PE.AP4 Cardio-Respiratory System: Breathing and Gaseous Exchange

Total Marks

AQA 8582 · Calculators not allowed · about 50 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Air travels through several structures on its way from the mouth/nose to the lungs. Which of the following gives the structures in the correct order?

- ☐ A) Trachea, bronchi, bronchioles, alveoli
- ☐ B) Bronchi, trachea, bronchioles, alveoli
- ☐ C) Alveoli, bronchioles, bronchi, trachea
- ☐ D) Trachea, bronchioles, bronchi, alveoli

(Total for Question 1 is 1 mark)

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2 State the name of the tiny air sacs in the lungs where gaseous exchange takes place.

(Total for Question 2 is 1 mark)

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3 Explain three features of the alveoli that make them well suited to efficient gaseous exchange.

(Total for Question 3 is 3 marks)

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4 Explain the process of gaseous exchange that takes place at the alveoli between the air breathed in and the blood in the surrounding capillaries.

(Total for Question 4 is 2 marks)

5 During inspiration (breathing in), two sets of muscles work together to increase the volume of the thoracic cavity.

(a) Name the dome-shaped muscle that contracts and flattens during inspiration. **(1)**

(b) Name the muscles between the ribs that contract to pull the ribcage upward and outward during inspiration. **(1)**

(Total for Question 5 is 2 marks)

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6 Explain how the contraction of the diaphragm and the external intercostal muscles causes air to move into the lungs during inspiration.

(Total for Question 6 is 3 marks)

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7 During expiration (breathing out) at rest, the diaphragm and external intercostal muscles relax.

(Total for Question 7 is 1 mark)

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8 During intense exercise, a rower needs to breathe out much more forcefully and quickly than at rest.

(a) Name the additional set of muscles used to force air out of the lungs during forced expiration. **(1)**

(b) Explain how these muscles help increase the speed of expiration. **(1)**

(Total for Question 8 is 2 marks)

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9 State the name of the two branches that the trachea splits into, each one leading to a lung.

(Total for Question 9 is 1 mark)

10 State the term used for the smaller tubes that the bronchi branch into within the lungs, before reaching the alveoli.

(Total for Question 10 is 1 mark)

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11 A swimmer performs an interval training session, breathing much more deeply and rapidly than at rest.

(a) State the term used for the volume of air breathed in or out in one breath. **(1)**

(b) Explain why an increase in both tidal volume and breathing rate during exercise increases the amount of oxygen available to the working muscles. **(2)**

(Total for Question 11 is 3 marks)

12 Table 1 gives descriptions of structures and terms in the respiratory system, with the name missing.

Table 1

Part	Description
(a)	The tube that carries air from the throat down towards the two bronchi
(b)	The dome-shaped muscle beneath the lungs that contracts and flattens during inspiration
(c)	The maximum volume of air that can be forcibly breathed out after the deepest possible breath in
(d)	The number of breaths taken in one minute
(e)	The muscles between the ribs that contract during inspiration to pull the ribcage up and out

(a) Name the structure/term described in row (a) of Table 1. **(1)**

(b) Name the structure/term described in row (b) of Table 1. **(1)**

(c) Name the structure/term described in row (c) of Table 1. **(1)**

(d) Name the structure/term described in row (d) of Table 1. **(1)**

(e) Name the structure/term described in row (e) of Table 1. **(1)**

(Total for Question 12 is 5 marks)

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13 A distance runner completes a 12-week aerobic training block. Explain how long-term aerobic training can increase vital capacity, and how this benefits the runner's performance.

(Total for Question 13 is 3 marks)

14 The alveoli are surrounded by a dense network of capillaries, and both structures have walls that are only one cell thick.

Evaluate how the combination of structural features of the alveoli and the surrounding capillaries makes the lungs efficient at supplying oxygen to a marathon runner during a two-hour race.

