2.4 Respiration and gas exchange

Name: _____ Class: _____ Date: _____ **Total: 27 marks**

Objective

Build the skills to answer exam questions on **respiration and gas exchange** : aerobic and anaerobic respiration, the structure of the thorax, breathing in and out, the alveoli, the effects of smoking and the effect of exercise on breathing.

You must be able to:

- write word equations for aerobic and anaerobic respiration
- explain how breathing in and out happens
- explain the effects of smoking on the lungs
- analyse breathing data before and after exercise

1 Key knowledge and worked examples

Respiration and breathing

idea	rule
respiration	releases energy (as ATP) from glucose in every living cell
aerobic	glucose + oxygen → carbon dioxide + water; releases a lot of energy
anaerobic	no oxygen; releases much less energy per glucose
gas exchange	oxygen and carbon dioxide move by diffusion across the alveolus walls
breathing rate	breaths ÷ time in minutes
volume per minute	breathing rate × volume of each breath

Worked example 1: breathing rate. A student takes 45 breaths in 3 minutes. Find the breathing rate.

1. Known: 45 breaths; 3 min.
2. Rule: breaths ÷ minutes.
3. Numbers: $45 \div 3$.
4. Result: 15 **breaths per minute**.

Worked example 2: volume per minute. Each breath is 0.5 dm^3 at 15 breaths per minute. Find the volume per minute.

1. Known: 15 per min; 0.5 dm^3.
2. Rule: rate × volume per breath.
3. Numbers: 15×0.5.
4. Result: 7.5 **dm^3 per minute**.

Answer shapes: in breathing, name the muscle, say whether it contracts or relaxes, then the change in volume and pressure.

2 Practice

2.1 Write the word equation for anaerobic respiration in human muscle. [2]



2.2 Describe a test for carbon dioxide in exhaled air, and give the result. [2]

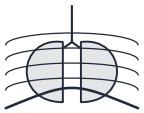


2.3 Give **two** features of the alveoli that make gas exchange fast. [2]



3 Exam-style questions

3.1 Describe how the intercostal muscles and the diaphragm cause air to enter the lungs. [3]



3.2 Explain **three** ways in which smoking damages the gas exchange system. [3]



3.3 A student measures her breathing rate at rest and for 5 minutes after running. She also measures the volume of each breath. The results are shown.

(a) Calculate the volume of air breathed per minute at rest and in the first minute after exercise. How many times greater is it after exercise? [3]



time	rest	1 min	2 min	3 min	4 min	5 min
breaths per min	14	30	24	18	15	14
volume per breath / dm^3	0.5	1.5	1.2	0.9	0.6	0.5

(b) Explain why the breathing rate stays high for several minutes after the exercise stops. [3]

(c) Calculate the percentage increase in breathing rate from rest to the first minute after exercise, and the time taken for the rate to return to the resting value. [3]

(d) Compare aerobic and anaerobic respiration in the student's leg muscles during the run. [6]

Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

- glucose →
- lactic acid

2.2

- bubble the air through limewater (or hydrogencarbonate indicator)
- limewater turns milky (indicator turns from red to yellow)

2.3

Any two (1 mark each):

- a large surface area (many alveoli)
- thin walls, one cell thick, so a short diffusion distance
- a good blood supply keeps a steep concentration gradient
- a moist lining for gases to dissolve

3.1

- the external intercostal muscles contract, moving the ribs up and out
- the diaphragm contracts and flattens
- the volume of the thorax increases, so the pressure falls below air pressure and air moves in

3.2

Any three (1 mark each):

- tar can cause lung cancer
- smoke damages the cilia, so mucus and bacteria collect: bronchitis
- alveolus walls break down (emphysema), giving a smaller surface area
- carbon monoxide joins to haemoglobin, so the blood carries less oxygen

3.3

(a) rest: $14 \times 0.5 = 7.0$ dm^3; after: $30 \times 1.5 = 45$ dm^3; $45 \div 7.0 = \mathbf{6.4}$ times

(b) during the run some respiration was anaerobic, making lactic acid; extra oxygen is needed to break down the lactic acid (the oxygen debt); fast breathing also removes the extra carbon dioxide

(c) $(30 - 14) \div 14 \times 100 = \mathbf{114}\%$; 5 minutes

(d) points to include:

- aerobic respiration uses oxygen; anaerobic does not (K)
- aerobic: glucose + oxygen → carbon dioxide + water; anaerobic: glucose → lactic acid (K)
- aerobic releases much more energy from each glucose molecule (K)
- during hard running the blood cannot supply oxygen fast enough, so anaerobic respiration adds energy (An)
- anaerobic respiration makes lactic acid, which causes muscle fatigue (An)
- lactic acid must later be broken down with oxygen, but carbon dioxide and water from aerobic respiration are simply removed (An)

Levels: **5–6** a full, logical answer with correct biology and correct terms; **3–4** several correct points, partly linked; **1–2** one or two relevant points.