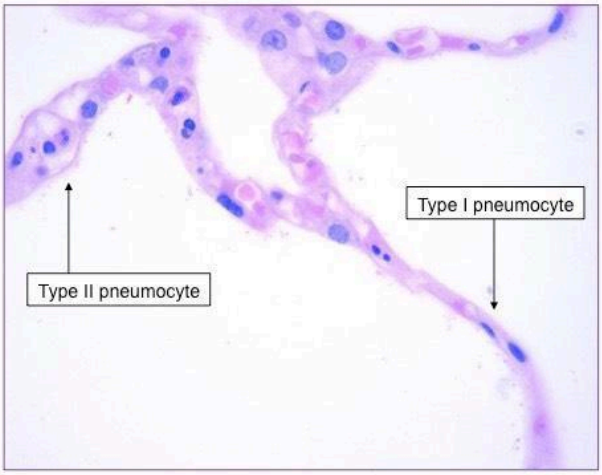
IB Biology

Revision

Topic 6.4 – Gas Exchange



Alveolar Air Spaces (High Magnification)

Name:

Teacher: Mr Trent

1. *[1 mark]*

A cell from the lungs, observed under the microscope, contains a large number of secretory organelles. Which conclusion can be drawn about the cell?

A. It is a type I pneumocyte.

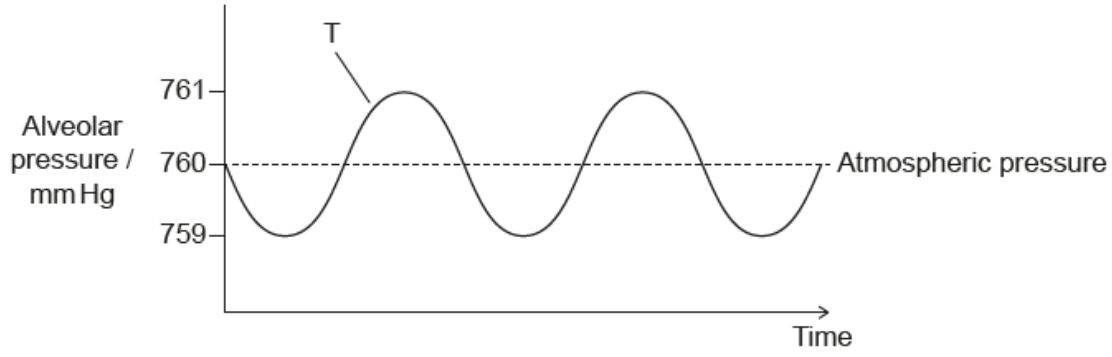
B. It is a type II pneumocyte.

C. It could be either a type I or type II pneumocyte.

D. It is a red blood cell.

2. *[1 mark]*

Pressure changes inside the thorax cause the movement of air in and out of the lung alveoli during ventilation. Alveolar pressure correlates to thoracic pressure. The diagram shows pressure changes in lung alveoli during ventilation in relation to normal atmospheric pressure. What causes forced movement of air out of the lungs at T?



A.	external intercostal muscles contract	diaphragm relaxes
B.	internal intercostal muscles contract	abdominal muscles contract
C.	internal intercostal muscles contract	diaphragm contracts
D.	external intercostal muscles relax	abdominal muscles relax

3. *[1 mark]*

Which process results in the exchange of gases across the membrane of pneumocytes?

A. Active transport

B. Simple diffusion

C. Facilitated diffusion

D. Mass flow

4. *[1 mark]*

What is produced by type II pneumocytes?

