

2022 VCE Physical Education external assessment report

General comments

The 2022 Physical Education examination provided students with the opportunity to display key knowledge and skills using a range of questions.

The extended answer questions and understanding of energy system contribution and interplay (Questions 1c., 5a. and 11b.) required very specific application of knowledge as well as referencing of the sporting situation being explained. In Question 1c., students were required to discuss two different swimming events. In Question 5a., students were required to discuss the role of the two anaerobic pathways in the penalty shootout scenario described. In Question 11b., students were required to integrate knowledge of acute responses in their analyses.

Some students are still offering generic answers to energy system interplay questions rather than specifically addressing the situation. In Question 1d., many students stated that the adenosine triphosphate (ATP) / phosphocreatine (PC) system (ATP–PC system) and the anaerobic system were ‘exhausted’ before the aerobic system came into play, which is not an accurate understanding of interplay.

Students are reminded to respond to the command words in questions such as compare, justify, explain, discuss, contrast, analyse and outline.

Questions 4c. and 10c. required specific knowledge and application of training principles to training situations. In Question 4c., many students suggested why the program was correct but did not reference training principles in their answer. Question 10c. required comprehensive knowledge of training principles in designing a fartlek training session. Sound knowledge of training principles forms the basis of application to training situations.

Students should take care with the accuracy of descriptions and explanations. This can be seen in Question 2a.ii., in which students needed to give the characteristics of an open skill. Similarly, Questions 3a., 6a. and 7b. required specific and accurate reference to a formula or definition. Accurate use of terminology is a key skill required in the study design. In Question 6a., some students could not provide an accurate definition of aerobic power; and in Question 6c., some students referred to the ‘beep test’, which is not an accurate name for the 20-metre shuttle run test.

A sound knowledge of both acute responses to exercise as well as chronic adaptations to training is required by students.

Teachers and students are reminded that many key skills and much knowledge can be explored by using practical opportunities during class time as well as making observations while viewing various sports or sporting actions.

Specific information

Note: Student responses reproduced in this report have not been corrected for grammar, spelling or factual information.

This report provides sample answers or an indication of what answers may have included. Unless otherwise stated, these are not intended to be exemplary or complete responses.

The statistics in this report may be subject to rounding resulting in a total more or less than 100 per cent.

Section A – Multiple-choice questions

All questions showed a correct response factor of well over 50 per cent. Grey shading indicates the correct response.

Question	Correct answer	% A	% B	% C	% D	Comments
1	A	79	19	2	1	
2	A	79	9	5	7	
3	D	11	14	7	68	
4	C	8	9	82	1	
5	B	18	71	10	1	
6	D	1	8	18	73	
7	B	8	84	8	1	
8	A	81	8	10	1	
9	D	1	1	1	97	
10	C	2	22	63	13	
11	B	2	63	25	10	Phosphate recovery is more suitable and specific than 30-second Wingate test in a basketball context.
12	C	21	16	56	6	Coach-led learning is more suited to direct coaching approach.
13	B	3	91	3	3	
14	A	56	8	14	21	Answer D is incorrect as carbohydrates do not provide energy at the slowest rate.
15	D	12	8	15	64	

Section B

Question 1ai.

Marks	0	1	Average
%	8	92	0.9

The correct response was autonomous stage.

Question 1aii.

Marks	0	1	2	Average
%	10	29	61	1.5

Acceptable responses included (two of):

- high levels of skill/performance
- few errors
- ability to detect own errors
- ability to correct own errors
- able to focus on other aspects of performance (for example, tactical awareness)
- easy adjustment to skill performance (for example, change in speed/tempo)
- skill performance is automatic.

Question 1b.

Marks	0	1	2	3	Average
%	23	15	32	31	1.7

Students were required to comment on both frequency and use of augmented and intrinsic feedback as a performer moved through the stages of learning. Students who scored highly were able to articulate a reduced frequency as well as greater use of intrinsic feedback as a performer moved through the stages.

