Exercise and respiration 2

Name: _____

Class: _____

Date: _____

Time: **75 minutes**

Marks: **75 marks**

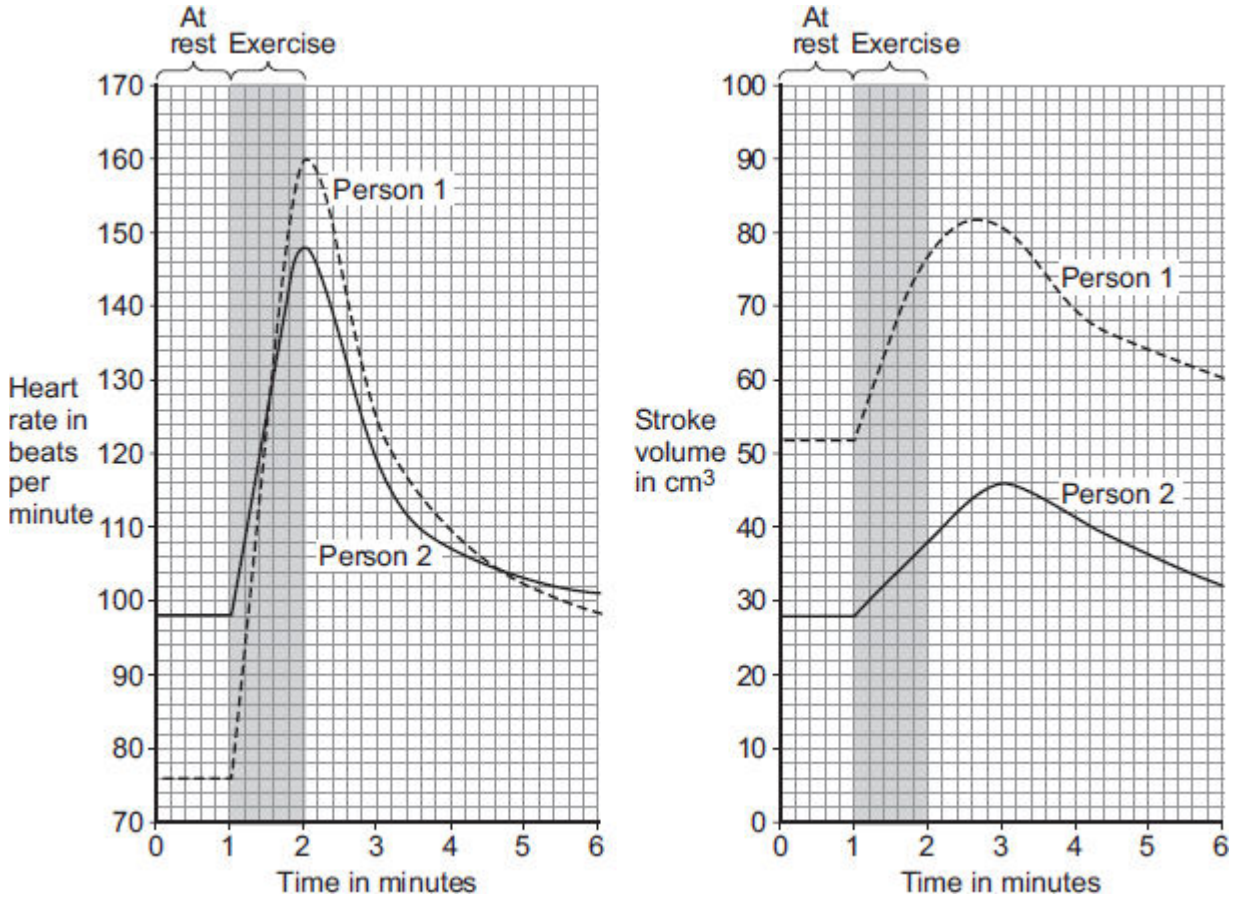
Comments:

1. During exercise, the heart beats faster and with greater force.

The 'heart rate' is the number of times the heart beats each minute.The volume of blood that travels out of the heart each time the heart beats is called the 'stroke volume'.

In an investigation, **Person 1** and **Person 2** ran as fast as they could for 1 minute. Scientists measured the heart rates and stroke volumes of **Person 1** and **Person 2** at rest, during the exercise and after the exercise.

The graph below shows the scientists' results.



(a) The 'cardiac output' is the volume of blood sent from the heart to the muscles each minute.

Cardiac output = Heart rate × Stroke volume

At the end of the exercise, **Person 1**'s cardiac output = 160 × 77 = 12 320 cm^3 per minute.

Use information from the figure above to complete the following calculation of **Person 2**'s cardiac output at the end of the exercise.

At the end of the exercise:

Person 2's heart rate = _____ beats per minute

Person 2's stroke volume = _____ cm^3

Person 2's cardiac output = _____ cm^3 per minute

(3)

(b) **Person 2** had a much lower cardiac output than **Person 1.**

(i) Use information from the figure above to suggest the **main** reason for the lower cardiac output of **Person 2**.

_____

_____

(1)

(ii) **Person 1** was able to run much faster than **Person 2**.

Use information from the figure above and your own knowledge to explain why.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(5)

(Total 9 marks)

2. **Figure 1** shows an athlete running on a treadmill.

Figure 1

© Starush/istock/Thinkstock

After running for several minutes, the athlete's leg muscles began to ache.
This ache was caused by a high concentration of lactic acid in the muscles.