A. Epinephrine

B. Elastase

C. Pulmonary surfactant

D. Alpha 1-antitrypsin

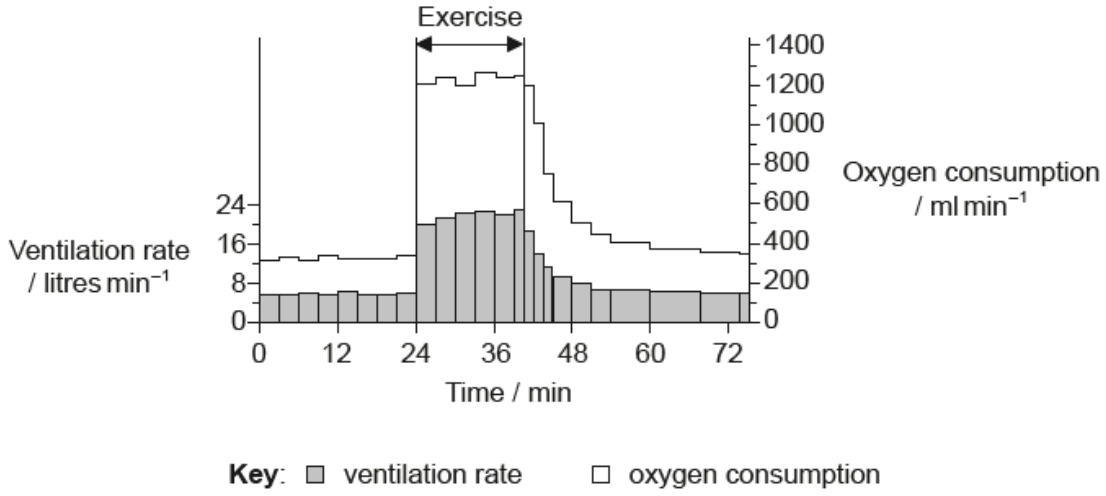
5. *[1 mark]*

How are the insides of alveoli prevented from sticking together?

	Method of prevention	Produced by
A.	Surfactant	Type I pneumocytes
B.	Surfactant	Type II pneumocytes
C.	Pressure	Mixture of O_2 and CO_2 within alveoli
D.	Pressure	CO_2 concentration gradient inside capillaries

6. *[1 mark]*

The graph shows the ventilation rate and the oxygen consumption of a subject before, during and after a period of exercise.



[Source: adapted from W E Huckabee (1958) *The Journal of Clinical Investigation*, 37 (2), page 256. Republished with permission of American Society for Clinical Investigation, permission conveyed through Copyright Clearance Center, Inc.]

Which could be a reason for the oxygen consumption to remain high for some time after the end of the period of exercise?

