Unit 18 · Respiratory System

ANSWER KEY · FOR TEACHERS

Full marks 32

Give the marks for the points in the marking scheme; an answer in other words that says the same is right.

1 Key words

1. conchae
2. cricoid
3. pleura
4. surfactant
5. carbonic anhydrase
6. chloride shift
7. carbaminohemoglobin
8. Bohr effect

K · 4

Each carries 0.5 mark.

2 Label the diagram

1. trachea
2. right main bronchus
3. lobar bronchus
4. bronchioles
5. C-shaped cartilage rings
6. segmental bronchi

K · 3

Each carries 0.5 mark.

3 Multiple choice

i. **d.** cricoid — K · 1

The **cricoid** is single, like the thyroid cartilage and the epiglottis. The arytenoid, corniculate and cuneiform cartilages are pairs.

ii. **c.** posterior surface — K · 1

The gap faces **backwards** (posterior), towards the esophagus, and is closed by smooth muscle, so a mouthful passing down the esophagus can bulge into it.

iii. **c.** the chest grows, so the pressure in the lungs falls below the air's — U · 1

The diaphragm and external intercostals enlarge the **chest**; the lungs follow it, the air in them has more room and its **pressure falls below atmospheric**, so air flows in. The lungs themselves have no muscle to suck with.

iv. **d.** it reduces surface tension in the alveoli, making them easier to expand during inhalation — U · 1

Surfactant, from type II pneumocytes, **lowers the surface tension** of the water film lining the alveoli, so they don't collapse when small and are easy to inflate.

v. **b.** the right bronchus is wider and more nearly vertical — A · 1

The **right main bronchus** is wider, shorter and runs more steeply down, almost in line with the trachea, so anything falling down the windpipe tends to drop into it.

4 Short answers

a. MARKING SCHEME — K · 2

- ✓ The four pairs named.
- ✓ One function (lighter skull, or resonance of the voice).

b. MARKING SCHEME — U · 2

- ✓ Quiet: the muscles relax and elastic recoil pushes the air out, with no contraction.
- ✓ Forced: internal intercostals and abdominal muscles contract.

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c. MARKING SCHEME A · 2

✓ The fire makes carbon monoxide in the closed room.
✓ CO binds hemoglobin far more strongly than oxygen (carboxyhemoglobin), so the tissues get too little oxygen.

d. MARKING SCHEME U · 3

✓ Alveolar epithelium, capillary endothelium and the basement membrane between them.
✓ Very thin and moist, with a huge surface area.
✓ Gradients kept up by breathing and blood flow.

5 Long answers

a. ANSWER U · 4

Air flows from higher pressure to lower; the muscles change the size of the chest and so the pressure in the lungs.

- **Inspiration (active):** the **external intercostal muscles** contract, pulling the ribs and sternum **upward and outward**; the **diaphragm** contracts and **flattens**.
- The chest grows in all directions; the lungs, held to it by pleural fluid, expand; the pressure in the lungs **falls below atmospheric**, and air rushes in.
- **Expiration (passive):** the external intercostals and diaphragm **relax**; the ribs fall downward and inward, the diaphragm rises into its **dome**, and the elastic lungs **recoil**.
- The chest gets smaller, the pressure in the lungs **rises above atmospheric**, and air flows out.

MARKING SCHEME

✓ Inspiration: external intercostals lift the ribs up and out; the diaphragm contracts and flattens.
✓ The chest and lungs enlarge, pressure falls below atmospheric, air flows in.
✓ Expiration: muscles relax, diaphragm domes, lungs recoil.
✓ The chest shrinks, pressure rises above atmospheric, air flows out.

b. ANSWER A · 4

- **Dissolved in the plasma**, about **7%**.
- **As bicarbonate**, about **70%**: in the red cells **carbonic anhydrase** joins CO_2 and H_2O into **H_2CO_3**, which splits into H^+ and **HCO_3^-**. The H^+ is taken up by **hemoglobin**, so the blood hardly becomes more acid.
- The HCO_3^- moves out into the **plasma**, and **Cl^-** moves into the red cell in exchange: the **chloride shift** (Hamburger phenomenon).
- **As carbaminohemoglobin**, about **23%**: CO_2 joins the amino groups of hemoglobin.

In the lungs, where PCO_2 is lower, all three reverse, and the CO_2 diffuses into the alveoli.

MARKING SCHEME

✓ About 7% dissolved in plasma.
✓ About 70% as bicarbonate, made in red cells by carbonic anhydrase; H^+ taken up by hemoglobin.
✓ HCO_3^- leaves for the plasma in exchange for Cl^- (chloride shift).
✓ About 23% as carbaminohemoglobin; all reverse in the lungs.

6 Think

ANSWER HA · 3

A working muscle uses more oxygen, so its **PO_2 falls lower**; on the **steep middle part** of the S-shaped curve a small fall in PO_2 makes hemoglobin give up a lot more oxygen.
The working muscle also makes more **carbon dioxide, acid and heat**: high PCO_2, low pH and high temperature shift the curve **to the right** (the **Bohr effect**).
So at the same PO_2, hemoglobin holds less oxygen and **unloads more** into the working muscle.

MARKING SCHEME

✓ Lower PO_2 in a working muscle; the steep part of the curve releases much more oxygen.
✓ More CO_2, acid and heat shift the curve to the right (Bohr effect).
✓ So hemoglobin unloads more oxygen at the same PO_2.

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7 Activity: Count your breaths

(not marked)

WHAT STUDENTS SHOULD FIND

At rest about **12–16** breaths a minute, shallow. Just after running the rate rises sharply and each breath is **deeper**; it falls back over a few minutes. The running muscles respire faster, making more **carbon dioxide** (and acid) and using more oxygen; the rise in CO_2 is sensed by the brain's breathing centers, which make breathing faster and deeper.

Marks by level	Knowledge	Understanding	Application	Higher ability	Total
Marks	11	11	7	3	**32**

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