Student note

Forms of assessment

OCR 'A' Level in Physical Education consists of three components:

Physiological factors affecting performance

Psychological factors affecting performance

Socio-cultural issues in physical activity and sport

These components are externally assessed using a mixture of multi-choice, short, medium and extended response questions, and they assess assessment objectives known as AO1, AO2 and AO3 as outlined in the table below. Marks will be allocated according to the assessment level the answer achieves. For example, AO3 represents a good answer that has a high level of accurate and relevant knowledge that is articulated well, and critically examines a wide range of issues balancing ideas against each other. Some short questions, for example, a 2 mark question, may only examine AO1 assessment level.

Please note that most answers are not exact, and that equivalent answers are usually acceptable. This is particularly relevant to the answers allocated to the Sport and Society questions. Mark allocations are used as a guide for revision purposes, and so do not necessarily reflect exam weighting. Note that in your exam, crossed-out work is marked unless you have replaced it with an alternative response.

Many of the answers, to the extended questions located within the Revision Guide, are presented in bullet format. This style has been used to assist you in identifying key points. In your exams, you will be expected to write in good prose that exhibits a natural flow of speech, grammatical structure, sentences and paragraphs.

When answering a question, remember what the examiners are looking for when they allocate maximum marks. In addition, you are advised to read accredited OCR examination material that will give further insight into the application of an exam answer to the banding system adopted by OCR.

Exam papers are presented in a booklet format and so you write your answers in the spaces provided. Read the question carefully before you start to answer it. You are advised to prepare an outline plan for your answers to extended questions. Note that calculators are permitted in your external exams.

Assessment objectives

OCR divide their marks into 3 categories:
AO1 – Knowledge identified and described.
AO2 – Application identified and explained.
AO3 – Analysis/evaluation.

Marks for an 8 mark answer are normally split as follows:
AO1 = 1, AO2 = 3 and AO3 = 4.

An eight mark answer scheme is marked at three ascending levels:

Level	Mark	Descriptor
	0	No rewardable material.
AO1	1	Demonstrate knowledge and understanding of the factors that underpin performance and involvement in physical activity and sport.
AO2	3	Apply knowledge and understanding of the factors that underpin performance and involvement in physical activity and sport.
AO3	4	Analyse and evaluate the factors that underpin performance and involvement in physical activity and sport.

The answers provided within this Revision Guide do not identify these assessment objectives. When looking at a sample answer you are encouraged to identify the appropriate assessment levels within the answer.

Synoptic assessment

Practice questions (located at the end of each chapter) examine the material within the chapter.

Synoptic assessment forms part of the OCR assessment protocol, and is the understanding of connections between different elements of the subject. It involves the explicit drawing together of knowledge, skills and understanding within different parts of the 'A' Level course.

A synoptic question is likely to be asked within an extended response question. You are advised to refer to OCR examination papers for examples.

We wish you all the best during your two year course and final exams and trust that this Revision book has assisted you in this process.

Jan Roscoe
Dennis Roscoe

CHAPTER 1: *Energy for exercise*

Practice questions - text book pages 31 to 34

1) Which of the following reactions would liberate the most energy?
   a. complete oxidation of a molecule of glucose to carbon dioxide and water.
   b. conversion of a molecule of ADP to ATP.
   c. respiration of molecule of glucose to lactic acid.
   d. conversion of a molecule of glucose to carbon dioxide and water.

Answer: a.
Explanation:
The most energy liberated would come from choice a. when 36 possible ATPs are produced from one molecule of glucose.

2) Which activity below is fuelled primarily by the anaerobic energy system?
   a. walking for 30 minutes.
   b. jogging for 50 minutes.
   c. taking part in an 400m race.
   d. playing football.

Answer: c.
Explanation:
Options a, b and d will predominantly rely on the aerobic energy system because of the duration and intensity of these activities. A 400 metre race requires a shorter duration and higher intensity and so will be more reliant on the anaerobic energy system.

3) Mary runs up a hill for as hard as she can. After two minutes she is so tired she cannot continue to run. Physiologically what is happening?
   a. Mary's aerobic system has been her predominant energy pathway during this bout of physical exertion.
   b. ATP was produced to fuel muscle contraction using an anaerobic energy pathway and lactic acid has now accumulated as a result of this process and is causing her to stop exercising at such a high intensity.
   c. ATP is being produced by the breakdown of fats and protein and her aerobic conditioning is inadequate to meet the demands of this exercise.
   d. Mary's blood pressure has decreased to the point where she has to stop and this has allowed lactic acid to build up in her system.

Answer: b.
Explanation:
Muscle fatigue is the result of lack of oxygen and so a switch to the anaerobic energy pathway as work intensity increases. Lactic acid starts to accumulate, causing her to stop running.

4) Which one of the following would result in the greatest decrease in muscle glycogen concentration?
   a. four 30 second sprint intervals (total time = 2 minutes).
   b. six 30 second endurance intervals at 100% $\dot{V}O_{2max}$.
   c. 4 minutes of continuous exercise at 100% $\dot{V}O_{2max}$.
   d. 60 minutes of continuous exercise at 75% $\dot{V}O_{2max}$.

Answer: a.
Explanation:
Per unit of ATP produced, anaerobic glycogenolysis depletes muscle glycogen stores many times more rapidly than would occur if ATP were being produced aerobically. The first 30-second interval would deplete muscle glycogen concentration by approximately one third. For exercise at 100% $\dot{V}O_{2max}$, although there is some anaerobic energy production, most of the ATP would come from aerobic metabolism.

