PE.AP5 Energy Systems: ATP-PC, Lactic Acid and Aerobic

Total Marks

AQA 8582 · Calculators not allowed · about 50 minutes

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 Which term describes exercise that can be sustained because the body is able to supply working muscles with enough oxygen to produce energy?

- ☐ A) Anaerobic exercise
- ☐ B) Aerobic exercise
- ☐ C) Isometric exercise
- ☐ D) Ballistic exercise

(Total for Question 1 is 1 mark)

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2 Exercise can be classified as aerobic or anaerobic depending on whether oxygen is used to produce energy.

(a) State what is meant by the term 'aerobic exercise'. **(1)**

(b) State what is meant by the term 'anaerobic exercise'. **(1)**

(Total for Question 2 is 2 marks)

3 The body uses three energy systems to produce ATP for muscle contraction, each suited to different intensities and durations of exercise.

(a) Name the energy system that provides energy immediately for very short, maximal-intensity efforts. **(1)**

(b) Name the energy system that provides energy for high-intensity exercise lasting up to a few minutes, producing lactic acid as a by-product. **(1)**

(c) Name the energy system that provides energy for long-duration, lower-intensity exercise using oxygen. **(1)**

(Total for Question 3 is 3 marks)

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4 State the fuel used, and the by-product (if any), of the ATP-PC system.

(Total for Question 4 is 2 marks)

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5 State the fuel used, and the main by-product, of the lactic acid system.

(Total for Question 5 is 2 marks)

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6 State the fuels used, and the by-products, of the aerobic system.

(Total for Question 6 is 2 marks)

7 A sprinter explodes out of the blocks and completes a 100 m race in around 10 seconds, working at maximal intensity throughout.

(a) Name the energy system that provides most of the energy for this race. **(1)**

(b) Explain why this energy system, rather than the aerobic system, is used for this race. **(1)**

(Total for Question 7 is 2 marks)

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8 An 800 m runner completes their race in around 2 minutes, running at a high but not maximal intensity throughout.

(a) Name the energy system that provides most of the energy for the majority of this race. **(1)**

(b) Explain why the ATP-PC system alone could not supply the energy needed for the whole race. **(1)**

(Total for Question 8 is 2 marks)

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9 A marathon runner completes a 26.2 mile race in just over 2 hours, running at a steady, sustainable pace throughout.

(a) Name the energy system that provides most of the energy for this race. **(1)**

(b) Explain why the lactic acid system could not be used to fuel the whole marathon. **(1)**

(Total for Question 9 is 2 marks)

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10 Explain why a build-up of lactic acid in a muscle causes muscle fatigue during high-intensity exercise.

(Total for Question 10 is 2 marks)

11 After a hard 400 m race, a runner continues to breathe heavily and their heart rate stays elevated for several minutes as they recover.

(a) State the term used for the extra oxygen the body consumes during recovery from exercise, above what it would consume at rest. **(1)**

(b) State one reason why this extra oxygen is needed during recovery. **(1)**

(Total for Question 11 is 2 marks)

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12 A rugby union match lasts 80 minutes and involves a constantly changing mix of walking, jogging, sprinting and maximal-effort tackling or scrummaging.

Explain how a rugby player uses all three energy systems at different points during a match, and evaluate why relying on any single system throughout the whole 80 minutes would not be possible.

(Total for Question 12 is 6 marks)

13 Table 1 gives sporting examples with the main energy system used missing.

Table 1

Part	Sporting example	Approximate duration
(a)	A golf swing	Under 1 second
(b)	A 400 m sprint	Around 45-60 seconds
(c)	A cross-country running race	Over 20 minutes

(a) Name the main energy system used for the action described in row (a) of Table 1. **(1)**

(b) Name the main energy system used for the action described in row (b) of Table 1. **(1)**

(c) Name the main energy system used for the action described in row (c) of Table 1. **(1)**

(Total for Question 13 is 3 marks)

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14 Explain why the ATP-PC system can only supply energy for a very short period of time before the muscle must rely on another energy system.

(Total for Question 14 is 2 marks)

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15 A tennis player plays a long rally involving a sprint to the net, followed by a period of standing and light movement while waiting for the next point.