A. Epinephrine keeps the ventilation rate high.

B. Part of the exercise was done using anaerobic respiration.

C. A low ventilation rate keeps the consumption high.

D. More ATP is necessary for cross bridge formation while muscles cool down.

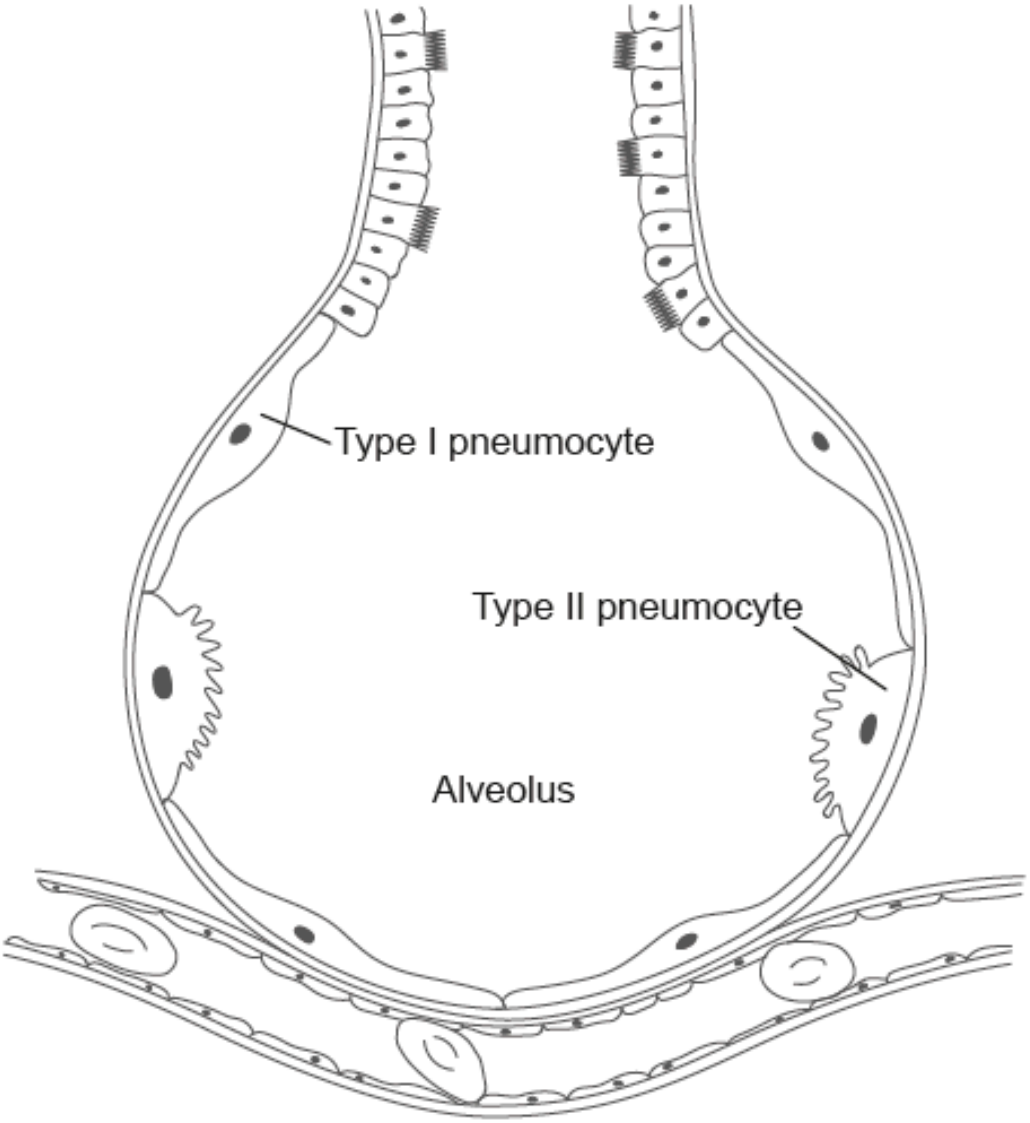
7. *[1 mark]*

Which conditions are correct for inspiration?

	Muscles contracted	Pressure in thorax
A.	external intercostal	decreases
B.	internal intercostal	increases
C.	diaphragm	increases
D.	abdominal	decreases

8a. *[2 marks]*

The diagram shows the structure of an alveolus and an adjacent capillary.



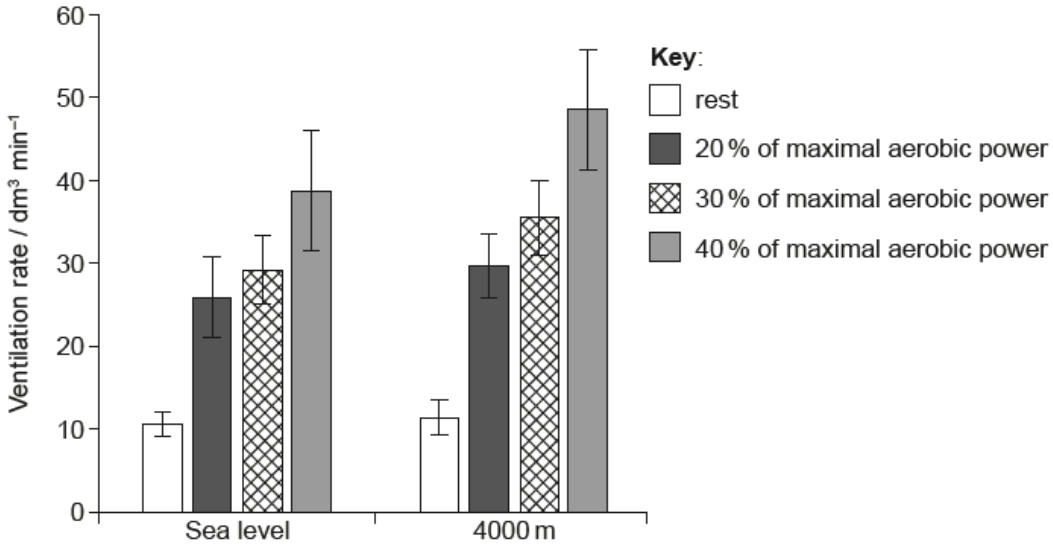
Outline the functions of type I and type II pneumocytes.

8b. *[3 marks]*

Explain how gases are exchanged between the air in the alveolus and the blood in the capillaries.

9a. *[1 mark]*

A study was conducted on 25 healthy, non-smoking males to look at the effect of exercise and altitude on ventilation rate. Subjects were first asked to rest in a sitting position for six minutes. They then pedalled for three periods of six minutes at increasing exercise intensity: at 20 %, 30 % and 40 % of their maximal aerobic power. The entire study was conducted either in normal sea level oxygen conditions or in lower oxygen conditions simulating an altitude of 4000 m. The results are shown in the bar chart.



State **one** other variable that should have been controlled in this study.

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9b. *[2 marks]*

Compare and contrast the effect of increasing exercise intensity at sea level and at an altitude of 4000 m

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9c. *[2 marks]*

Outline how ventilation rate could have been monitored in this study.