5) Which one of the following would have least effect on the maximal anaerobic capacity of a muscle?
a. an increase in muscle glycogen concentration.
b. an increase in phosphocreatine (PC) concentration.
c. an increase in muscle Na^+/K^+ pump capacity.
d. an increase in muscle buffering capacity.

Answer: a.
Explanation:
Although glycogen is broken down extremely quickly during exercise at maximal anaerobic power, the time to fatigue is so short that glycogen depletion is not a limiting factor. The other three choices are important determinants of muscle anaerobic capacity.

6) For which of the following sports would a training programme for increasing phosphocreatine (PC) stores be least important?
a. basketball.
b. 100 metres track event.
c. high jump.
d. javelin throw.

Answer: a.
Explanation:
Explosive events such as sprinting, jumping or throwing derive almost all of their ATP energy supply from PC hydrolysis. A basketball game is predominantly aerobic and so is least reliant on energy derived from PC stores.

7) a) Define energy, and briefly describe how energy is released from food in the body. 5 marks

Answer:
1 mark for definition:
- *Energy is the capacity or ability to perform work.*

4 marks for how energy is released from food in the body:
- *Fuel foods are fuel stored in the body, the first is carbohydrate CHO (digested to glucose).*
- *The second type of fuel food consists of fats (digested to fatty acids & glycerol).*
- *These are used to create chemical energy in the form of adenosine triphosphate (ATP).*
- *This is an endothermic reaction (it takes in energy from the food and creates the ATP).*
- *This process is both aerobic and anaerobic, within all living tissue.*
- *ATP is an immediate usable form of chemical energy for all body processes.*
- *Including that used by skeletal muscle to perform mechanical work.*
- *The usage of ATP to create energy is an exothermic reaction.*

b) Identify the only form of usable energy in the body. 1 mark

Answer:
- *Adenosine Triphosphate (ATP).*

c) What is meant by an exothermic reaction? Illustrate this definition with an example. 2 marks

Answer:
- *Exothermic reaction is a reaction that releases energy.*
- *For example: ATP → ADP + P_i + energy.*

d) What is meant by an endothermic reaction? Illustrate this definition with an example. 2 marks

Answer:
- *Endothermic reaction is a reaction that takes in energy.*
- *For example: restoration of ATP from ADP.*
- *Or ADP + P_i + energy → ATP.*

8) Explain the specialist role of mitochondria in energy production. 4 marks

Answer:
- *Located within living cells.*
- *Major energy source.*
- *Each mitochondrion has an outer and inner membrane.*
- *And oxidative enzymes.*
- *For ATP resynthesis.*
- *Outer membrane and oxidative enzymes of the citric acid or Kreb's cycle, produce a net gain of 2 ATP.*
- *Inner membrane or cristae and oxidative enzymes of electron transport chain, produce a net gain of between 32-34 ATPs.*

9) Explain the differences between chemical, potential and kinetic energy. 3 marks

Answer:
- *Chemical energy is the energy within compounds.*
- *Potential energy is the energy that is stored.*
- *Kinetic energy is the energy of motion.*

10) During any event of low or high intensity, all three energy systems are used. However the physical demands of the event will determine the relative proportions of the energy system(s) being used. Complete the gaps in table 1.4 identifying the major energy systems and examples in sporting activities in relation to performance time. 8 marks

Table 1.4

Answer:

Area	Performance time	Major energy systems related to performance time	Examples of type of activity
1	Less than 10 s	ATP –PC	100m sprint / gymnastics vault / discus throw
2	10 –30 s	*Lactic acid*	*100m hurdles / 200m sprint*
3	20 s to 1.5 minutes	*Lactic acid*	*100m butterfly / 400m hurdles / 800m*
4	1.5 –3 minutes	*Lactic acid / aerobic*	*gymnastic floor sequence / boxing / judo*
5	greater than 3 minutes	*Aerobic*	*1500m / 800m swim / hockey game*

11) An elite swimmer performs a flat-out 100 metre freestyle swim in 50 seconds. Describe how most of the ATP is regenerated during the swim. Sketch a graph which shows the use of the appropriate energy systems against time during the swim. 10 marks

Answer:

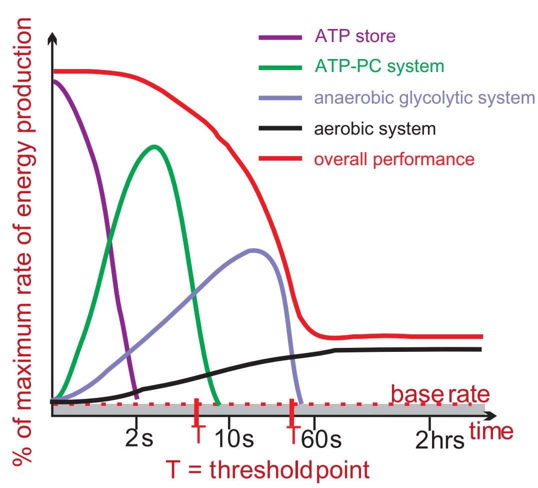
An elite swimmer performs a flat-out 100 metre freestyle:
- *Via the anaerobic glycolytic (lactic acid) system.*
- *Process called glycolysis or the incomplete breakdown of sugar.*
- *Glycolytic enzymes (for example, phosphofructokinase PFK) assist breakdown of glucose.*
- *Without oxygen being present.*
- *Takes place in the muscle cell sarcoplasm.*
- *One molecule of glucose is broken down to release 2 ATP.*
- *This is converted into pyruvic acid which is converted to lactic acid.*
- *By enzyme lactate dehydrogenase (LHD).*