(a) The equation shows how lactic acid is made.

glucose ⟶ lactic acid (+ energy)

Name the process that makes lactic acid in the athlete's muscles.

_____

(1)

(b) Scientists investigated the production of lactic acid by an athlete running at different speeds.

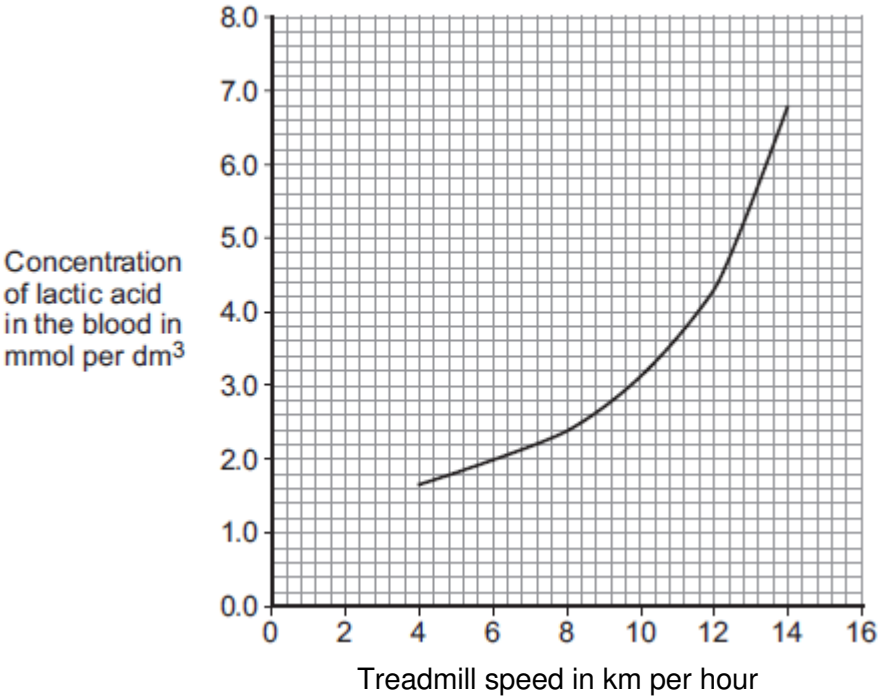
In the investigation:

- the athlete ran on the treadmill at 4 km per hour
- the scientists measured the concentration of lactic acid in the athlete's blood after 2 minutes of running.

The investigation was repeated for different running speeds.

Figure 2 shows the scientists' results.

Figure 2



(i) How much more lactic acid was there in the athlete's blood when he ran at 14 km per hour than when he ran at 8 km per hour?

_____

_____

_____

Answer = _____ mmol per dm^3

(2)

(ii) Why is more lactic acid made in the muscles when running at 14 km per hour than when running at 8 km per hour?

_____

_____

_____

_____

_____

_____

(3)

(Total 6 marks)

3. Scientists investigated how exercise affects blood flow to different organs in the body.

The scientists made measurements of blood flow to different organs of:

- a person resting in a room at 20°C
- the same person, in the same room, doing vigorous exercise at constant speed on an exercise cycle.

The table shows the scientists' results.

Organ	**Blood flow in cm^3 per minute whilst …**	
	resting	**doing vigorous exercise**
Brain	750	750
Heart	250	1000
Muscles	1200	22 000
Skin	500	600
Other	3100	650

(a) In this investigation, it was better to do the exercise indoors on an exercise cycle than to go cycling outdoors on the road.

Suggest **two** reasons why.

Do **not** include safety reasons.

1. _____

_____

_____

2. _____

_____

_____

(2)

(b) Blood flow to **one** organ did **not** change between resting and vigorous exercise.

Which organ?_____

(1)

(c) (i) How much more blood flowed to the muscles during vigorous exercise than when resting?

_____

_____

Answer = _____ cm^3 per minute

(2)

(ii) Name **two** substances needed in larger amounts by the muscles during vigorous exercise than when resting.

1. _____

2. _____

(2)

(iii) Tick (✓) **one** box to complete the sentence.

The substances you named in part (c)(ii) helped the muscles to

make more lactic acid. ☐

respire aerobically. ☐

make more glycogen. ☐

(1)

(iv) The higher rate of blood flow to the muscles during exercise removed larger amounts of waste products made by the muscles.

Which **two** substances need to be removed from the muscles in larger amounts during vigorous exercise?

Tick (✓) **two** boxes.

Amino acids	☐
Carbon dioxide	☐
Glycogen	☐
Lactic acid	☐

(2)

(d) The total blood flow was much higher during exercise than when resting.

One way to increase the total blood flow is for the heart to pump out a larger volume of blood each beat.

Give **one** other way to increase the blood flow.