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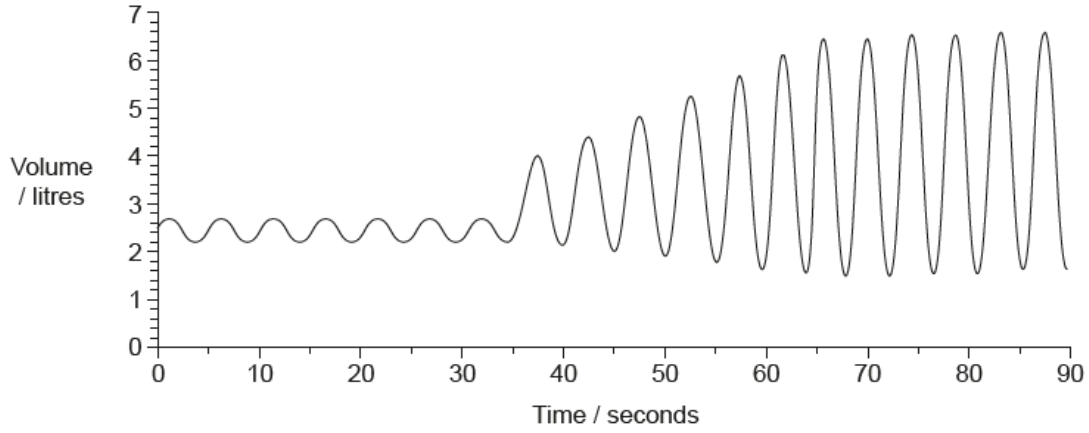
10. *[7 marks]*

Adult humans may absorb more than five hundred litres of oxygen per day. Explain how gas exchange is maintained in the human respiratory system.

11a. *[1 mark]*

Measurements of the lung capacity of a student were recorded using a spirometer and displayed with a data logger. Initially the student was at rest, then changed to carrying out strenuous exercise. The results are displayed in the graph.



Calculate the ventilation rate at rest, giving the units.

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11b. *[2 marks]*

Explain the changes in ventilation after 35 seconds.

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11c. *[1 mark]*

Suggest how the total lung volume at rest would differ for a patient with emphysema.

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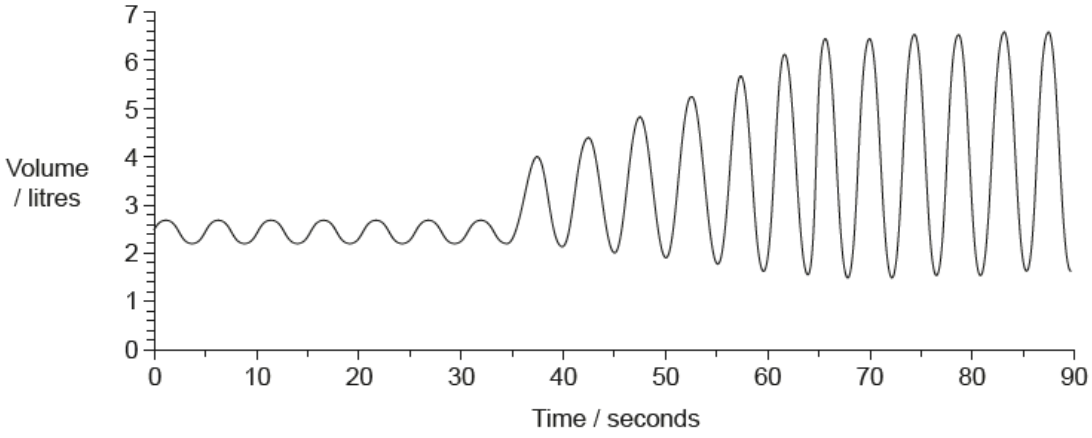
12a. *[1 mark]*

Measurements of the lung capacity of a student were recorded using a spirometer and displayed with a data logger. Initially the student was at rest, then changed to carrying out strenuous exercise. The results are displayed in the graph.



Calculate the ventilation rate at rest, giving the units.

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12b. *[2 marks]*

Explain the changes in ventilation after 35 seconds.

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12c. *[1 mark]*

Suggest how the total lung volume at rest would differ for a patient with emphysema.

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12d. *[2 marks]*

Outline the function of pneumocytes in the lungs.