Sketch a graph which shows the use of the appropriate energy systems:

Answer:
- *See sketch graph figure Q1.1.*

- *The ATP store is used up after 2 seconds or less.*
- *The ATP or PC system builds to a peak at 3 seconds and drops to zero after 9 seconds.*
- *The lactacid system peaks at around 20 seconds and then drops to zero at around 50 seconds.*
- *The aerobic system builds gradually from zero, always less than other system contributions.*

figure Q1.1 – variation in contribution of energy system



12) a) Taking part in a triathlon involved swimming, cycling and running. Briefly describe how the aerobic energy system within the cell mitochondria supports this endurance event. 6 marks

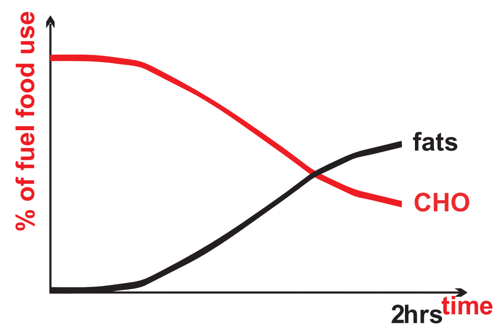
Answer:
3 marks for:
- *In the presence of oxygen.*
- *In the cell mitochondria.*
- *Oxaloacetic acid and acetyl coA combine to form citric acid.*
- *To enter Kreb's cycle where pairs of hydrogen atoms are released.*
- *CO_2 is formed.*
- *2 ATPs are produced.*

3 marks for:
- *Co-enzymes transport hydrogen atoms (ions and electrons) into the electron transport chain.*
- *Hydrogen ions and electrons are charged with potential energy.*
- *Which is released in a step-by-step manner.*
- *As O_2 is delivered to react with the hydrogen ions and electrons.*
- *To create a large energy yield per molecule of glucose (32 or 34 ATPs) and water.*

b) Construct a graph, which illustrates the food fuel usage against time during a triathlon race lasting 2 hours. 3 marks

Answer:
- *See figure Q1.2.*
- *1 mark for shape of carbohydrate curve.*
- *1 mark for shape of fat curve.*

figure Q1.2 – food fuel usage during a triathlon



13) Compare the relative efficiency of ATP production via the aerobic and anaerobic routes. Explain your answer. 3 marks

Answer:
1 marks for one of:
- *The aerobic route is 18-19 times more efficient than anaerobic route.*
- *36-38 ATP molecules are produced aerobically per molecule of glucose.*
- *Compared with 2 ATP molecules, produced anaerobically for one molecule of glucose.*

Explanation, 2 marks for 2 of:
- *Anaerobic production of ATP is the incomplete breakdown of one molecule of glucose (glycolysis), therefore there is very limited ATP production.*
- *Whereas the aerobic production of ATP completely breaks down the glucose molecule.*
- *To release all potential energy (energy stored in the molecules).*
- *Hence a much higher energy yield.*

14) Identify the predominant energy system being used in the following activities: shot put, 200 metres breaststroke, a game of hockey, 100 metres hurdles race, gymnastics vault and modern pentathlon. 6 marks

Answer:
Table Q1.1 – **table of activities**

activity	energy system
shot-put	• *ATP-PC*
200 metres breaststroke	• *Lactic acid*
a game of hockey	• *Aerobic*
100 metres hurdles race	• *ATP-PC*
gymnastics vault	• *ATP-PC*
modern pentathlon	• *Aerobic*

15) Figure 1.32 illustrates the contribution of the anaerobic and aerobic energy systems to the total energy requirements for four different track events: 200 metres, 400 metres, 800 metres and 1500 metres.

a) Which column, grey or pink, represents the contribution from the anaerobic system? 1 mark

Answer:
Grey.

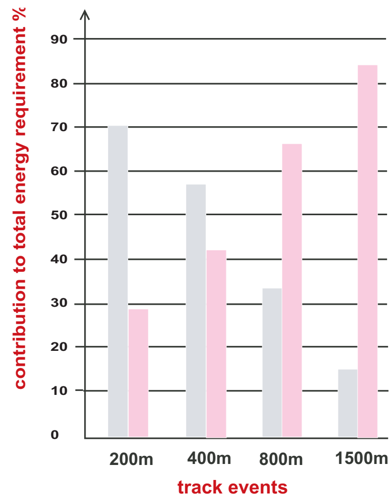


figure 1.32 – energy system contributions

b) With reference to the data provided, justify your answer. 3 marks

Answer:
3 marks for three of:

- *Although all anaerobic and aerobic energy systems contribute to ATP regeneration during an activity, one or other of the energy systems usually provides the major contribution as illustrated in figure 1.32.*
- *Skeletal muscle can perform work in the absence of an adequate supply of oxygen for only a short period of time.*
- *Oxygen, stored as oxymyoglobin, in muscle tissue, partly contributes towards aerobic energy production from the start of high intensity exercise, and so will contribute towards the 28% of oxygen supplied in the 200 metre event.*
- *The 70% anaerobic energy contribution is due to limited energy being created via the ATP-PC and the anaerobic glycolytic (lactic acid) systems.*
- *The relative contribution of the aerobic and anaerobic energy systems is closest during 400 metre running as the running pace is just under submaximal.*
- *The anaerobic glycolytic system is stressed predominantly after the 300 metre mark of the race, due to lactate stacking that results from high blood lactate levels.*
- *The relative contributions of the anaerobic and aerobic energy systems to the total energy requirements for the 800 metres and 1500 metres adjust as the intensity of the exercise decreases and duration of the exercise increases.*
- *The 1500 metres the event is predominantly aerobic, illustrated by in excess of 80% contribution of total energy requirement, reflecting a steady state of oxygen consumption and energy expenditure.*

c) What is the role of the anaerobic systems in the 1500 metre event? In your response, refer to the data provided. 2 marks