_____

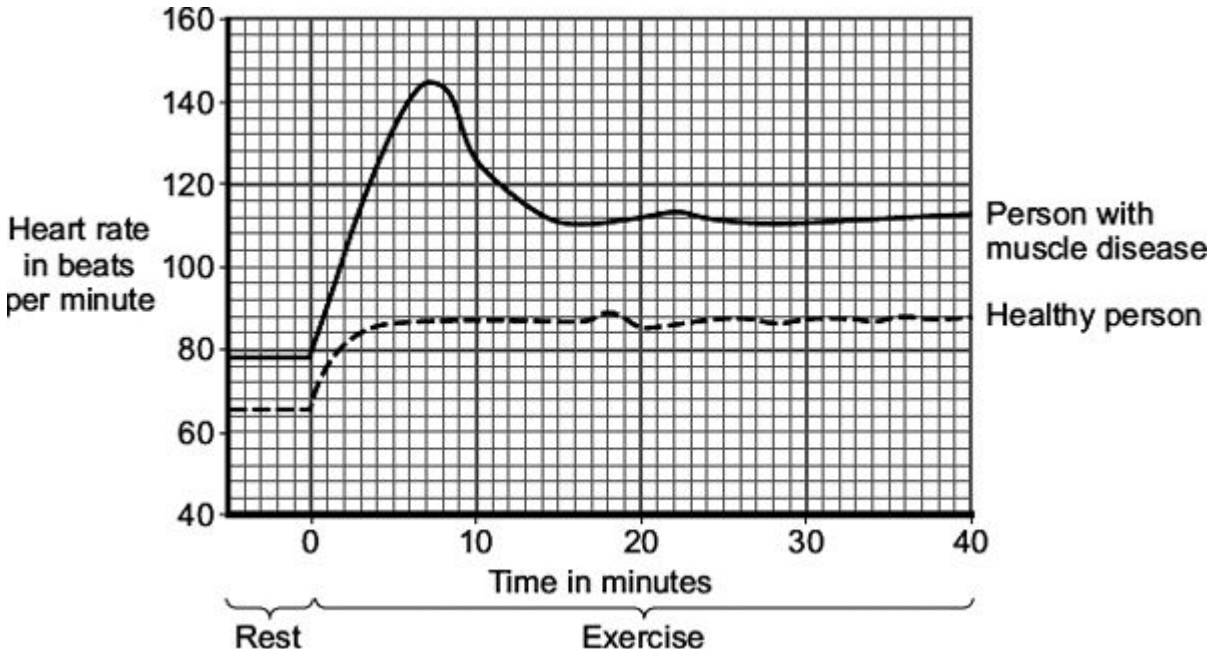
_____

(1)

(Total 11 marks)

4. Two people did the same amount of gentle exercise on an exercise cycle.
One person had a muscle disease and the other had healthy muscles.

The graph shows the effect of the exercise on the heart rates of these two people.



(a) Describe **three** ways in which the results for the person with the muscle disease are different from the results for the healthy person.

To gain full marks in this question you need to include data from the graph in your answer.

1. _____

_____

2. _____

_____

3. _____

_____

(3)

(b) The blood transports glucose to the muscles at a faster rate during exercise than when a person is at rest.

(i) Name **one** other substance that the blood transports to the muscles at a faster rate during exercise.

_____

(1)

(ii) People with the muscle disease are not able to store glycogen in their muscles.

The results shown in the graph for the person with the muscle disease are different from the results for the healthy person.

Suggest an explanation for the difference in the results.

