 marks**

KEY WORDS carbon dioxide 二氧化碳 • bohr shift 波尔位移 • carbonic anhydrase 碳酸酐酶 • oxygen dissociation curve 氧解离曲线 • haemoglobinic acid 血红蛋白酸

Objective

Build the skills to answer exam questions on the **transport of oxygen and carbon dioxide** — the **oxygen dissociation curve** 氧解离曲线, the **Bohr shift** 波尔位移, and how carbon dioxide is carried.

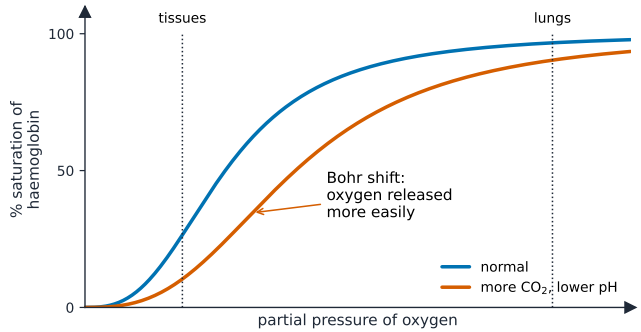
You must be able to:

- 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

1 Worked examples

The oxygen dissociation curve

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



Bohr shift (right): ↑ CO_2/ ↓ pH → lower O_2 affinity → unload at tissues

Haemoglobin loads O_2 in the lungs (high pO_2) and unloads it in tissues (low pO_2); the Bohr shift moves the curve right

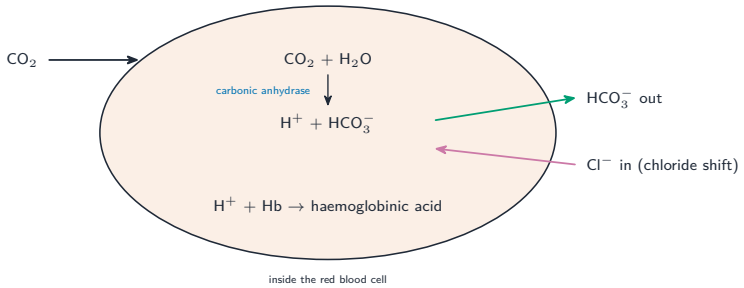
- in the lungs (high pO_2), haemoglobin becomes almost fully saturated (loads O_2).
- in respiring tissues (low pO_2), haemoglobin unloads O_2 for the cells.

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

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.

Carbon dioxide transport



Most CO_2 travels as hydrogencarbonate ions; the chloride shift balances charge; haemoglobin mops up H^+

Most CO_2 is carried as **hydrogencarbonate ions** 碳酸氢根离子: **carbonic anhydrase** 碳酸酐酶 catalyses CO_2 + water → carbonic acid → $H^+ + HCO_3^-$. 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).

2 Practice

2.1 State where on the dissociation curve haemoglobin (a) loads oxygen and (b) unloads oxygen. [2]

2.2 Name the enzyme that catalyses the reaction of carbon dioxide with water. [1]

3 Exam-style questions

3.1 In which form is **most** carbon dioxide carried in the blood? [1]

A B
C D

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

3.2 The Bohr shift moves the oxygen dissociation curve to the right. This means that, at a given partial pressure of oxygen, haemoglobin: [1]

A B
C D

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

3.3 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. [1]

(b) Explain how the Bohr shift increases the oxygen delivered to exercising muscle. [3]

3.4 Explain the importance of the chloride shift. [2]

3.5 The graph described below shows two oxygen dissociation curves for human haemoglobin: curve **P** at a carbon dioxide partial pressure of 5 kPa, and curve **Q** at 9 kPa, which lies to the right of **P**.

(a) Explain the shape of curve **P**, referring to the effect of binding the first oxygen molecule. [3]

(b) Name the shift from **P** to **Q**, and explain how carbon dioxide causes it. [3]

(c) Explain the benefit of this shift to a person during vigorous exercise. [3]

(d) Describe **two** ways, other than as carbaminohaemoglobin, in which carbon dioxide is carried in the blood, and give the equation for the main one. [3]