The following is an example of a high-scoring response.

As the learner progresses through the stages the frequency of augmented feedback reduces to give the learners the opportunity to explore their own internal error correction techniques. In the early stages the learner is provided with a lot of augmented feedback to help them develop a basic understanding of the movement skill. As the learner moves to the autonomous stage the learner is able to utilize more intrinsic feedback to make small adjustments to performance and relies on a smaller amount of augmented feedback.

Question 1c.

Marks	0	1	2	3	4	5	6	Average
%	10	14	22	23	18	10	3	2.7

Students were required to discuss the reason that the 200-metre freestyle was completed faster than the 400-metre freestyle using their knowledge of energy system interplay. High-scoring responses demonstrated knowledge of energy system interplay and explained the 200-metre freestyle, due to its shorter duration, had

a greater contribution from the two anaerobic systems. As these energy systems supply energy at a faster rate, a faster average time is achieved.

Some students gave generic answers of energy system interplay and repeated these for both events. Others stated that both anaerobic systems were exhausted before the aerobic system became the major system, which was an incorrect application of interplay.

The following is an example of a high-scoring response.

In both events, Titmus will rely on all 3 energy systems working together with the relative amount of contribution of each system varying according to event.

Due to the 200m event being of shorter duration there will be an increased overall contribution from the anaerobic systems. The ATP/PC will be relied upon heavily at the start due to its explosive rate but low yield. This will be augmented heavily by the Anaerobic Glycolysis system which also provides energy at a rapid rate with a relatively low yield. The aerobic system with its slower rate and high yield will also be used to provide energy for the event. As the event is shorter there is a higher relative contribution from the anaerobic systems so a greater speed of 56.75 per 100m is possible.

The 400m event is also reliant on all 3 systems. However due to its longer overall duration the anaerobic systems can be relied on for a smaller percentage of the race. This means there is a greater reliance on the aerobic system which has a slower rate accounting for the slower relative speed of 59.17 per 100m.

Question 2ai.

Marks	0	1	Average
%	8	92	0.9

The correct response was open skill.

Question 2aii.

Marks	0	1	2	Average
%	15	49	36	1.2

Acceptable responses included (two of):

- externally paced (based on the pitcher)
- there is high inter-trial variability (each pitch is different)
- environment is unpredictable and variable.

Question 2b.

Marks	0	1	2	3	Average
%	6	14	54	26	2.0

The correct responses were:

- Coaching approach – Direct
- Stage of learning – Associative
- Practice variation – Blocked.

Practising with a ball machine in this context would suit an associative learner seeking to refine skill. Information in the question stem refers to practise and hitting balls in a short period, which means skill has already been learnt but requires practise. The focus on one specific movement refers to a blocked practice variation. The reduction of variables with the bowling machine leads to a direct coaching approach.

Question 2c.

Marks	0	1	2	3	4	Average
%	29	22	27	14	8	1.5

Students were required to discuss how a pitcher could use the principles of force summation to attain maximal force while pitching. Students should have explained at least three of the following summation of momentum principles in their answer:

- provide a stable base or stabilise body parts
- use as many body parts as possible
- start with larger body parts and progress to smaller body parts
- transfer body parts when previous body part is at maximal velocity (sequential acceleration)
- use a follow-through.

The following is an example of a high-scoring response.

To apply the principle of summation of momentum to gain maximal force the pitcher should aim to use as many body parts as possible. They should be used in a sequential manner starting with the larger parts and finishing with smaller parts. In the case of a pitcher the momentum can be initiated via the step forward and the larger muscles of the leg and trunk. As these body parts slow and provide a stable base momentum is transferred to the muscles of the shoulder and arm and finally the fingers.

It is also important to transfer the momentum from one body part to another when at maximum velocity and in a coordinated movement, so momentum is not lost. Finally, a follow through should be used so the pitcher is able to deliver the ball at maximal velocity/power.