(Total for Question 14 is 6 marks)

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15 Explain why the walls of the alveoli and the surrounding capillaries need to be moist.

(Total for Question 15 is 2 marks)

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16 A cyclist notices their breathing rate and depth both increase noticeably as soon as a hill climb begins. State the two variables that together make up 'minute ventilation' (the total volume of air breathed in one minute).

(Total for Question 16 is 2 marks)

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17 Before air reaches the trachea, it passes through two further structures at the back of the mouth and throat.

(a) Name the passage directly behind the mouth and nose that both air and food pass through. **(1)**

(b) Name the structure below the pharynx, containing the vocal cords, that air passes through before reaching the trachea. **(1)**

(Total for Question 17 is 2 marks)

18 Describe, step by step, how oxygen breathed into a footballer's lungs eventually reaches their working leg muscles during a match.

(Total for Question 18 is 3 marks)

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19 A resting adult typically breathes at around 12-15 breaths per minute.

(a) State what happens to breathing rate during exercise, compared with at rest. **(1)**

(b) Explain why an increased breathing rate is needed during exercise. **(2)**

(Total for Question 19 is 3 marks)

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20 Which structure closes over the trachea to stop food or drink entering the airway when a person swallows?

- ☐ A) Larynx
- ☐ B) Epiglottis
- ☐ C) Pharynx
- ☐ D) Bronchi

(Total for Question 20 is 1 mark)

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21 An asthmatic hockey player's bronchioles narrow (bronchoconstriction) during a hard training session. Explain why this makes breathing more difficult during exercise.

(Total for Question 21 is 2 marks)

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22 A long-term lung condition can permanently damage and reduce the surface area of some of a person's alveoli. Suggest one effect this would have on gaseous exchange.

(Total for Question 22 is 2 marks)

Mark scheme · PE.AP4 Cardio-Respiratory System: Breathing and Gaseous Exchange

Question 1

- **B1** A
- **Answer: A (trachea, bronchi, bronchioles, alveoli)**

Question 2

- **B1** alveoli
- **Answer: Alveoli**

Question 3

- **B1** walls that are only one cell thick, giving a short diffusion pathway/distance for gases, oe
- **B1** surrounded by a dense network of capillaries, also with walls one cell thick, keeping the diffusion pathway short and maintaining a steep concentration gradient, oe
- **B1** millions of alveoli give the lungs a very large total surface area for gaseous exchange to take place across, oe (also accept: moist lining, which allows gases to dissolve before diffusing)
- **Answer: The alveoli have walls only one cell thick, are surrounded by a dense network of capillaries with walls also one cell thick, and there are millions of them giving a very large total surface area; together these features give gases the shortest possible diffusion distance and the largest possible area to diffuse across.**

Question 4

- **B1** oxygen diffuses from the alveoli (where its concentration is higher) into the blood in the capillaries (where its concentration is lower), oe
- **B1** at the same time, carbon dioxide diffuses from the blood in the capillaries (where its concentration is higher) into the alveoli (where its concentration is lower), to be breathed out, oe
- **Answer: Oxygen diffuses from the alveoli, where its concentration is higher, into the blood in the surrounding capillaries, where its concentration is lower; at the same time, carbon dioxide diffuses from the blood, where its concentration is higher, into the alveoli, where its concentration is lower, ready to be breathed out.**

Question 5

- (a) **B1** diaphragm
- **(a) Answer: Diaphragm**
- (b) **B1** (external) intercostal muscles
- **(b) Answer: External intercostal muscles**

Question 6

- **B1** the diaphragm contracts and flattens, and the external intercostal muscles contract, pulling the ribcage up and out, oe
- **B1** this increases the volume of the thoracic cavity/chest, which decreases the air pressure inside the lungs, oe
- **B1** because the air pressure inside the lungs is now lower than the air pressure outside the body, air moves (is 'pushed') into the lungs, from high to low pressure, until the pressures equalise, oe
- **Answer: The diaphragm contracts and flattens while the external intercostal muscles contract and pull the ribcage up and out, which increases the volume of the thoracic cavity; this decreases the air pressure inside the lungs below atmospheric pressure, so air moves into the lungs from the higher pressure outside until the pressures equalise.**