(a) Name the energy system most likely used during the explosive sprint to the net. **(1)**

(b) Name the energy system most likely used during the light movement between points. **(1)**

(Total for Question 15 is 2 marks)

16 Which of the following is a by-product of the lactic acid system, but NOT a by-product of the aerobic system?

- ☐ A) Carbon dioxide
- ☐ B) Water
- ☐ C) Lactic acid
- ☐ D) Oxygen

(Total for Question 16 is 1 mark)

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17 A 400 m runner starts the race at a fast, near-maximal pace, then has to fight to maintain their speed over the final 100 m as their legs feel heavy.

(a) Name the energy system that dominates in the first few seconds of the race. **(1)**

(b) Explain why the runner's legs feel heavy in the final part of the race. **(2)**

(Total for Question 17 is 3 marks)

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18 A weightlifter performs a single maximal one-repetition lift, taking only a few seconds. Explain one advantage of the ATP-PC system, rather than the lactic acid system, for this type of effort.

(Total for Question 18 is 2 marks)

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19 A boxer trains at high altitude, where the air contains a lower concentration of oxygen than at sea level.

(a) State what happens to the amount of oxygen available to the boxer's working muscles at altitude, compared with at sea level. **(1)**

(b) Suggest how this might affect how much the aerobic system can contribute during a hard training session, compared with training at sea level. **(2)**

(Total for Question 19 is 3 marks)

20 The ATP-PC system and the lactic acid system are both anaerobic energy systems, but they differ in other ways.

(a) State one difference between the ATP-PC system and the lactic acid system in terms of the by-product each one produces. **(1)**

(b) State one difference between the ATP-PC system and the lactic acid system in terms of how long each can supply energy for. **(1)**

(Total for Question 20 is 2 marks)

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21 A hockey player performs repeated 20-30 metre sprints during a match, each followed by a short recovery period of jogging or standing.

(a) Name the energy system that dominates during each individual sprint. **(1)**

(b) Explain why the recovery periods of jogging or standing between sprints are important for the player's ability to keep sprinting throughout the match. **(1)**

(Total for Question 21 is 2 marks)

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22 A javelin thrower's whole throwing action, from the final stride to the release of the javelin, lasts less than 2 seconds and requires a maximal, explosive effort.

(a) Name the energy system used for this action. **(1)**

(b) Explain why this energy system is well suited to a single explosive throw like this, but could not fuel an entire training session of repeated throws with only very short rests. **(2)**

(Total for Question 22 is 3 marks)

Mark scheme · PE.AP5 Energy Systems: ATP-PC, Lactic Acid and Aerobic

Question 1

- **B1** B (aerobic exercise)
- **Answer: B (aerobic exercise)**

Question 2

- (a) **B1** exercise performed at a low enough intensity that the body can supply enough oxygen to produce the energy needed, oe
- **(a) Answer: Exercise performed at a low enough intensity that the body can supply enough oxygen to produce the energy needed.**
- (b) **B1** high-intensity exercise where energy is produced without using oxygen, oe
- **(b) Answer: High-intensity exercise where energy is produced without using oxygen.**

Question 3

- (a) **B1** ATP-PC system (alactic system)
- **(a) Answer: ATP-PC system (alactic system)**
- (b) **B1** lactic acid system (anaerobic glycolysis)
- **(b) Answer: Lactic acid system (anaerobic glycolysis)**
- (c) **B1** aerobic system
- **(c) Answer: Aerobic system**

Question 4

- **B1** fuel: stored ATP and phosphocreatine (PC) already present in the muscle, oe
- **B1** by-product: none/no fatiguing by-products are produced, oe
- **Answer: Fuel: stored ATP and phosphocreatine (PC) already present in the muscle. By-product: none (no fatiguing by-products are produced).**

Question 5

- **B1** fuel: glucose/glycogen, oe
- **B1** by-product: lactic acid, oe
- **Answer: Fuel: glucose/glycogen. By-product: lactic acid.**

Question 6

- **B1** fuel: carbohydrates and fats, oe
- **B1** by-products: carbon dioxide and water, oe
- **Answer: Fuels: carbohydrates and fats. By-products: carbon dioxide and water.**