Answer:

- *The 17% anaerobic energy contribution reflect the use of anaerobic energy production to support changes in pace such as a quick start to get to the front of the pack or a quick burst in pace during laps.*
- *This limited energy supply is provided by the ATP-PC system.*
- *The energy supporting a fast kick to the finish line would utilise the energy produced by the anaerobic glycolytic system (lactic acid system).*

16) Elite games players require high levels of fitness and psychological preparation, therefore regular fitness testing and after-match performance analysis are common. Using your knowledge of energy systems, outline and explain the relationship between energy sources and intensity of exercise. 20 marks

Answer:

- *At low intensity levels of exercise energy sources comes from a mixture of fats and carbohydrates and a small amount of excess protein.*
- *Which are broken down aerobically, using oxygen within the aerobic energy system.*

The aerobic energy system

- *Stage 1: Glycolysis/anaerobic Glycolysis: readily available blood glucose is broken down to pyruvic acid and converted to acetyl-CoA within the muscle cell sarcoplasm.*
- *2 ATPs are resynthesised.*
- *During this stage a process called β-oxidation breaks down fatty acid molecules to generate acetyl-CoA.*

- *Fats are slower to release energy since it takes around 20 to 30 minutes to mobilise fats stores for aerobic-based activities.*
- *Protein serves as a potentially important energy substrate for long duration, endurance-type activities during a chemical process called deamination, to produce ATP aerobically or to be converted to fat for further future energy needs.*

- *Stage2 : Krebs cycle, occurs within the muscle cell mitochondria and involves the oxidation of acetyl-CoA to produce citric acid.*
- *This cycle produces carbon dioxide, 2 ATPs and hydrogen carried by NADs and FADs into the electron transport chain.*

- *Stage 3: Electron transport chain: hydrogen is split into hydrogen ions (H^+) and electrons (e^-).*
- *The hydrogen ions are oxidised and combine with oxygen to form water and electron provides the energy to resyntheise ATP, yielding a maximum of 34 ATPs.*

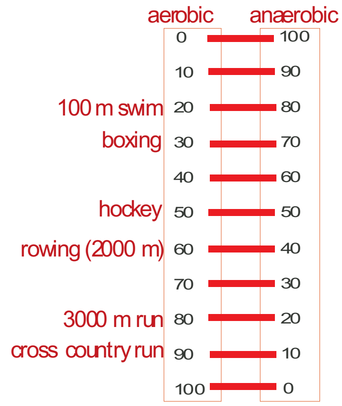
- *At high levels of exercise intensity carbohydrates are the only energy source when broken down to glucose.*
- *At high levels of exercise intensity fat and protein use is limited by oxygen availability since fats or proteins cannot be catabolised anaerobically.*

Anaerobic glycolysis

- *Quick release of energy from carbohydrates (converted from glycogen into glucose) anaerobically within muscle cell sarcoplasm, is called anaerobic glycolysis.*
- *To produce pyruvic acid.*
- *Because no oxygen is available the pyruvic acid is converted into lactic acid by the enzyme lactate dehydrogenase.*
- *It is only during recovery that lactic acid can be removed.*
- *Extra oxygen is taken up to remove lactic acid by changing it back to pyruvic acid which either continues down the aerobic pathway of energy release or gets converted back to glucose (Cori cycle).*
- *Only 2 ATPs per molecule of glucose are resynthesised.*

17) The diagram in figure 1.33 is an energy continuum in relation to a variety of sports activities.

figure 1.33 – variation in contribution of energy system



a) Explain the concept 'the energy continuum'. 2 marks

Answer:

- *The energy continuum is a concept used to describe the type(s) of respiration.*
- *And describes the shares of anaerobic and aerobic types of respiration.*
- *Demanded by different types of physical activities (games or sports).*

b) At each end of the continuum examples of sporting activities have been omitted. Give one example of a sporting activity that is predominantly anaerobic and one example of a sporting activity that is predominantly aerobic. 2 marks

Answer:

Anaerobic:

- *100 metres sprint, javelin throw, long jump, weight lift.*

Aerobic:

- *Marathon, jogging, long distance swimming, long distance cycling.*

c) Suggest two factors that need to be considered in evaluating sports activities on the basis of their relative position on the energy continuum. 2 marks

Answer:

- *The total amount of ATP required during that activity.*
- *Or power or rate at which ATP is required during the performance.*
- *Intensity and duration of the exercise period.*

d) Explain, using specific examples, why a game of hockey has aerobic and anaerobic components. 4 marks

Answer:

4 marks for four of:

- *Both the aerobic and anaerobic energy systems are important during a hockey game.*
- *Physiological profiles of elite hockey teams reveal the importance of aerobic endurance, anaerobic power and endurance, muscular strength and speed.*

- *The ATP-PC system is used to supply energy in the game when players are taking free hits.*
- *The player is exerting their energy on one swing from a static position.*
- *This is an anaerobic movement as O_2 is not necessary.*
- *It occurs quickly and uses readily available ATP for the powerful short lived action.*

- *Anaerobic glycolysis is used to supply a limited amount of energy in the game when players are in the middle of a play, such as a battle for the ball, carrying the ball or chasing the ball.*
- *This is generally about 30 seconds to a minute depending on the play.*
- *The sprinting involved creates lactic acid build up because glucose is partially broken down in the lower body muscles.*