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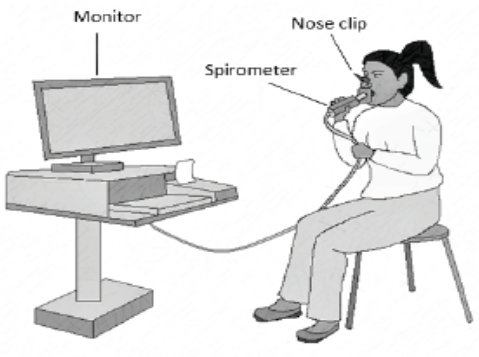
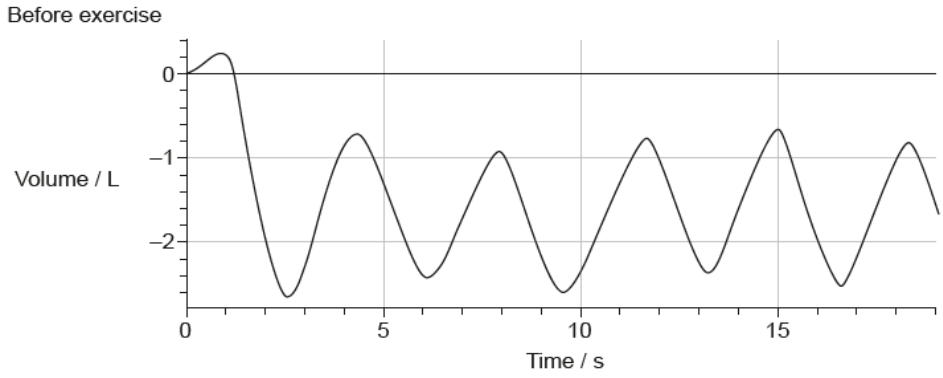
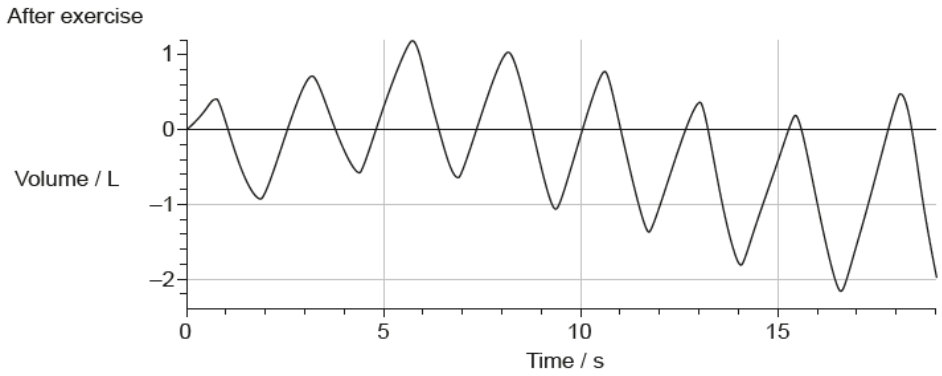
13a. *[2 marks]*

In an experiment to explore the effect of exercise on ventilation rate, a subject breathed into a data logging sensor that measured air flow.



The graphs show the result before the subject exercised and immediately after the exercise had finished.





Determine the ventilation rate after exercise.

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13b. *[2 marks]*

Describe how the mean tidal volume after exercise could be determined using the graph.

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13c. *[1 mark]*

Predict, with a reason, the effect of exercise on the rate of cell respiration.

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13d. *[1 mark]*

Identify a muscle responsible for increasing the volume of the chest cavity.

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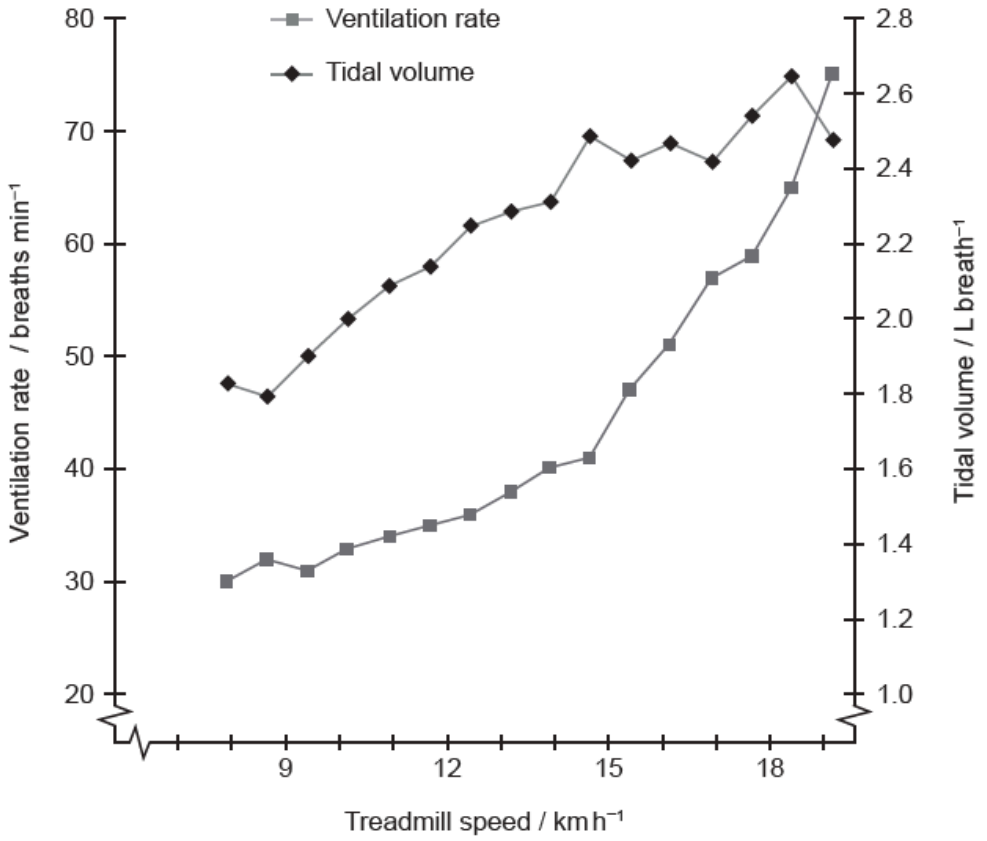
14a. *[1 mark]*