_____

_____

_____

_____

_____

_____

_____

_____

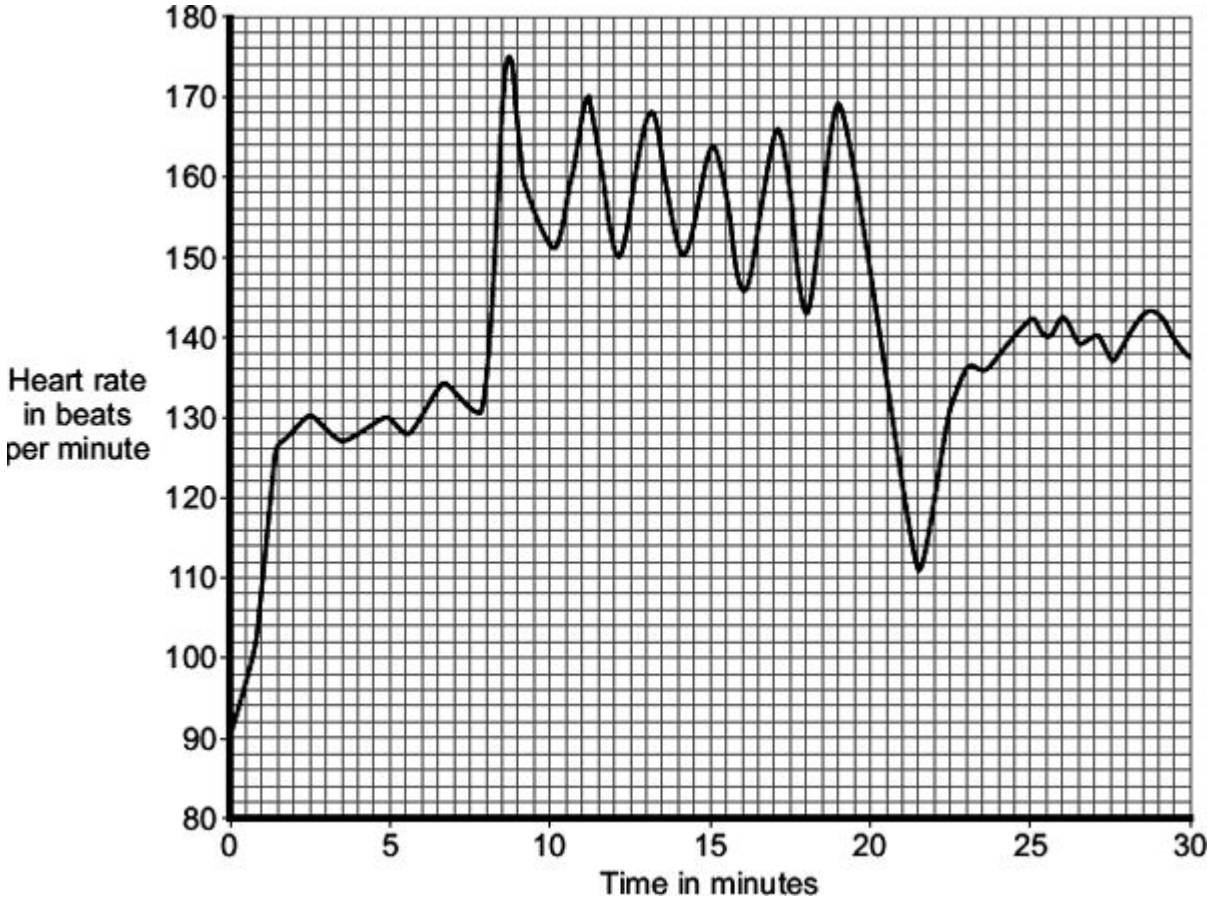
_____

(3)

(Total 7 marks)

5. One type of training exercise involves alternating periods of walking and running.

The graph shows how an athlete's heart rate changed during one 30-minute training session.



(a) (i) The athlete ran 6 times during the 30-minute training session.

Describe the evidence for this in the graph.

_____

_____

(1)

(ii) Immediately after the final run, the athlete rested for a short time before he started to walk again.

For how many minutes did this rest last?

_____ minutes

(1)

(b) The heart rate increases during exercise.

This increase in heart rate increases blood flow to the muscles.

Explain, as fully as you can, why this increase in heart rate is necessary.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 6 marks)

6. The table shows the volume of blood flowing through different organs at three levels of exercise.

Organ(s)	**Volume of blood flowing through organ(s) in cm^3 per minute**		
	Light exercise	**Moderate exercise**	**Heavy exercise**
Gut	1 100	600	300
Kidneys	900	600	250
Brain	750	750	750
Heart muscles	350	750	1 000
Skeletal muscles	4 500	12 500	22 000
Skin	1 500	1 900	600
Other	400	500	100
Total	**9 500**	**17 600**	**25 000**

(a) (i) Which organ has a constant flow of blood through it?

_____

(1)

(ii) Which organ has the greatest reduction in the volume of blood supplied during heavy exercise compared with light exercise?

_____

(1)

(iii) What proportion of the blood flows through the heart muscle during heavy exercise?

_____

(1)

(b) The volume of blood flowing through the skeletal muscles increases greatly during exercise.

Give **two** ways in which the body brings about this increase.

1. _____

_____

2. _____

_____

(2)

(c) During exercise, the concentration of carbon dioxide in the blood increases.

Explain what causes this increase.

_____

_____

_____

_____

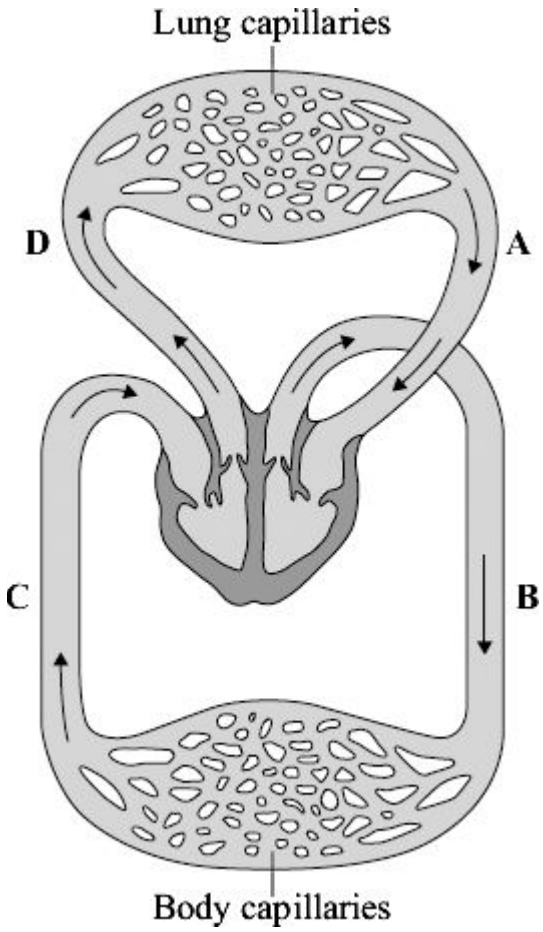
_____

_____

(3)

(Total 8 marks)

7. The diagram shows the human circulation system.



(a) (i) Give the letter of **one** blood vessel that is an artery.

(1)

(ii) Give the letter of **one** blood vessel that carries oxygenated blood.

(1)

(b) During exercise, the heart rate increases.

Explain, as fully as you can, why this increase is necessary.

_____

_____

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 6 marks)

8. Lactic acid production during exercise affects an athlete's performance.

Explain why lactic acid is produced during exercise.