Question 7

- (a) **B1** ATP-PC system
- **(a) Answer: ATP-PC system**
- (b) **B1** the race is too short and too intense for the aerobic system, which is slower to supply energy and better suited to longer, lower-intensity exercise; the ATP-PC system can supply energy immediately for maximal effort, oe
- **(b) Answer: The race is too short and too intense for the aerobic system, which supplies energy more slowly and is better suited to longer, lower-intensity exercise; the ATP-PC system can release energy immediately, which is needed for a maximal 10-second sprint.**

Question 8

- (a) **B1** lactic acid system
- **(a) Answer: Lactic acid system**
- (b) **B1** the muscle's stores of phosphocreatine are very limited and are used up within about the first 10 seconds, so the ATP-PC system cannot supply energy for a race lasting around 2 minutes, oe
- **(b) Answer: The muscle's stores of phosphocreatine are very limited and are used up within about the first 10 seconds, so the ATP-PC system cannot supply energy for the remainder of a race lasting around 2 minutes.**

Question 9

- (a) **B1** aerobic system
- **(a) Answer: Aerobic system**
- (b) **B1** the lactic acid system produces lactic acid, which builds up and causes muscle fatigue if relied on for more than a few minutes, so it cannot sustain energy production for a race lasting over two hours, oe
- **(b) Answer: The lactic acid system produces lactic acid as a by-product, which builds up and causes muscle fatigue if relied on for more than a few minutes, so it cannot sustain energy production for a race lasting over two hours.**

Question 10

- **B1** lactic acid builds up in the muscle when it is produced faster than the body can remove/break it down, oe
- **B1** this build-up interferes with muscle contraction, causing a burning sensation, reduced force production and eventual fatigue, forcing the performer to slow down or stop, oe
- **Answer: Lactic acid builds up in the muscle when it is produced faster than the body can remove it; this build-up interferes with muscle contraction, causing a burning sensation, reduced force production and eventual fatigue, forcing the performer to slow down or stop.**

Question 11

- (a) **B1** oxygen debt (excess post-exercise oxygen consumption, EPOC)
- **(a) Answer: Oxygen debt (EPOC).**
- (b) **B1** any one of: to help break down/remove the lactic acid that built up during the race / to replenish the muscle's stores of ATP and phosphocreatine (PC) / to restore the levels of oxygen stored in the muscle (myoglobin)
- **(b) Answer: For example, to help break down the lactic acid that built up during the race.**

Question 12

- **Level 3** (5-6): A detailed and coherent answer that correctly explains when each of the three energy systems is used during a rugby match, with accurate durations and by-products, and clearly evaluates why no single system could fuel the whole 80 minutes.
- **Level 2** (3-4): At least two energy systems are correctly linked to appropriate match actions, with some evaluation of why a single system would not be sufficient, but development or accuracy may be limited.
- **Level 1** (1-2): One or two relevant points about energy systems in rugby are made, with little explanation or evaluation.
- **Level 0** (0): No relevant content.
- **Indicative content:**
  - The ATP-PC system fuels very short, maximal actions such as a sprint to the try line, a tackle or a scrum drive, which last up to around 10 seconds and use stored ATP and phosphocreatine.
  - The lactic acid system fuels harder, sustained bursts of running lasting from around 10 seconds up to a few minutes, such as a prolonged phase of open play, producing lactic acid which contributes to fatigue if not allowed to clear.
  - The aerobic system fuels the lower-intensity periods of jogging, walking and standing that make up most of the 80 minutes, using oxygen to break down carbohydrates and fats, and also contributes to recovery between higher-intensity bursts.
  - The ATP-PC system alone could not fuel the match because its phosphocreatine stores are used up within about 10 seconds and take time to be replenished, so it can only cover the very shortest actions.
  - The lactic acid system alone could not fuel the match because the lactic acid it produces builds up and causes fatigue if relied on continuously for more than a few minutes, and its fuel (glycogen) would also be exhausted well before 80 minutes.
  - The aerobic system alone could not fuel the sprints and tackles because it releases energy too slowly to meet the sudden, very high energy demand of a maximal, explosive action.
  - A balanced evaluation might conclude that a rugby match's constantly changing intensity means the body must switch rapidly between all three systems, using each for the type of action it is suited to, rather than any one system being able to fuel the whole game alone.