The graph shows the ventilation rate and tidal volume of a well-trained runner during exercise on a treadmill. The tidal volume is the volume of air being moved in and out of the lungs in each breath.



[Source: The Editor In Chief of the Journal of Exercise Physiology online grants permission to publish the article by Amonette W E and Dupler T L, which was published in *JEPonline* 2002;5(2):29-35 issue.]

State the apparatus used to measure the tidal volume.

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14b. *[2 marks]*

Calculate the total volume of air inhaled during one minute during the highest velocity of the treadmill in this test, giving the units.

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14c. *[2 marks]*

Compare and contrast the effect of increasing treadmill speed on the ventilation rate and tidal volume in this runner.

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15a. *[4 marks]*

Outline the process of inhalation.

15b. *[7 marks]*

Explain the process of gas exchange taking place in the alveoli.

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16. *[7 marks]*

Explain how ventilation and lung structure contribute to passive gas exchange.

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17. *[4 marks]*

Outline the process of inspiration in humans.

18a. *[4 marks]*

Outline the role of the parts of an alveolus in a human lung.

18b. *[4 marks]*

Explain how antibiotic resistance can evolve in bacteria, such as those causing pneumonia.

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19. *[4 marks]*

All living organisms depend on a continuous supply of energy.

Outline how ventilation in humans ensures a supply of oxygen.

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20. *[4 marks]*

The human circulatory system is structured to serve the organs and tissues of the body efficiently.

Describe what happens in alveoli.

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1. *[1 mark]*

B

2. *[1 mark]*

B

3. *[1 mark]*

B

4. *[1 mark]*

C

5. *[1 mark]*

B

6. *[1 mark]*

B

7. *[1 mark]*

A

8a. *[2 marks]*

Markscheme

type I:

a. carry out gas exchange
OR
diffusion of gases/CO_2/O_2 ✔

type II:

b. secrete fluid/surfactant ✔

8b. *[3 marks]*

Markscheme

a. O_2 concentration in alveolar air greater than in capillary/blood «prior to gas exchange»
OR
hemoglobin in blood binds oxygen maintaining the concentration gradient ✔

b. O_2 gas dissolves in water lining the alveolus ✔

c. O_2 diffuses through wall of alveolus and capillary into blood ✔

d. CO_2 concentration in blood greater than in alveolar air «prior to gas exchange» ✔

e. CO_2 diffuses through wall of capillary and alveolus into alveolar airspace ✔

9a. *[1 mark]*

Markscheme

age/height/fitness level/weight/room temperature/rest in between tests/model or type of bike ✔

Other valid factor. Only mark first factor listed.

Do not accept sex, health, smoking, oxygen level or altitude as this already listed.

9b. *[2 marks]*

Markscheme

a. in both sea level and 4000m ventilation rate while exercising «at all intensities» is «significantly» more than at rest
OR
both sea level and 4000m show an increase in ventilation rate «$dm^3\ min^{-1}$» as exercise intensity increased ✔

b. ventilation rate at 4000m «slightly» higher than at sea level for all conditions
OR
higher ventilation rate at 4000m not «significantly» different as error bars overlap ✔

Accept positive correlation.

9c. *[2 marks]*

Markscheme

a. «data logging» with spirometer
OR
chest belt ✔

b. «tidal» volume recorded for a given period of time
OR
average «tidal» volume found and multiplied by number breaths per minute ✔

Do not accept confusion with respirometer (measuring oxygen consumption or CO_2 release).

Must include a reference to time.