_____

_____

_____

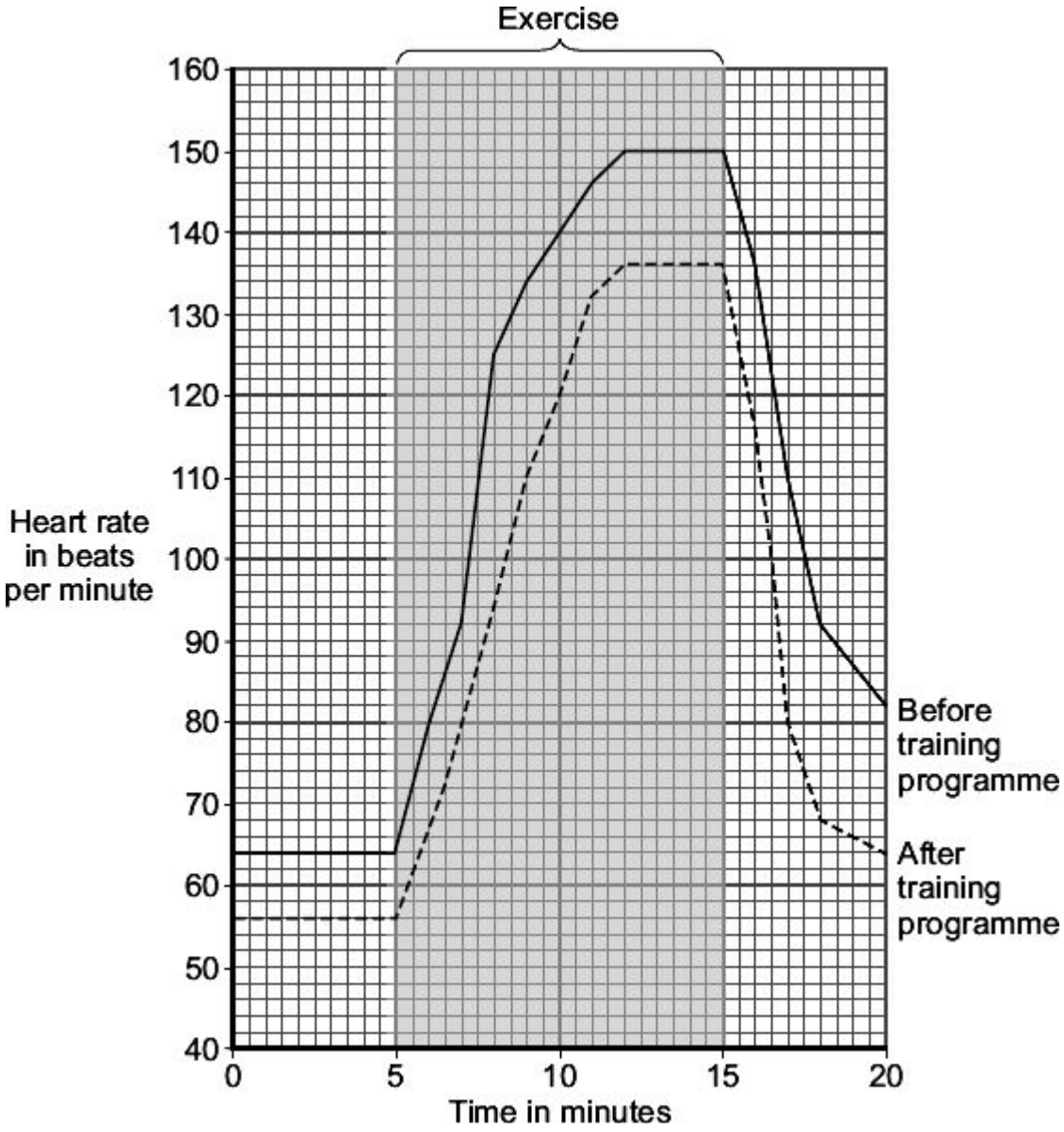
_____

_____

(Total 2 marks)

9. An athlete did a 6-month training programme.

The graph shows the effect of the same amount of exercise on his heart rate before and after the training programme.



(a) (i) What was the maximum heart rate of the athlete during exercise before the training programme?

_____ beats per minute

(1)

(ii) Give **two** differences between the heart rate of the athlete before and after the training programme.

After the training programme

Difference 1 _____

_____

Difference 2 _____

_____

(2)

(b) Which **two** substances need to be supplied to the muscles in larger amounts during exercise?

Tick (✓) **two** boxes.