Question 3a.

Marks	0	1	Average
%	40	60	0.6

The correct response was $\text{Ventilation} = \text{Respiratory rate} \times \text{Tidal volume}$.

Question 3b.

Marks	0	1	2	Average
%	75	19	6	0.3

Students were required to explain how a trained aerobic athlete could have lower ventilation than an untrained individual.

Students who scored highly were able to highlight an efficient use of available oxygen by linking it to a chronic adaptation such as increased arteriovenous oxygen (AVO_2) difference or increased pulmonary diffusion.

Some students merely stated the formula for ventilation and explained how the respiratory rate may decrease, which does not explain lower ventilation.

The following is an example of a high-scoring response.

Trained aerobic athletes are more efficient with the oxygen they bring into their body. They can extract more oxygen through increased pulmonary diffusion and their muscles can utilize more oxygen through an increased AVO₂ difference. These changes mean that lower ventilation is required.

Question 4a.

Marks	0	1	2	3	4	Average
%	22	23	25	20	10	1.8

Students were required to contrast the different height and angle of release of the two players and how these differences helped to improve Player A's serve. Students who scored highly stated that the higher release of Player A enabled a decreased angle of release and therefore a faster, flatter serve.

Some students were able to identify the greater height of release but were not able to link this to the decreased angle made possible.

The following is an example of a high-scoring response.

Player A throws the ball up and jumps to hit the ball which increases the height of release, compared to Player B who remains standing on the ground. This means that Player A can have a decreased angle of release which results in a flatter trajectory and more horizontal pathway, compared to B who requires a larger vertical component to clear the net. The results in Player A's serve being more successful and harder to return.

Question 4b.

Marks	0	1	2	3	Average
%	52	26	16	5	0.8

Students were required to use Newton's third law to explain the movement of the volleyball players' arms and legs as shown in the picture. As the arms and legs are in angular motion, students had to describe the law in an angular context.

In this case Newton's third law states that for every action/torque, there is an equal and opposite reaction/torque.

High-scoring responses stated that the arms and legs were moving in an anti-clockwise or clockwise direction. They also recognised that angular momentum is conserved, and the bending of the arm decreases the moment of inertia and is counteracted by an increase in angular velocity.

The following is an example of a high-scoring response.

Newton's Third Law states that for every action/torque, there is an equal and opposite reaction/torque.

As the arm moves backwards in a clockwise direction (action), the legs move back in an anticlockwise direction (reaction). As the arms and legs bend there is a decrease in the radius and therefore the moment of inertia thus angular velocity increases to quickly move the limbs back as angular momentum is conserved.

Question 4c.

Marks	0	1	2	3	4	Average
%	44	24	14	11	7	1.2

Students were required to discuss three correct applications of training principles relating to muscular power in the program. They were also required to make one specific recommendation to improve an error in the program.

High-scoring responses clearly linked a training principle to a correct application.

Responses that did not score well did not state a training principle in their response, instead just explained the part of the program that they thought was effective.

The following is an example of a high-scoring response.

The following training principles are used correctly in the muscular power program.

Intensity – fast contraction speed mimics the explosive requirements of muscular power and the load ranges given are suitable for muscular power in all three exercises.

Time – The three-minute rest period for weighted squats is suitable to regain energy required for muscular power movements

Specificity – the exercises selected mimic the movement patterns that would be required for powerful jumps in volleyball.

A possible recommendation is to increase the rest time for the dead lift and kettlebell swings to 3 minutes to ensure adequate recovery.

Note: Students could have used other correct training principles such as frequency (three times per week) or made other correct recommendations.

Question 4d.

Marks	0	1	2	3	Average
%	22	18	28	31	1.7

Students were required to explain how the adaptations of increased phosphocreatine stores and motor unit recruitment could improve the performance needed in volleyball.

High-scoring responses identified specific advantages of these adaptations and how they could assist in winning a point.