10. *[7 marks]*

Markscheme

a. ventilation/inhaling brings fresh air/air with high oxygen concentration to the lungs
OR
ventilation/exhaling gets rid of stale air/air with high concentration of carbon dioxide ✔

b. ventilation due to muscle contractions causing pressure/volume changes in the thorax ✔

c. contraction of external intercostal muscles ***AND*** diaphragm occurs during inspiration
OR
contraction of internal intercostal muscles/abdomen wall muscles during «forced» expiration ✔

d. alveoli surrounded by «many» capillaries ✔

e. blood flow/pumping of heart «brings blood to/takes blood away from alveoli/lungs» ✔

f. concentration gradients «of oxygen/ CO_2» maintained «by ventilation/blood flow» ✔

g. O_2 AND CO_2 diffuse ✔

h. CO_2 from capillaries/blood/vessel to alveolus/air ***AND*** O_2 from alveoli into capillaries/blood/vessel ✔

i. large numbers of alveoli increase surface area ✔

j. short distance so rapid diffusion/gas exchange ✔

k. type I pneumocytes/alveolus wall/capillary walls are one cell thick/very thin ✔

l. alveoli «lining» moist for dissolving of gases/rapid diffusion
OR
type II pneumocytes keep the «lining of» the alveolus moist ✔

m. type II pneumocytes secrete surfactant to reduce surface tension/prevents alveoli from collapsing ✔

11a. *[1 mark]*

Markscheme

12 breaths per minute/6 litres per minute ✔

breaths per minute.

Accept answers from 5.5 to 6 litres per minute.

Answer must include breaths or litres and a standard unit of time.

Correct:
eg: 12 breaths / minute
eg: 0.1 L sec^{-1} or 6 L min^{-1}

Incorrect:
eg: but 12 breaths = 0 marks

11b. *[2 marks]*

Markscheme

a. the volume of air per breath increases
OR
the volume of each breath reaches a maximum/levels off
OR
frequency of ventilation/breaths per minute increases ✔

b. exercise increases «rate of cellular» respiration/energy use/blood CO_2/acidity ✔

c. exercise causes increased demand for oxygen/removal of carbon dioxide ✔

d. maximum rate/depth of ventilation is determined by the capacity of the student ✔

11c. *[1 mark]*

Markscheme

«total resting lung volume» would be greater ✔

12a. *[1 mark]*

Markscheme

12 breaths per minute/6 litres per minute ✔

Accept answers from 11 to 12 breaths per minute.

Accept answers from 5.5 to 6 litres per minute.

Answer must include breaths or litres and a standard unit of time.

Correct:
eg: 12 breaths / minute
eg: 0.1 L sec^{-1} or 6 L min^{-1}

Incorrect:
eg: but 12 breaths = 0 marks

12b. *[2 marks]*

Markscheme

a. the volume of air per breath increases
OR
the volume of each breath reaches a maximum/levels off
OR
frequency of ventilation/breaths per minute increases ✔

b. exercise increases «rate of cellular» respiration/energy use/blood CO_2/acidity ✔

c. exercise causes increased demand for oxygen/removal of carbon dioxide ✔

d. maximum rate/depth of ventilation is determined by the capacity of the student ✔

12c. *[1 mark]*

Markscheme

«total resting lung volume» would be greater ✔

12d. *[2 marks]*

Markscheme

a. type I pneumocytes carry out gas exchange ✔
OWTTE

b. type II pneumocytes secrete surfactant/fluid *OWTTE*
OR
type II pneumocytes create a moist surface inside the alveoli
OR
type II pneumocytes reduce surface tension between alveoli
OR
type II pneumocytes prevent the sides of the alveolus adhering to each other ✔

13a. *[2 marks]*

Markscheme

a. four breaths in 10 s = 4 × 6 «breaths min^{-1}»
OR
six breaths in 15 s = 6 × 4 «breaths min^{-1}»

b. 24 «breaths min^{-1}»

13b. *[2 marks]*

Markscheme

a. measure a volume difference for an individual breath
OR
maximum − minimum for an individual breath

b. repeat for several breaths and determine a mean

13c. *[1 mark]*

Markscheme

increased due to increased demand for ATP/energy «from muscle activity»

13d. *[1 mark]*

Markscheme

diaphragm
OR
external intercostal muscles

14a. *[1 mark]*

Markscheme

spirometer

14b. *[2 marks]*

Markscheme

a. tidal volume x ventilation rate
OR
litres breath^{-1} × breath min^{-1}

b. 186 L (min^{-1})

14c. *[2 marks]*

Markscheme

a. both ventilation rate and tidal volume increase with increase in treadmill speed/ intensity of exercise

b. at low treadmill speed/below 14.2 km h^{-1}, the tidal volume increases more steeply than ventilation rate
OR

at high treadmill speed, ventilation rate increases more steeply than tidal volume
OR
tidal volume plateaus while ventilation rate does not

15a. *[4 marks]*

Markscheme

a. diaphragm contracts / moves downwards/flattens ✔

b. external intercostal muscles contract ✔

c. (muscle contraction) moves the rib cage upwards and outwards ✔

d. increases volume of the thorax / lungs ✔

e. difference in pressure/decreasing pressure causes air to flow into lungs / lungs inflate ✔