- *The aerobic system (the complete breakdown of glucose to produce large amounts of ATP) is used throughout the game as players continue to run to maintain position.*
- *Players are running through all 70 minutes of the game using their aerobic system which begins a fat burn.*
- *The aerobic energy supply acts as recovery time from both the ATP-PC use and anaerobic glycolysis used in the game.*

18) Competitive swimmers will often compete in several events and suffer from fatigue due to limited recovery time. Explain the possible causes of fatigue during a race. 6 marks

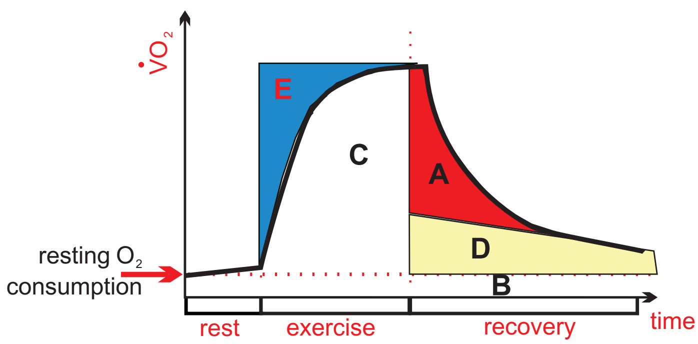
Answer:

6 marks for six of:

- *Build up of lactic acid accumulation of hydrogen ions/OBLA.*
- *Glycogen depletion/needed for glycolysis.*
- *Dehydration/reduces blood flow/loss of electrolytes/increase.*
- *Body temperature.*
- *Reduced levels of calcium.*
- *Reduced levels of acetylcholine/slows nerve impulse and inhibits contraction.*
- *Depletion of glycogen stores.*

19) Figure 1.34 shows oxygen uptake of an elite games player undertaking exercise followed by a recovery period.

figure 1.34 – oxygen consumption during exercise and recovery



a) Using the appropriate letters, identify the oxygen deficit and Excess Post Oxygen Consumption (EPOC). 3 marks

Answer:

- *Oxygen deficit = E.*
- *EPOC = A and D.*

b) Why does the elite player incur an oxygen deficit during exercise? 2 marks

Answer:

- *The oxygen deficit represents the difference between the oxygen required during the exercise.*
- *And the oxygen actually consumed during the activity.*

c) Excess Post Oxygen Consumption (EPOC) is considered to have two components. State two aims of the first component and explain how this component is achieved. 4 marks

Answer:

1 mark for one of:

- *The first component is called the alactacid component and involves the restoration of muscle phosphagen.*
- *So that exercise can begin again within 3 minutes of recovery time.*

3 marks for explanation:

- *This component involves the conversion of ADP back to PC and ATP.*
- *Firstly, there is aerobic conversion of carbohydrates into CO_2 and H_2O to resynthesise ATP from ADP and P_i.*
- *Then some of the ATP is immediately utilised to create PC using the coupled reaction: ATP + C ➔ ADP + PC.*

d) Describe the process of ATP production that restores the oxygen debt or EPOC. 6 marks

Answer:

Description or equivalent diagram:

- *Stage 1 = glycolysis in sarcoplasm.*
- *Energy yield 2ATPs per molecule of glucose.*
- *Stage 2 = Kreb's cycle in cell mitochondria.*
- *In presence of oxygen (O_2).*
- *Yields 2 ATPs per molecule of glucose.*
- *And carbon dioxide (CO_2) .*
- *Releases H^+ and e^- into next stage.*
- *Stage 3 = Electron transport stage.*
- *In inner cristae of mitochondria.*
- *Oxygen used to create ATP as H^+ and e^- meet.*
- *With water (H_20) given off.*
- *Creates 32 or 34 ATPs per molecule of glucose.*

20) An elite games player performs an interval training session during which the rate of muscle phosphagen levels during the recovery period was recorded. Results from this training session are given in table 1.5.

a) Using the results in table 1.5, plot a graph of recovery time against the percentage of muscle phosphagen restored. 3 marks

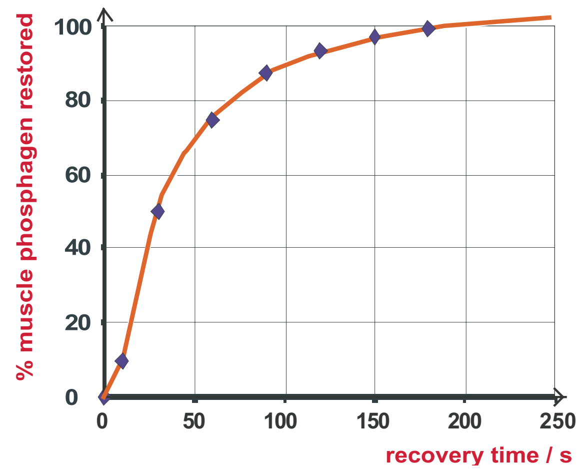
Table 1.5 – **muscle phosphagen during recovery**

recovery time / s	muscle phosphagen restored / %
10	10
30	50
60	75
90	87
120	93
150	97
180	99
210	101
240	102

Answer

- *See figure Q1.3*

figure Q1.3 – phosphagen recovery



b) What resting value would you recommend for a full recovery, and what would be the effect of restarting the exercise after 30 seconds? 2 marks

Answer:

1 mark for resting value:

- *180-210 seconds needed for full recovery.*

1 mark for the effect of restarting exercise:

- *50% of muscle phosphagen would have been restored.*
- *Or 50% muscle phosphagen would have been depleted.*

c) Part of the recovery mechanism after anaerobic exercise involves myoglobin. Explain the function of myoglobin during the recovery process. 3 marks

Answer:

- *Myoglobin is an iron protein molecule located within skeletal muscle.*
- *Structure is similar to haemoglobin.*
- *Myoglobin facilitates transportation of O_2 from HbO_2.*
- *Into the muscle cell or the mitochondria.*
- *It acts as a temporary storage site for O_2.*

21) How could information on oxygen debt recovery be of use to an athlete and coach in designing training sessions? 5 marks

Answer:

2 marks for two of:

- *Recovery of the phosphagens (PC) is rapid - maximum 2 minutes.*
- *Therefore athlete is able to perform many repetitions of high quality of short duration i.e. between 8-10 seconds maximal exercise.*
- *Build up of lactic acid inhibits enzyme activity and performance deteriorates.*
- *EPOC removes lactic acid.*
- *Removal of lactic acid relies on the limited buffering capacity of muscle tissue.*
- *And much larger buffering capacity of the hydrogencarbonate ion.*

3 marks for three of implications for training sessions:

- *Athlete must have adequate rest relief between repetitions.*
- *Use active recovery between repetitions, and cool-down to facilitate the removal of lactate.*
- *Variation of workload from one session to the next.*
- *For example, one high intensity session where the lactic acid system is stressed.*
- *Followed by a moderately intense aerobic or anaerobic (ATP-PC system) session.*

22) A high anaerobic capacity is important to any team player. Outline the physiological processes that will happen during a 30 minute recovery phase following an intense period of anaerobic exercise and discuss their implications when planning anaerobic interval training sessions. 20 marks

Answer:

- *The main aim of the recovery phase (known as excess post-oxygen consumption (EPOC)) is to restore the body to its pre-exercise state (what it was like before exercise started).*
- *EPOC involves the removal of by-products, such as lactic acid) produced during exercise and replenish the fuels used up during exercise.*

- *EPOC consists of two components:*
- *The initial rapid recovery stage (known as the alactacid component)*
- *The alactacid component involved the conversion of ADP back to PC and ATP, known as the restoration of muscle phosphagens.*
- *It takes 3 minutes for the ATP/PC stores to fully recover (in about 30 seconds for 50% of recovery and about 75% recovery in 60 seconds).*
- *This process also uses 3-4 litres of oxygen.*
- *During recovery, with elevated cardiac output and ventilation rates, there is a surplus of O_2 available for myoglobin to be replenished with oxygen within two minutes.*
- *Since phosphagen recovery is rapid only short recovery periods are required between short bouts of exercise.*
- *For example, 8 x 30 metre sprint starts with 3 minutes rest relief between each start.*
- *Since there is no fatigue associated with the predominant use of the ATP-PC energy system, it is possible to stress this system over several subsequent training sessions.*

- *The slow recovery stage known as the lactacid component.*
- *Lactacid oxygen recovery primarily responsible for the removal/re-conversion of lactic acid/lactate that takes the following pathways:*
  - *The majority of the lactic acid (65%) changes back into pyruvic acid, enters the Krebs' Cycle/electron transport chain where it is oxidised into carbon dioxide and water and energy is released.*
  - *20% gets converted into glycogen which is then stored in muscle and liver tissues (Cori cycle).*
  - *10% gets converted into proteins.*
  - *5% gets converted into glucose.*

- *EPOC is to support the elevated metabolism functions taking place after exercise, including:*
  - *Body temperatures remain elevated after vigorous exercise.*
  - *Hormones, like adrenaline, remain in the blood stimulating metabolism.*
  - *Cardiac output remains high, helping to reduce temperature and deliver oxygen to recovering body tissues.*

- *During a high intensity interval training session for a 400 metre athlete, the number of repetitions will reduce with increased recovery between the reps. For example, 3 x 300 metres flat out with 20 minutes rest relief with active rest relief between repetitions.*
- *It is not advisable to repeat this training session until muscle fatigue has diminished.*

- *At the end of such a training session, an active cool-down continues to provide oxygen to skeletal muscle.*
- *Thereby continuing the oxidation of lactic acid.*
- *And reducing the delayed onset of muscle soreness (DOMS).*
- *A hypertonic sports drink immediately following the training session with assist in replenishing depleted blood glucose levels.*

23) A friend comments 'I workout with free weights and swim regularly, yet on the odd occasion when I do some hill running, my leg muscles are sore a day or two after the event'. Explain why this is so. 4 marks

Answer:

4 marks for four of:

- *The human body adapts to specific regular activity involving range of movement, movement patterns and duration and intensity of the exercise period.*
- *And so skeletal muscles will not react with stiffness or soreness when an exercise regime is repeated on a regular basis.*
- *When an new exercise, such as hill running, is performed on the odd occasion, specific active muscles react by becoming sore for a day or two after the event.*
- *This is because the muscles are not familiar with this exercise type.*
- *This reaction is commonly known as the delayed onset of muscle soreness (DOMS).*
- *And creates inflammation, tenderness and pain.*
- *DOMS is particularly apparent due to eccentric muscle action, performed during activity such as downhill running.*
- *High muscle forces damage sarcolemmas and muscle contractile myofibrils (known as micro tears).*
- *Metabolites (e.g. calcium and lactic acid) accumulate to abnormal levels in the muscle tissue to produce more cell damage and reduce force capacity.*

24) How can an understanding of the energy systems assist in the planning of a warm-up routine? 10 marks

Answer:

6 marks for six of:

- *A warm-up is intended to raise the body temperature and prepare an athlete physiologically and psychologically to train or compete in a competitive situation.*
- *Consists of all round body activity exercise such as jogging, followed by general and mainly active stretching into a sport specific section (providing skill rehearsal for the activity).*
- *Priming exercise is a way of manipulating a warm-up to speed up how quickly the aerobic system starts at the onset of exercise by manipulating the intensity of the 'pulse raiser' element of the warm-up.*
- *With increased body temperature, the range of motion around joints will also improve and will get close to the athletes' optimal efficiency very quickly.*
- *Limiting the anaerobic glycolytic system will reduce the build up of the metabolic effects of fatigue associated with this energy system.*
- *Positive benefits from priming have generally shown to be just below or just above the maximum steady state.*
- *Priming exercise is of most benefit to anaerobic activities since the increased oxygen delivery to active tissue cells will delay the onset of OBLA.*
- *The gap from 6 and 20 minutes has been shown to be effective between the end of the priming exercise and the start of the performance.*
- *In aerobic activities a less intense and shorter warm-up is recommended to prepare the body for steady state performance.*

25) How can priming for exercise assist an athlete in the planning of a warm-up routine? 6 marks

Answer:

- *Priming exercise is a way of manipulating a warm-up to speed up how quickly the aerobic system starts at the onset of exercise by changing the intensity of the 'pulse raiser' element of the warm-up.*
- *Physiologists refer to this as O_2 uptake kinetics. There are several factors that are important in priming exercise:*
    - *Positive benefits from priming has generally shown to be just below or just above the maximum steady state,*
    - *Provided there is a long enough gap between the end of the priming exercise and the start of the performance.*
    - *There is most benefit to anaerobic activities since the increased oxygen delivery to active tissue cells will delay OBLA.*
    - *Duration of the gap - competitive event or activity should begin within several minutes after the end of a warm-up to conserve energy store.*
- *Somewhere between 6 and 20 minutes has been shown to be effective, less than this produces some residual fatigue.*

26) Discuss how elite athletes utilise recovery techniques as part of their training programmes. 20 marks

Answer:

4 marks for four of:

- *Short-term recovery is sometimes referred to as active recovery and occurs in the hours immediately after intense exercise.*
- *Active recovery refers to engaging in low-intensity exercise after workouts during both the cool-down phase immediately after a hard workout.*
- *By maintaining elevated respiratory and cardiovascular levels, as well as during the days following the workout.*
- *Both types of active recovery are linked to performance benefits.*
- *Cool-down is a major way of reducing DOMS, by gradually returning the body to its former resting state.*
- *This is achieved by performing low intensity exercise such as jogging and stretching.*

4 marks for four of:

- *Most well-designed training schedules will include recovery days and complete rest from the athlete's chosen sport.*
- *Particularly at the end of the competitive phase of the periodised year.*
- *This is also the reason why athletes and coaches vary a training programme throughout the periodised year by adding cross training,*
- *Modifying workout types.*
- *And make changes in variables such as intensity, time, and distance.*
- *Both short and long-term recovery are important for optimal sports performance.*

3 marks for three of:

- *Ideal recovery plans include total rest and active recovery. Rest is an essential component of recovery (known as passive recovery), particularly following an intense training session.*
- *Most athletes know that getting enough rest after exercise is essential to high-level performance.*
- *Building recovery time, including rest days, into any training programme is important because this is the time that the body adapts to the stress of exercise and the real training effect takes place.*
- *Recovery also allows the body to replenish energy stores and repair damaged tissues.*

3 marks for three of:

- *Exercise or any other physical work causes changes in the body such as muscle tissue breakdown.*
- *And the depletion of energy stores (muscle glycogen) as well as fluid loss.*
- *Recovery time allows these stores to be replenished and allows tissue repair to occur.*
- *Without sufficient time to repair and replenish, the body will continue to breakdown from intense exercise.*

3 marks for:

- *Most elite athletes will train twice a day and have an afternoon nap, aimed at giving the body short-term recovery before the start of the second training session of the day.*
- *This is in addition to 8-9 hours sleep. During sleep, blood flow is redirected towards muscles and organs.*
- *And carries nutrients, such as amino acids and glucose, that support substantial tissue repair and muscle and liver glycogen restoration.*

3 marks for three of:

- *When an athlete completes a hard training session, glycogen depletion will have taken place.*
- *It is essential that a restoration of energy stores is completed for recovery of the athlete prior to the next session or competition.*

Post-competition or training nutrition should consist of:

- *A hypertonic sports drink (figure 1.27) immediately after exercise has finished.*
- *This begins replenishment of blood glucose and glycogen stores.*
- *A high CHO meal within 15 minutes of exercise ending (or as soon as possible) continues glycogen replenishment.*
- *For optimal recovery, carbohydrate mixed with protein enhances all-round recovery due to an increase in protein synthesis post-exercise.*

27) Discuss factors affecting the proportions of energy systems during low and high intensity exercise. 20 marks

Answer:

1 mark for introduction of topic:

- *The major energy pathway for ATP production differs depending on the intensity and duration of the exercise.*

3 marks for brief description and application of the ATP-PC energy system:

- *In intense exercise of short duration, for example 100 metres sprint, the energy is derived from the already present stores of intramuscular ATP and PC stores otherwise called the ATP-PC system.*
- *This is an immediate energy system.*
- *It does not require oxygen.*
- *And is controlled by the enzyme creatine kinase.*

5 marks for brief description and application of the lactic acid energy system:

- *For intense exercise of longer duration (15 seconds-2 minutes) energy is generated mainly form the anaerobic reactions of glycolysis or lactic acid system - again a short-term energy system.*
- *Carbohydrate from the food a person has eaten is stored as glycogen and converted to glucose.*
- *It is the incomplete breakdown of glucose, assisted by enzymes such as glycogen phosphorylase, which provides the limited energy released during glycolysis.*
- *Since there is no oxygen present, the end product of this reaction is lactic acid.*
- *The enzyme facilitating the conversion from pyruvic acid to lactic acid is lactate dehydrogenase (LDH).*

- *Peak power output is a measure which represents the highest power generated during any 3-5 second period of maximum exercise. The fitter the person the quicker and greater the power output.*
- *Power trained athletes have a higher percentage of fast twitch muscle fibres, when compared with untrained people.*
- *Resulting from hypertrophy and hyperplasia of fast twitch muscle fibres.*
- *Hence power athletes have increased muscle cell stores of substances such as ATP, PC and glycogen.*
- *And increase in anaerobic enzymes such as creatine kinase.*
- *And improved toleration to lactate acid.*
- *And improved ability to remove lactate acid from muscle cells into blood.*
- *Thus enhancing the ATP-PC-lactate threshold and lactate-aerobic threshold.*
- *And reducing the delayed onset of muscle soreness (DOMS).*
- *Therefore the bigger the anaerobic capacity the better the anaerobic performance.*
- *Producing amazing performances such as those witnessed by the Global superstar sprinter Usain Bolt in the Beijing and London Olympic Games.*

5 marks for brief description and application of the aerobic acid energy system:

- *As exercise progresses into several minutes, the aerobic system predominates and oxygen consumption becomes an important factor.*
- *Assisted by aerobic enzymes such as glycogen phosphorylase needed for the breakdown of glucose during glycolysis.*
- *And lipoprotein lipase needed for the breakdown of fats within Kreb's cycle.*

- *The longer the exercise period, the more the performer reaches a steady rate of oxygen uptake.*
- *Representing a balance between the energy requirements of the working muscles and the aerobic resynthesis of ATP.*

- *The aerobic system depends on CHO in the form of glucose, derived from glycogen stores in mainly slow twitch muscle fibres.*
- *After approximately 30 minutes fats (FFAs) begin to contribute towards energy production by a process called B-oxidation.*
- *A high CHO diet would assist replenishment of glycogen stores.*
- *And therefore sustain endurance running times in events such as marathons and the energy levels of a group of walkers on a full day's mountain walk.*

- *During prolonged exercise endurance athletes utilise FFAs sooner that untrained people.*
- *This training adaptation enables the trained athlete to not use glycogen up immediately, but save it for later on in an exercise effort or when the intensity of the exercise increases.*
- *This training adaptation is called glycogen sparing.*

27) continued

5 marks for brief description and application of the aerobic capacity:

- *The maximum capacity for aerobic resynthesis of ATP is measured as the maximum oxygen consumption of $\dot{V}O_{2max}$.*
- *This is one of the important indicators of one's ability for sustained exercise.*
- *As work intensity increases, lactic acid starts to accumulate above resting values.*
- *The onset of blood lactate accumulation (OBLA) represents a point where the production of lactate exceeds the speed of its removal.*
- *And is characterised by muscle fatigue, pain and deterioration of physical performance.*
- *OBLA can be expressed as a percentage of $\dot{V}O_{2max}$.*
- *Hence, trained athletes begin OBLA at higher work intensities (85-90% of their $\dot{V}O_{2max}$) compared with untrained athletes (50-55% of their $\dot{V}O_{2max}$).*
- *Which means for the trained endurance athlete, the lactic-aerobic threshold moves to higher values of $\dot{V}O_{2max}$.*
- *And therefore an endurance-trained athlete is capable of a better endurance performances.*
- *For example, cross-country skiers have very high $\dot{V}O_{2max}$ values needed to sustain a very demanding physical activity.*

1 mark for summary:

- *The fitter a person is the greater the intensity and duration of the exercise period a person can work towards.*
- *This is because the human body physiologically adapts as a natural response to long-term training.*

28) How can a knowledge and understanding of excess post exercise oxygen consumption assist a coach in maintaining the training efficiency for his or her athlete? 10 marks

Answer:

4 marks for four of general comments on recovery:

- *The intensity and duration of an exercise period will determine the recovery or rest relief needed between repetitions/sets and training sessions.*
- *This concept is known as the work-rest relief ratio.*
- *When planning training sessions, rates of recovery must be take into account.*
- *Recovery between bouts of exercise is dependent on heart rate values.*
- *As heart rate (HR) falls during recovery, its value is a measure of alactacid/lactacid recovery.*
- *Therefore repeating an exercise bout may not be possible until HR has fallen by a certain amount.*

3 marks for three of:

- *The alactacid recovery component is quick i.e within 3 minutes.*
- *And so it is possible to do many short, fast repetitions within a short period of time.*
- *And repeat high quality sessions within a short period of time.*
- *For example, a typical speed training session: 2 sets (6 x 60 metres sprints at 100%) 3 minutes recovery between repetitions, 8 minutes recovery between sets.*

3 marks for three of:

- *The lactacid component of recovery is a much slower process.*
- *Hence the rest relief ratio is much greater.*
- *For example, a typical 400 metres athlete's summer training session: 2 sets (2 x 300 metres sprints at 90%) 15 minutes recovery between repetitions, 20 minutes recovery between sets.*
- *Active recovery or cool-down speeds up removal of lactic acid.*
- *Variance in the intensity of workload in sessions is important, so that the lactic acid system is not stressed in every session.*
- *And so reducing the training intensity will give a recovery time between lactacid training sessions.*