Question 13

- (a) **B1** ATP-PC system
- **(a) Answer: ATP-PC system**
- (b) **B1** lactic acid system
- **(b) Answer: Lactic acid system**
- (c) **B1** aerobic system
- **(c) Answer: Aerobic system**

Question 14

- **B1** the muscle can only store a small, limited amount of phosphocreatine (PC), oe
- **B1** this limited store is used up within about 10 seconds of maximal effort, after which the muscle must switch to the lactic acid system to continue producing energy at a high rate, oe
- **Answer: The muscle can only store a small, limited amount of phosphocreatine; this is used up within about 10 seconds of maximal effort, after which the muscle must switch to the lactic acid system to keep producing energy quickly.**

Question 15

- (a) **B1** ATP-PC system
- **(a) Answer: ATP-PC system**
- (b) **B1** aerobic system
- **(b) Answer: Aerobic system**

Question 16

- **B1** C (lactic acid)
- **Answer: C (lactic acid)**

Question 17

- (a) **B1** ATP-PC system
- **(a) Answer: ATP-PC system**
- (b) **B1** by this stage the lactic acid system is providing most of the energy, oe
- (b) **B1** lactic acid has been building up in the muscles, which interferes with muscle contraction and causes fatigue/a heavy feeling in the legs, oe
- **(b) Answer: By this stage in the race the lactic acid system is providing most of the energy, and lactic acid has been building up in the muscles; this build-up interferes with muscle contraction, causing the fatigue and heavy feeling the runner experiences.**

Question 18

- **B1** the ATP-PC system can release energy immediately and at a very high rate, which suits the short, maximal force needed for the lift, oe
- **B1** it produces no fatiguing by-products (unlike the lactic acid system, which produces lactic acid), so the muscle is not fatigued by using it and can recover quickly for another attempt, oe
- **Answer: The ATP-PC system can release energy immediately and at a very high rate, which suits the short, maximal force needed for the lift, and it produces no fatiguing by-products, so the muscle is not left fatigued and can recover quickly for another attempt.**

Question 19

- (a) **B1** it decreases (less oxygen is available/delivered to the working muscles), oe
- **(a) Answer: It decreases; less oxygen is available to the working muscles.**
- (b) **B1** with less oxygen delivered to the working muscles, the aerobic system may not be able to produce energy as quickly as at sea level, oe
- (b) **B1** so the boxer may have to rely more on the anaerobic (lactic acid) system sooner than they would at sea level, oe
- **(b) Answer: With less oxygen delivered to the working muscles, the aerobic system may not be able to produce energy as quickly as at sea level, so the boxer may have to rely on the anaerobic (lactic acid) system sooner than they would at sea level.**

Question 20

- (a) **B1** the ATP-PC system produces no fatiguing by-product, whereas the lactic acid system produces lactic acid, oe
- **(a) Answer: The ATP-PC system produces no fatiguing by-product, whereas the lactic acid system produces lactic acid.**
- (b) **B1** the ATP-PC system can only supply energy for up to about 10 seconds, whereas the lactic acid system can supply energy for longer, up to a few minutes, oe
- **(b) Answer: The ATP-PC system can only supply energy for up to about 10 seconds, whereas the lactic acid system can supply energy for longer, up to a few minutes.**

Question 21

- (a) **B1** ATP-PC system
- **(a) Answer: ATP-PC system**
- (b) **B1** the lower-intensity recovery periods allow the aerobic system to help replenish the muscle's stores of phosphocreatine, so the ATP-PC system is ready to fuel the next maximal sprint, oe
- **(b) Answer: The lower-intensity recovery periods allow the aerobic system to help replenish the muscle's phosphocreatine stores, so the ATP-PC system is ready to provide immediate energy again for the next sprint.**

Question 22

- (a) **B1** ATP-PC system
- **(a) Answer: ATP-PC system**
- (b) **B1** it is well suited because it releases energy immediately and at a very high rate, matching the sudden, maximal force needed for one throw, oe
- (b) **B1** but it could not fuel repeated throws with only very short rests because the muscle's small phosphocreatine store takes time to be replenished (using the aerobic system), so without enough recovery time between throws the store would stay partly depleted, reducing power on later throws, oe
- **(b) Answer: It is well suited to a single throw because it releases energy immediately and at a very high rate, matching the sudden, maximal force needed. It could not fuel repeated throws with only very short rests, because the muscle's small phosphocreatine store takes time to be replenished, so without enough recovery time it would stay partly depleted, reducing power on later throws.**