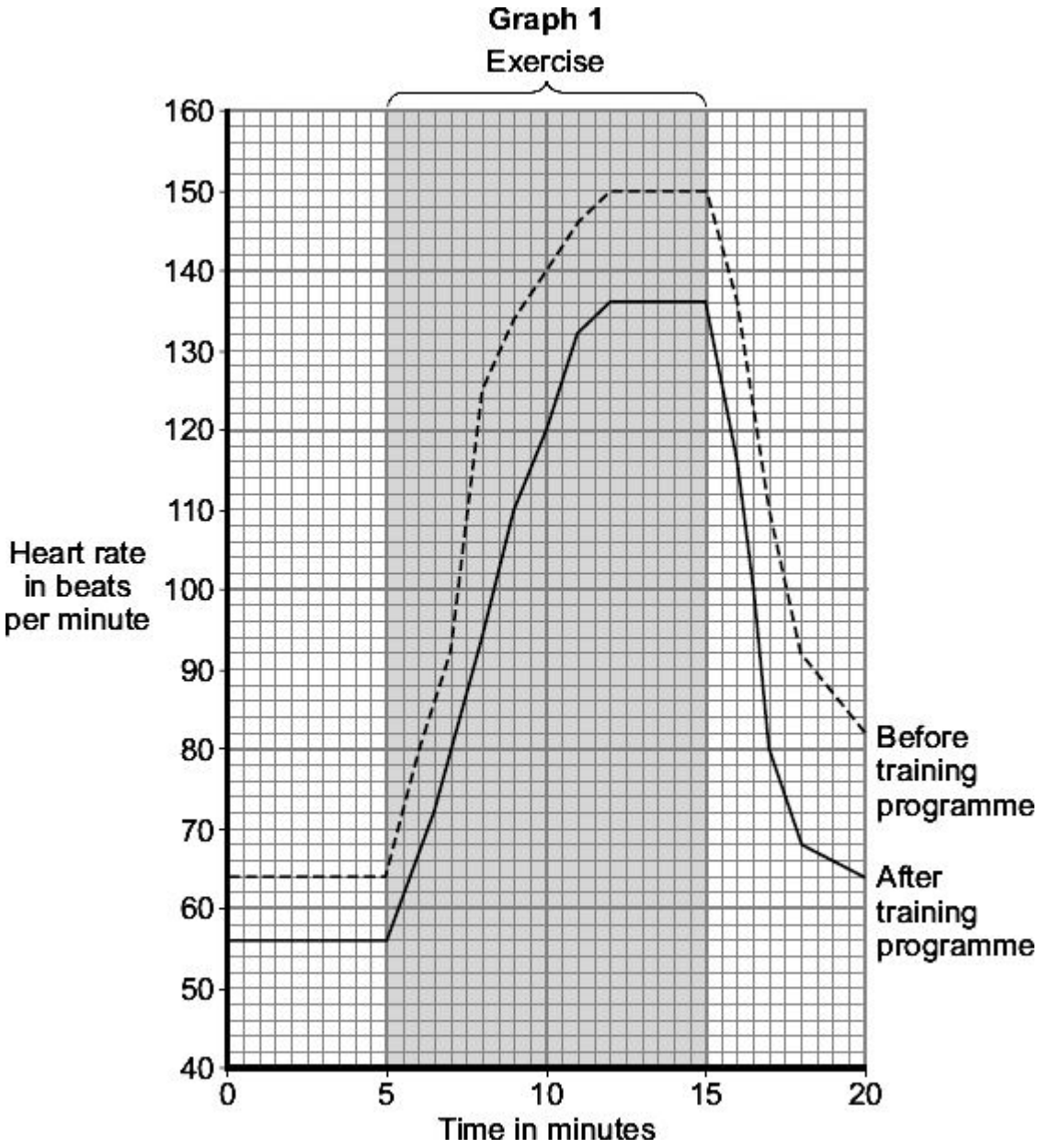
Carbon dioxide	☐
Glucose	☐
Lactic acid	☐
Oxygen	☐
Urea	☐

(2)

(Total 5 marks)

10. An athlete carried out a 6-month training programme.

Graph 1 shows the effect of the same amount of exercise on his heart rate before and after the training programme.



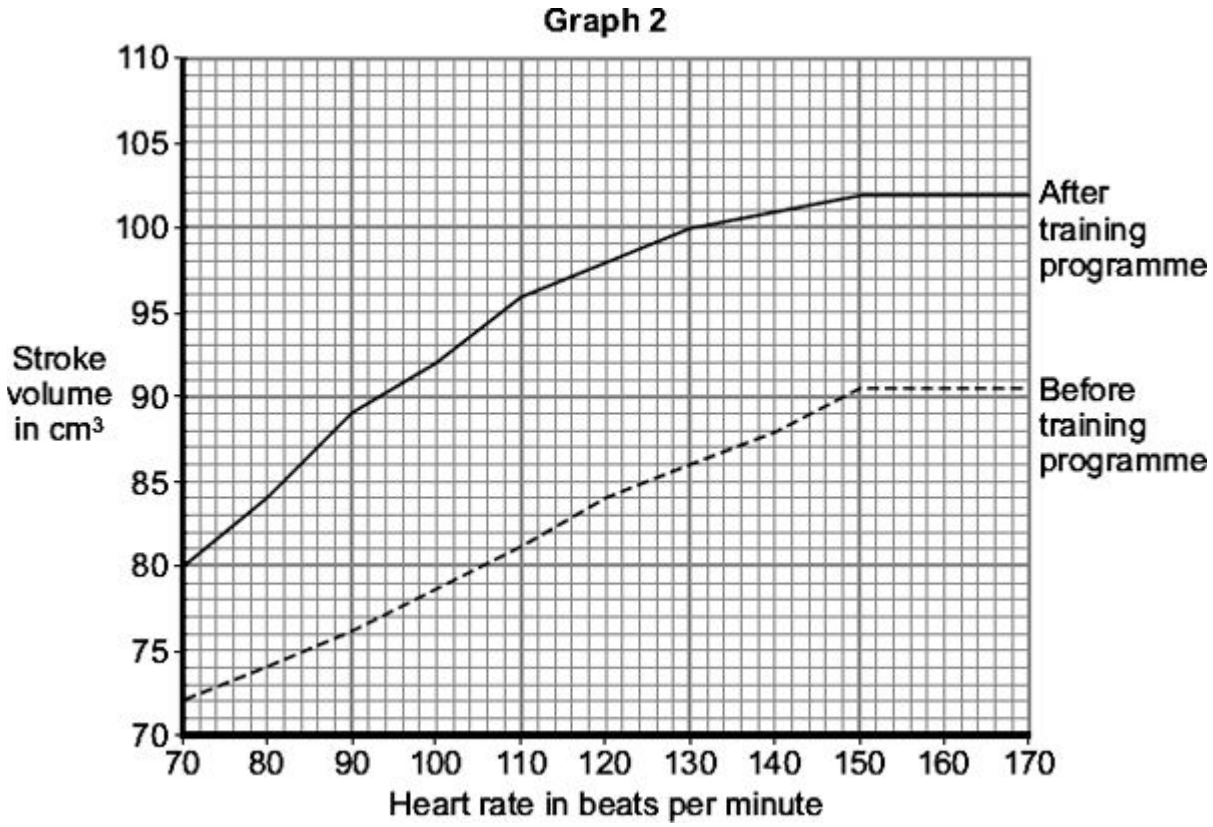
(a) (i) Use **Graph 1** to find the heart rate of the **trained** athlete 5 minutes after the start of the exercise.