The following is an example of a high-scoring response.

An increase in CP stores increases the ability of the body to use the ATP-CP system which produces energy at the fastest rate meaning they could use this system throughout a longer point. An increase in motor unit recruitment means more motor units are recruited resulting in greater force production allowing for a higher jump to make a spike or block.

Question 5a.

Marks	0	1	2	3	4	Average
%	33	13	19	22	13	1.7

Students were required to discuss the contributions of the two anaerobic pathways in a specific hockey goalkeeping situation.

High-scoring responses described how the ATP–PC system could provide energy at a fast rate and would be used at the start of each penalty. They described how the rest period between shots was able to replenish this system. They stated the importance of the anaerobic glycolysis system for longer penalties or when there was shortfall of ATP–PC.

The following is an example of a high-scoring response.

During the sprint out the ATP-CP system will make the greatest contribution as it provides energy at the fastest rate for a maximal effort. The ATP-CP system will also make a great contribution during the explosive leaps and dives to save the ball. During the short period of rest/passive recovery CP stores will be partially restored. However, during periods of repeated efforts such as moving from side to side, when CP depletes, the anaerobic glycolysis system increases contribution.

Question 5b.

Marks	0	1	2	Average
%	53	18	29	0.8

Students were required to identify a psychological strategy to reduce arousal during a penalty shootout and how the strategy could be used to improve the goalkeeper's performance.

Acceptable strategies were:

- breathing control / controlled breathing
- set routines
- progressive muscle relaxation
- calming self-talk.

Students are reminded to select an appropriate psychological strategy for the context of the question rather than a 'one size fits all' approach. Some students selected any psychological technique regardless of whether it could be used to decrease arousal.

The following is an example of a high-scoring response.

Slow controlled breathing decreases heart rate/anxiety to lower arousal which will make them calm and more focused on saving the ball.

Question 6a.

Marks	0	1	2	Average
%	43	40	17	0.8

Students were required to name and provide a definition for aerobic power. Some students incorrectly associated the Yo-Yo test as a test of anaerobic capacity.

The following is an example of a high-scoring response.

Aerobic Power – the maximum rate of energy production from the aerobic system.

Question 6b.

Marks	0	1	2	3	Average
%	46	23	29	3	0.9

Students were required to justify the selection of the Yo-Yo intermittent recovery test from a physiological perspective. Integration of relevant data was required, particularly the bouts of high-intensity running done in a game along with periods of walking. This is similar to what occurs in the Yo-Yo test, making it a more specific test. High-level players also would have the physiological capacity to complete this exhaustive test.

The following is an example of a high-scoring response.

The varied intensities and movement patterns of the test is specific to the physiological requirements of the sport with the running and walking mimicking the movement patterns of the sport - high intensity running (163m) and walk recovery (362m). Physiologically, the 17-year-old males – state level players are likely to be fit and able to cope with the maximal test.

Question 6ci.

Marks	0	1	2	Average
%	43	26	30	0.9

Students were required to outline an alternative test for aerobic power. Possible tests that could be used were:

- 20-metre multi-stage test or 20-metre shuttle run test
- Cooper 12-minute run test
- 2.4 km run test
- Rockport 1.6 km walking test
- VO₂ max. Astrand-Rhyming cycle ergometer test
- VO₂ max. treadmill test
- Harvard step-test.

Students should note the correct terminology for fitness tests. Some students used the term 'beep test' to describe the 20-metre multi-stage test.

Question 6cii.

Marks	0	1	2	Average
%	51	32	17	0.7

Students were required to outline from a sociocultural and psychological perspective the use of the alternative test that they identified.

The following is an example of a high-scoring response.

The Cooper 12-minute run is very accessible and requires limited equipment/resources therefore is suitable from a sociocultural (socioeconomic) perspective. It can also be completed altogether, and participants can motivate each other so would also be suitable from a psychological perspective.

Question 6d.