Question 7

- **B1** the volume of the thoracic cavity decreases, increasing the air pressure inside the lungs above atmospheric pressure, so air is forced/pushed out of the lungs, oe
- **Answer: The volume of the thoracic cavity decreases, increasing the air pressure inside the lungs above atmospheric pressure, so air is forced out of the lungs.**

Question 8

- (a) **B1** (internal) intercostal muscles
- **(a) Answer: Internal intercostal muscles**
- (b) **B1** they actively pull the ribcage down and in more quickly/forcefully than relaxation alone, decreasing the volume of the thoracic cavity faster and increasing lung pressure more, forcing air out more quickly, oe
- **(b) Answer: The internal intercostal muscles actively pull the ribcage down and in more quickly and forcefully than relaxation alone would, decreasing the thoracic cavity's volume faster and forcing air out of the lungs more quickly.**

Question 9

- **B1** bronchi
- **Answer: Bronchi**

Question 10

- **B1** bronchioles
- **Answer: Bronchioles**

Question 11

- (a) **B1** tidal volume
- **(a) Answer: Tidal volume**
- (b) **B1** a greater tidal volume means more air (and so more oxygen) enters the lungs with each breath, oe
- (b) **B1** a faster breathing rate means this larger volume of air is breathed in more often per minute, so overall more oxygen reaches the alveoli (and diffuses into the blood) each minute, oe
- **(b) Answer: A greater tidal volume means more air (and oxygen) enters the lungs with each breath, and a faster breathing rate means this happens more often per minute, so overall more oxygen reaches the alveoli and diffuses into the blood each minute.**

Question 12

- (a) **B1** trachea
- **(a) Answer: Trachea**
- (b) **B1** diaphragm
- **(b) Answer: Diaphragm**
- (c) **B1** vital capacity
- **(c) Answer: Vital capacity**
- (d) **B1** breathing rate (respiratory rate)
- **(d) Answer: Breathing rate**
- (e) **B1** external intercostal muscles
- **(e) Answer: External intercostal muscles**

Question 13

- **B1** long-term aerobic training strengthens the respiratory muscles (the diaphragm and intercostal muscles), oe
- **B1** this can increase the depth of each breath the runner is able to take, increasing their vital capacity, oe
- **B1** a greater vital capacity allows more oxygen to be taken in with each breath, which can be delivered to the working muscles, delaying fatigue and improving endurance performance, oe
- **Answer: Long-term aerobic training strengthens the respiratory muscles (the diaphragm and intercostal muscles), which can increase the runner's vital capacity; a greater vital capacity allows more oxygen to be taken in with each breath, helping delay fatigue and improving endurance performance.**

Question 14

- **Level 3** (5-6): A detailed and coherent evaluation that explains at least three structural features of the alveoli/capillaries (e.g. short diffusion distance, large surface area, dense capillary network maintaining a steep concentration gradient) and clearly links each to sustained oxygen supply during a two-hour race, using accurate terminology throughout.
- **Level 2** (3-4): At least two structural features are explained with reasonable accuracy, with some link made to the runner sustaining oxygen supply, but development may be limited.
- **Level 1** (1-2): One or two relevant points about the structure of the alveoli or capillaries are made, with little explanation or link to the marathon context.
- **Level 0** (0): No relevant content.
- **Indicative content:**
  - Walls of the alveoli and capillaries are only one cell thick, giving the shortest possible diffusion distance for oxygen to pass from the air into the blood.
  - The lungs contain millions of alveoli, giving a very large total surface area across which diffusion of oxygen can take place at once.
  - The dense capillary network around each alveolus keeps a continuous supply of deoxygenated blood arriving and oxygenated blood leaving, maintaining a steep concentration gradient for oxygen to diffuse down.
  - During the two-hour race the runner's breathing rate and tidal volume both increase, moving more air (and so more oxygen) past the alveoli each minute, working alongside the structural features rather than replacing them.
  - An increased cardiac output during exercise also moves blood through the pulmonary capillaries faster, helping maintain the concentration gradient for oxygen diffusion throughout the two hours.
  - A balanced evaluation might conclude that the alveoli's structural features (short distance, large area, rich blood supply) are what make gaseous exchange efficient at any one moment, while the increased breathing rate and cardiac output during the race are what sustain a high rate of oxygen delivery over the full two hours.