Heart rate = _____ beats per minute

(1)

The stroke volume of the heart is the volume of blood pumped out of the left side of the heart in one heart beat.

Graph 2 shows the relationship between the stroke volume and the heart rate before and after the athlete did the training programme.



(ii) The *cardiac output* is defined as

cardiac output = heart rate × stroke volume

Calculate the cardiac output of the **trained** athlete 5 minutes after the start of the exercise. Use your answer to part (a)(i), and information from **Graph 2**.

Show clearly how you work out your answer.

_____

_____

Cardiac output = _____ cm^3 blood per minute

(2)

(b) **Graph 1** shows that, for the same amount of exercise, the heart of the trained athlete was beating more slowly than it did before the training programme.

Use information from **Graph 2** to explain why.

_____

_____

_____

_____

(2)

(c) An increased cardiac output will provide more oxygen and more glucose to the working muscles.

Explain how this helps the athlete during exercise.

_____

_____

_____

_____

_____

_____

_____

_____

(4)

(Total 9 marks)

11. (a) The table shows the effect of exercise on the action of one person's heart.

	At rest	**During exercise**
Heart rate in beats per minute	72	165
Volume of blood leaving the heart in each beat in cm^3	75	120
Heart output in cm^3 per minute	5400	

(i) Calculate the heart output for this person during exercise.

Show clearly how you work out your answer.

_____

_____

_____

_____

Answer = _____ cm^3 per minute

(2)

(ii) During exercise, more oxygen is carried to the working muscles.

Explain why this is helpful during exercise.

_____

_____

_____

_____

_____

(2)

(b) Give **two** other changes in the body that help to increase the amount of oxygen delivered to the working muscles during exercise.

1. _____

_____

2. _____

_____

(2)

(Total 6 marks)

Mark schemes

1.

(a) 5624

allow 2 marks *for:*

- *correct HR = 148* ***and*** *correct SV = 38 plus wrong answer / no answer*

or

- *only one value correct* ***and*** *ecf for answer*

allow 1 mark *for:*

- *incorrect values* ***and*** *ecf for answer*

or

- *only one value correct*

3

(b) (i) **Person 2** has low(er) stroke volume / SV / described

eg ***Person 2*** *pumps out smaller volume each beat*

do ***not*** *allow* ***Person 2*** *has lower heart rate*

1

(ii) **Person 1** sends <u>more blood</u> (to muscles / body / lungs)

1

(which) supplies (more) oxygen

1

(and) supplies (more) glucose

1

(faster rate of) respiration **or** transfers (more) energy for use

ignore aerobic / anaerobic

allow (more) energy release

allow aerobic respiration transfers / releases more energy (than anaerobic)

do ***not*** *allow makes (more) energy*

1

removes (more) CO2 / lactic acid / heat

allow less oxygen debt

or less lactic acid made

or (more) muscle contraction / less muscle fatigue

if no other mark awarded,

allow person 1 is fitter (than person 2) for max 1 mark

1

[9]

2.

(a) <u>anaerobic respiration</u>

allow phonetic spelling

1

(b) (i) 4.4

4.2, 4.3, 4.5 or 4.6 with figures in tolerance (6.7 to 6.9 and 2.3 to 2.5) and correct working gains 2 marks

4.2, 4.3, 4.5 or 4.6 with no working shown or correct working with one reading out of tolerance gains 1 mark

correct readings from graph in the ranges of 6.7 to 6.9 ***and*** *2.3 to 2.5 but no answer / wrong answer gains 1 mark*

2

(ii) more energy is needed / used / released

do ***not*** *allow energy production*

(at 14 km per hour)

ignore work

1

not enough oxygen (can be taken in / can be supplied to muscles)

allow reference to oxygen debt

do ***not*** *allow less / no oxygen*

1

so more anaerobic respiration (to supply the extra energy) **or** more glucose changed to lactic acid

allow not enough aerobic respiration

1

[6]

3. (a) any **two** from:

or *allow converse for outdoors*

- constant speed
  - *variable speed*
- constant effort
  - *variable terrain*
- constant temperature
  - *traffic conditions*
  - *variable temperature*
  - *wind (resistance)*
  - *rain / snow*

    allow weather

allow pollution only if qualified by effect on body function but ignore pollution unqualified

if no other marks obtained allow variable conditions outdoors

2

(b) Brain

1

(c) (i) 20 800

*correct answer with or without working gains **2** marks*

*if answer incorrect, allow **1** mark for use of 1200 and 22 000 only*

2

(ii) oxygen

apply list principle

1

*do **not** accept other named substances eg CO_2 water*

glucose / sugar

allow glycogen

ignore food / carbohydrate

1

(iii) respire aerobically

1

(iv) carbon dioxide

1

lactic acid

1

(d) increased heart rate

ignore adrenaline / drugs

accept heart beats more but not heart pumps more

1

[11]