Marks	0	1	2	Average
%	25	50	25	1.0

Students were required to outline the purpose of completing a Physical Activity Readiness Questionnaire (PAR-Q) prior to completing fitness testing. High-scoring responses outlined its importance in identifying pre-existing health concerns and if the test is suitable.

The following is an example of a high-scoring response.

A PAR-Q is used to identify any health risks or medical conditions for the athlete. It also ensures the test selected is suitable for the candidate, for example whether a maximal test is suitable or not given health conditions.

Question 6ei.

Marks	0	1	Average
%	22	78	0.8

The correct response was three days/week.

Question 6eii.

Marks	0	1	2	Average
%	20	17	63	1.4

Acceptable responses included (two of):

- continuous training
- long interval training
- fartlek training
- circuit training
- high-intensity interval training (HIIT).

Question 7a.

Marks	0	1	2	3	Average
%	9	19	39	32	2.0

Students were required to reference the graph to explain if a passive or active recovery is more beneficial in this situation. High-scoring responses identified an active recovery was beneficial due to the faster reduction in blood lactate concentration levels.

The following is an example of a high-scoring response.

*The active recovery is more beneficial as it allows for a **faster removal** of lactate by increasing blood flow. The data shows that after ~20 minutes the active recovery blood lactate concentration was 4mmol compared to the passive recovery blood lactate concentration being approximately 7mmol. This indicates the active recovery is more beneficial.*

Question 7b.

Marks	0	1	Average
%	28	72	0.7

The correct response was excess post-exercise oxygen consumption. EPOC is an acceptable abbreviation for this response.

Question 8a.

Marks	0	1	Average
%	27	73	0.8

The correct response was task constraint.

Question 8b.

Marks	0	1	2	3	Average
%	36	26	27	12	1.2

Students were required to explain how manipulating the constraint identified in the table influences skill performance and development.

High-scoring responses clearly identified the constraint (one- or two-touch passing) and used the table data to explain the effect on skills. Although not a requirement it was a benefit to use data from the table to assist in explaining the effect on performance.

The following is an example of a high-scoring response.

By reducing the number of touches from unlimited to one touch it increased the number of unsuccessful passes from 1.8 compared to 1.1. This could impact skill development and performance because players are under more pressure to pass the ball with one touch, causing them to have poorer skill execution compared to unlimited touches in a small-sided soccer game performance.

Question 8c.

Marks	0	1	2	Average
%	36	29	35	1.0

Acceptable responses included (two of):

- increased AVO_2 difference / increased oxygen extraction
- increased rate of motor unit recruitment
- increased firing rate
- increased metabolic by-product production
- increased muscle temperature
- decreased fuel stores
- decreased ATP and/or CP and/or glycogen
- increased enzyme activity
- increased blood flow to working muscle.

Question 8d.

Marks	0	1	2	Average
%	58	16	26	0.7

Students were required to explain how their selected response would assist the soccer player in their performance.

The following is an example of a high-scoring response.

By increasing the number of motor units recruited, this allows for increased force production enabling more force to be developed when kicking the ball in the small-sided soccer game.

Question 9a.

Marks	0	1	2	3	4	Average
%	32	24	23	13	8	1.4

Students were required to give two reasons why a driver would hit the ball further than a 9-iron based on the biomechanical principles of lever length and conservation of momentum.

High-scoring responses were able to identify that both clubs were third-class levers with a mechanical advantage of less than one. The driver, being longer, had a greater resistance arm and greater range of motion, increasing the speed at the end of the lever. The greater speed at the end of the lever means the momentum can be conserved and transferred to the ball after the collision, ensuring a longer hit.

Some students mentioned a greater mass of the driver although the question stated that the mass of the two clubs was the same.

The following is an example of a high-scoring response.