15b. *[7 marks]*

Markscheme

a. O_2 diffuses into blood and CO_2 diffuses out from blood ✔

b. blood entering the alveoli is high in CO_2/low in O_2 ✔
OR
air in alveolus is high in O_2/low in CO_2 ✔

c. diffusion (in either direction) take place due to concentration gradients ✔

d. concentration gradients maintained by ventilation/blood flow ✔

e. large surface area created by many alveoli/spherical shape of alveoli for more efficient diffusion ✔

f. rich supply of capillaries (around alveoli) allows efficient exchange ✔

g. type I pneumocytes are thin to allow easy diffusion/short distances ✔

h. gases must dissolve in liquid lining of alveolus in order to be exchanged ✔

i. type II pneumocytes secrete surfactants to reduce surface tension/prevent lungs sticking together ✔

j. type II pneumocytes create moist conditions in alveoli ✔

16. *[7 marks]*

Markscheme

a. air carried through trachea ***AND*** bronchi/bronchioles ***AND*** alveoli ✔ *All three required in correct order.*

b. alveoli increase the surface area/thin walled for gas exchange ✔

c. gas exchange carried out through type I pneumocytes ✔

d. type II pneumocytes secrete surfactant to reduce surface tension ✔

e. moist surface/surfactant allows gases to diffuse in solution ✔

f. ventilation/moving blood maintains concentration gradients of oxygen and carbon dioxide ✔

g. between air in alveoli and blood in «adjacent» capillaries
OR
oxygen diffuses from alveoli to capillaries and carbon dioxide from capillaries to alveoli ✔ *OWTTE*

h. external intercostal muscles/diaphragm contract during inspiration ✔

i. lowering air pressure «in lungs»/increasing thorax volume ✔

j. relaxation of external intercostal muscles/diaphragm enable «passive» expiration ✔

k. internal intercostal «and abdominal muscles» contract «to force» expiration ✔

l. expiration due to increasing air pressure «in lungs»/decreasing thorax volume ✔

Accept correctly annotated diagram.

17. *[4 marks]*

Markscheme

a. diaphragm and external intercostal muscles contract ✔

b. diaphragm moves down/becomes flatter
OR
external intercostals raise the ribcage/move the ribcage up/out ✔

c. muscles/diaphragm/intercostals increase volume of thorax/expand the thorax
OR
muscles/diaphragm/intercostals decrease pressure in the thorax ✔

d. as volume «of thorax/lungs» increases the pressure decreases ✔

e. air enters «lungs» due to decreased pressure/higher pressure outside body ✔

f. air flows to lungs through trachea and bronchi/bronchioles ✔

Accept thoracic cavity or chest cavity in place of thorax in any part of the answer.

Do not allow "oxygen" instead of air in mpe or mpf.

18a. *[4 marks]*

Markscheme

a. the (spherical) wall of an alveolus maximizes/allows gas exchange

b. pneumocytes I (optimize) gas exchange

c. pneumocytes II produce surfactant

d. adjacent capillaries enclose alveolus for efficient gas exchange with blood

e. surfactant reduces surface tension/prevents collapse of alveolus

f. (alveolar) macrophages/phagocytes help with defense/homeostasis/response to foreign substances

18b. *[4 marks]*

Markscheme

a. antibiotic resistance exists as a genetic variation (within the population)

b. (antibiotic resistance) may occur from transfer of genetic material
OR
(antibiotic resistance) may occur through mutation

c. resistance is specific to one antibiotic

d. only bacteria with resistance gene reproduce in the presence of antibiotic

e. frequency of resistant bacteria increases in population

f. resistant population replaces non-resistant over time

19. *[4 marks]*

Markscheme

a. ventilation is exchange of gases between lungs and air.

b. during inhalation diaphragm contracts ***AND*** lowers.

Both needed.

c. external intercostal muscles contract, raising ribs upwards and outwards

d. increase in volume ***AND*** decrease in pressure within thoracic cavity

e. air drawn into alveoli bringing fresh supply of oxygen

f. oxygen concentration in alveolar sacs is higher than in blood capillaries

g. «oxygen concentration gradient» causes oxygen to diffuse out of alveoli into red blood cells in capillaries

20. *[4 marks]*

Markscheme

a. gas exchange

b. oxygen diffuses from air to blood and carbon dioxide diffuses from blood to air

c. oxygen binds to hemoglobin in red blood cells

d. pressure inside/volume of alveoli increases/decreases / air enters/exits alveoli during inspiration/expiration/ventilation

e. blood flow through capillaries / concentration gradients of gases/oxygen/CO_2 maintained

f. type II pneumocytes secrete fluid/surfactant / secretion of surfactant to prevent sides of alveolus adhering

Accept answer in a clearly annotated diagram.