4. (a) person with muscle disease:

allow reverse argument for healthy person

any **three** from:

NB all points are comparative except peak (point 3)

*allow use of **two** approximate figures as a comparison*

- higher resting rate **or** higher at start
- when exercise starts / then increases more / more rapidly

  accept description eg rise …. fall
- peaks (then falls)
- levels off later than healthy person
- higher rate during exercise

  *if no other marks awarded allow **1** mark for 'it's higher'*
- greater range

3

(b) (i) oxygen

accept adrenaline

accept O_2

*do **not** accept O, O2 or O^2*

1

(ii) cannot release sugar / glucose (from glycogen)

or

cannot store glucose / sugar (as glycogen)

1

need to receive glucose / sugar (from elsewhere)

ignore oxygen

1

for energy / respiration / cannot store energy

ignore aerobic / anaerobic

1

[7]

5. (a) (i) 6 peaks in heart rate

*accept 6 increases / spikes **or** goes very high 6 times*

allow heart rate increases each time he runs

1

(ii) 2.5 / 2½

allow 2 minutes 30 seconds

*do **not** accept 2.3 / 2:3 / 2.30*

1

(b) *more / faster / a lot **must** be stated at least once for full marks*

(more) oxygen supplied / needed

allow less anaerobic (respiration)

or (more) aerobic respiration

***or** prevents oxygen debt*

1

(more) glucose / sugar / food supplied / needed

ignore feeding

1

(more) energy needed / released

allow energy produced / made

1

(more) carbon dioxide / heat / lactic acid removed (from muscles) **or** more cooling

or less lactic acid formed

1

[6]

6. (a) (i) brain

1

(ii) skin

1

(iii) 1/25 **or** 4% **or** 0.04 **or** 1 in 25 **or** 1:25 **or** 1 out of 25

allow $\frac{1000}{25000}$

1

(b) any **two** from:

- increased / high heart rate / pulse rate
  *do **not** allow pumps more blood unqualified*
- dilation / widening of <u>arteries / arterioles</u> (to skeletal muscles)
  accept vasodilation unqualified
  *do **not** accept reference to veins / capillaries*

  or
  less blood flow to other organs
- increased stroke volume / described

2

(c) *ignore references to breathing*

<u>more</u> respiration / description
or
<u>more</u> energy required **or** to provide <u>more</u> energy

1

respiration / process described → CO_2
*do **not** accept anaerobic respiration*

1

CO_2 <u>diffuses</u> into blood

1

[8]

7. (a) (i) B **or** D

1

(ii) A **or** B

1

(b) any **four** from:

more / faster must be implied at least once for full marks

- increased blood (flow)
  ignore reference to breathing
- (more) oxygen supplied **or** aerobic respiration
  *allow less anaerobic (respiration) **or** and prevents oxygen debt*
- (more) glucose / sugar / food supplied
  ignore feeding
- (higher rate of) respiration
- (more) energy needed / released
  allow made
- (more) carbon dioxide removed
- (muscles) doing (more) work **or** muscles contracting
- remove heat / cooling
- remove lactic acid **or** less lactic acid formed

4

[6]

8. insufficient / no oxygen available

1

for (just) aerobic respiration

or

respires anaerobically

1

[2]

9. (a) (i) 150

1

(ii) any **two** from:

accept correct use of numbers

accept pulse rate

- lower resting rate
- lower rate during exercise
- recovers faster after exercise

  allow a general statement about lower rate if neither of the first two points given

2

(b) glucose

1

oxygen

1

[5]

10. (a) (i) 120

1

(ii) 11 760 **or**
correct answer from candidate's answer to (a)(i)

correct answer with or without working

if answer incorrect

120 × 98 ***or***
candidate's answer to (a)(i) × corresponding SV gains ***1*** *mark*

if candidate uses dotted line / might have used dotted line(bod) in (a)(i) ***and*** *(a)(ii) no marks for (a)(i) but allow full ecf in (a)(ii) eg 140 x 88 = 12320 gains* ***2*** *marks*

2

(b) trained athlete has higher stroke volume / more blood per beat

1

same volume blood expelled with fewer beats

or for same heart rate more blood is expelled

1

(c) increased aerobic respiration

or

decreased anaerobic respiration

allow correct equation for aerobic respiration

accept don't have to respire anaerobically

1

increased energy supply / need

1

less lactic acid formed

or to breakdown lactic acid **or** less O_2-debt

1

can do more work **or** can work harder / faster / longer

accept muscle contraction for work

or less fatigue / cramp / pain

1

[9]

11. (a) (i) 19 800

for correct answer ignore working or lack of working

*165 × 120 but no answer / wrong answer = **1** mark (ignore extras)*

2

(ii) any **two** from:

- for respiration

  ignore oxygen debt

- energy released

  allow energy produced

- prevents anaerobic respiration

- prevents build-up of lactic acid

2

(b) any **two** from:

- increased breathing rate(*)
- increased depth of breathing **or** deep breathing(*)

  *(*)more breathing is max **1** mark*

  ignore increase in heart rate

  allow heavier breathing

  *do **not** allow harder breathing*

- dilation of arteries / vasodilation

  allow blood vessels dilate

  *do **not** allow veins / capillaries dilate*

- blood diverted from elsewhere

  ignore name of organ

2

[6]