By using the longer golf club, this has increased the length of the (third-class) lever therefore increasing the resistance arm. By increasing the resistance arm, this increases the speed and range of motion (ROM) of the lever, allowing the golf ball to be hit with more speed. When the golf club contacts the golf ball, momentum is conserved on impact and therefore imparted to the golf ball. By using a longer lever with an increased ROM, the increased velocity of the lever can be imparted onto the golf ball, allowing it to travel further.

Question 9b.

Marks	0	1	2	Average
%	9	31	60	1.5

Students were required to explain why using digital recording is the optimal method of observation to improve a golfer's swing technique. Students who undertook a qualitative movement analysis, as per the key skill in Unit 3, Area of study 1, were able to easily respond to this question.

Acceptable responses with relevant explanation included:

- ability to replay the swing multiple times
- ability for the athlete to observe their own swing
- ability to slow down and pause parts of the swing
- ability for the swing to be observed by multiple coaches for additional feedback.

The following is an example of a high-scoring response.

Digital recording allows the golf swing to be slowed down, paused and replayed which increases the accuracy of technique analysis. This can allow an improved performance as the coach can provide feedback to the player by discussing the footage and the player is also able to view their swing and identify areas of improvement.

Question 9c.

Marks	0	1	2	Average
%	19	39	42	1.2

Students were required to outline two limitations of using direct observation to analyse a golfer's swing technique.

Acceptable responses with relevant outline included:

- subjectivity of the analyst
- experience of the analyst
- method of feedback is singular
- no recorded reference for comparison
- dependent on memory
- likely to overlook aspects of the swing
- labour intensive
- cannot be viewed by a different coach for alternate feedback.

The following is an example of a high-scoring response.

When using the direct observation method, it is difficult to accurately observe all aspects of the swing as it is done at a very fast pace. This makes it difficult to detect small errors in technique.

Question 9d.

Marks	0	1	2	Average
%	45	16	39	1.0

Students were required to outline the two remaining steps of the qualitative analysis once the golf swing had been observed.

High-scoring responses outlined the requirement for an evaluation step as well as an error detection step.

Some students did not use correct terminology when outlining the final two steps.

The following is an example of a high-scoring response.

The coach needs to undertake an Evaluation of the golfer's technique where they will look at possible errors in technique. The coach would then undertake an error correction step where they will use relevant methods to help the golfer fix the errors identified.

Question 10a.

Marks	0	1	2	Average
%	39	29	33	1.0

Students were required to explain the benefits of the rehydration technique with reference to blood plasma.

High-scoring responses explained that the rehydration protocol will restore the blood plasma lost during the activity.

The following is an example of a high-scoring response.

During the soccer game, the referee will have lost blood plasma through sweating therefore the rehydration allows the blood plasma to be restored [which] enables increased blood flow to enhance recovery and rehydration.

Question 10b.

Marks	0	1	2	Average
%	49	42	10	0.6

Students were required to discuss the benefits of including carbohydrates in the rehydration fluid.

High-scoring responses explained this will restore lost glycogen faster, enabling recovery to be accelerated.

The following is an example of a high-scoring response.

The inclusion of carbohydrates restores the glycogen lost in the game and the carbohydrates are more easily absorbed in liquid form aiding speed of the referee's recovery.

Question 10c.

Marks	0	1	2	3	4	Average
%	35	23	24	14	5	1.3

Students were required to design the conditioning phase of a fartlek training session focusing on high-intensity and medium-intensity efforts.

High-scoring responses were able to:

- state the duration of the session being at least 20 minutes
- identify that the session should be running or jogging as specific to the soccer referee
- identify that the high-intensity efforts should be between 80% and 90% HR maximum or 8 to 9 RPE
- identify that the medium-intensity efforts should be between 65% and 85% HR maximum or 6 to 7 RPE
- state the duration of each effort should not exceed a minute and the program should not include rest/recovery times.

Some students mentioned a warm-up or a series of sessions, which was not required for this question.

The following is an example of a high-scoring response.

20 minutes of continuous running alternating between high and medium intensity periods.