Question 15

- **B1** gases must dissolve in moisture/liquid before they can diffuse across a cell membrane, oe
- **B1** so a moist lining allows oxygen and carbon dioxide to dissolve and diffuse efficiently across the thin walls of the alveoli and capillaries, oe
- **Answer: Gases must dissolve in moisture before they can diffuse across a cell membrane, so a moist lining allows oxygen and carbon dioxide to dissolve and diffuse efficiently across the thin walls of the alveoli and capillaries.**

Question 16

- **B1** tidal volume
- **B1** breathing rate (number of breaths per minute)
- **Answer: Tidal volume and breathing rate.**

Question 17

- (a) **B1** pharynx (throat)
- **(a) Answer: Pharynx**
- (b) **B1** larynx (voice box)
- **(b) Answer: Larynx**

Question 18

- **B1** oxygen diffuses from the alveoli into the blood in the surrounding capillaries, oe
- **B1** this oxygenated blood returns to the heart via the pulmonary vein, into the left atrium and then the left ventricle, oe
- **B1** the left ventricle pumps the oxygenated blood out via the aorta and its branching arteries to the leg muscles, where oxygen diffuses out of the capillaries into the muscle cells, oe
- **Answer: Oxygen diffuses from the alveoli into the blood in the surrounding capillaries; this oxygenated blood returns to the heart via the pulmonary vein into the left atrium and then the left ventricle; the left ventricle pumps it out via the aorta and its branching arteries to the leg muscles, where oxygen diffuses out of the capillaries into the muscle cells.**

Question 19

- (a) **B1** it increases
- **(a) Answer: It increases.**
- (b) **B1** the working muscles need more oxygen to release energy at a faster rate, and produce more carbon dioxide as a waste product, oe
- (b) **B1** so breathing rate increases to take in more oxygen and remove more carbon dioxide each minute, meeting the muscles' increased demand, oe
- **(b) Answer: The working muscles need more oxygen to release energy faster during exercise and produce more carbon dioxide as a waste product, so breathing rate increases to take in more oxygen and remove more carbon dioxide each minute, meeting this increased demand.**

Question 20

- **B1** B (epiglottis)
- **Answer: B (epiglottis)**

Question 21

- **B1** narrower bronchioles increase resistance to airflow, so more effort/muscular work is needed to move the same volume of air in and out of the lungs, oe
- **B1** this can reduce the amount of air (and so oxygen) reaching the alveoli each minute, making it harder to meet the working muscles' increased demand for oxygen, oe
- **Answer: Narrower bronchioles increase resistance to airflow, so more effort is needed to move the same volume of air in and out of the lungs, and this can reduce the amount of air (and oxygen) reaching the alveoli each minute, making it harder to meet the muscles' increased oxygen demand during exercise.**

Question 22

- **B1** a reduced total surface area of alveoli means less surface is available for gases to diffuse across, oe
- **B1** so less oxygen can diffuse into the blood (and less carbon dioxide out) each minute, making gaseous exchange less efficient, oe
- **Answer: With a reduced total surface area of alveoli, less surface is available for gases to diffuse across, so less oxygen can diffuse into the blood (and less carbon dioxide out) each minute, making gaseous exchange less efficient.**