High Intensity (85% max heart rate) for 60 seconds

Medium Intensity periods (70% max heart rate for 60 seconds.

Question 10d.

Marks	0	1	2	3	4	Average
%	22	23	29	20	6	1.7

Students were required to identify and justify which of the lines was taken at the completion of the fartlek program by referring to the data on the graph and two chronic adaptations.

High-scoring responses identified that Line B was the trained athlete based on either the lower submaximal heart rate or the increased test duration. They were also able to justify this by referring to two specific chronic adaptations to aerobic training.

The following is an example of a high-scoring response.

***Line B** is the trained athlete. This is because at the 10-minute mark of the test their heart rate was 160bpm as compared with Line A being 180bpm. This lower submaximal heart rate would indicate a higher stroke volume, increased left ventricle size meaning more blood can be ejected with each beat. It is also likely that the athlete would have a greater AVO₂ difference after the training which means that his muscles were able to use greater oxygen to enable him to undertake the test for longer (21.05min compared to 17:05 minutes).*

Question 10e.

Marks	0	1	2	Average
%	50	17	33	0.8

Acceptable responses included (two of):

- same time of day
- same warm-up
- same nutrition status
- same surface the test was completed on
- same clothing/footwear
- same protocols adhered to
- same weather conditions.

Some students made the reference to same environment, which does not specifically identify reliability of test results.

Question 11a.

Marks	0	1	2	Average
%	46	32	22	0.8

Students were required to identify and discuss a likely cause of fatigue for the trail runners given the parameters shown.

Acceptable responses with relevant discussion were restricted to:

- elevated body temperature (thermoregulatory fatigue)
- accumulation of metabolic by-products due to frequent uphill sections.

The following is an example of a high-scoring response.

Due to the heat the athlete may have thermoregulatory fatigue. This means they will have a redistribution of blood flow towards skin and away from working muscles, reducing available oxygen for aerobic ATP production.

Question 11b.

Marks	0	1	2	3	4	5	6	7	8	Average
%	16	10	15	21	18	11	6	2	1	2.9

Students were required to analyse the interplay of energy systems for the trail runner as well as discuss the role of acute responses to the cardiovascular and respiratory systems.

High-scoring responses demonstrated a strong understanding of energy system interplay as well as an integration of the role of acute respiratory and cardiovascular responses: for example, identifying the importance of these responses during the period of oxygen deficit.

Some students provided generic answers to the interplay of energy systems and listed acute responses at the end of the answer.

The following is an example of a high-scoring response.

Throughout the 12km trail run all 3 energy systems work together to provide the total energy for the event. Their relative contributions may change depending on the terrain and the relative incline of the uphill and downhill sections.

At the start of the run there is a period of oxygen deficit where the ATP/PC system and anaerobic glycolysis system increase contribution due to the delay/lag time in providing the necessary oxygen required to produce ATP aerobically.

During this time the body is undertaking several acute responses of both the cardiovascular and respiratory systems to deliver the required oxygen to muscles. These include an increase heart rate, stroke volume and cardiac output (Cardiovascular) to increase oxygen delivery to muscles and increased respiratory rate, tidal volume, ventilation, and pulmonary diffusion (Respiratory) to enhance oxygen uptake.

In addition to this the body redistributes blood from the internal organs to the working muscles to also help with oxygen supply. It does this through vasodilation and vasoconstriction of blood vessels.

Due to these acute responses, at around 4 minutes when heart rate reaches approximately 155 BM the aerobic system will begin to provide most of the energy for the 64-minute run. This is due to its slower rate but very high yield which ensures it remains the major contributor for the entire 12km.

There may be some periods of time when the athlete goes into oxygen deficit with an increased reliance on the anaerobic systems as these systems provide energy at a faster rate of energy for the increased intensity required for the uphill sections that can be seen between 8- 12 minutes, 28 to 32 minutes, and 48- 52 minutes.