

Student note

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.

Where questions require substantial answers, as is the case of the extended 8 marks and 15 marks questions, a banding system applies, consisting of four and five levels respectively. Note that each level indicates the allocation of marks that is relevant to both knowledge and the application of this knowledge to the question. See below for specific details.

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 AQA examination material that will give further insight into the application of an exam answer to the banding system adopted by AQA.

Both paper 1 and paper 2 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.

AQA 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 = 2, AO2 = 3 and AO3 = 4.

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

Level	Mark	Descriptor
	0	No rewardable material.
Level 1	1-2	Knowledge may be limited. Application of breadth or depth of knowledge may be limited or not evident. There may be little or no analysis and/or evaluation between different relevant factors and their impact. Relevant terminology is occasionally used. The answer may lack substantiated reasoning, clarity, structure and focus.
Level 2	3-4	Knowledge is sometimes accurate with some detail. Application of breadth or depth of knowledge is sometimes evident. Analysis and/or evaluation are sometimes made between different relevant factors and their impact, but may lack coherence. Relevant terminology is sometimes used. The answer occasionally demonstrates substantiated reasoning, but may lack clarity, structure and focus.
Level 3	5-6	Knowledge is usually accurate and detailed. Application of breadth or depth of knowledge is often evident. Analysis and/or evaluation are often made between different relevant factors and their impact, and are usually coherent. Relevant terminology is often used. The answer usually demonstrates substantiated reasoning, clarity, structure and focus.
Level 4	7-8	Knowledge is consistently accurate and well detailed. Application of breadth or depth of knowledge is clearly evident. Analysis and/or evaluation are coherently and consistently made between different relevant factors and their impact. Relevant terminology is consistently used. The answer almost always demonstrates substantiated reasoning, clarity, structure and focus.

Marks for a 15 mark answer are normally split as follows:

AO1 = 4, AO2 = 5 and AO3 = 6.

A fifteen mark answer scheme is marked at five ascending levels:

Level	Mark	Descriptor
	0	No relevant content.
Level 1	1-3	Knowledge is limited and may lack accuracy and detail. Application of breadth or depth of knowledge is likely to be limited or not evident. There may be very little or no analysis and/or evaluation made between different relevant factors and their impact. Relevant terminology used only very occasionally. The answer often lacks substantiated reasoning, clarity, structure and/or focus.
Level 2	4-6	Knowledge is sometimes accurate but may lack detail. Application of breadth or depth of knowledge is occasionally evident. Some analysis and/or evaluation are attempted between different relevant factors and their impact, but is likely to lack coherence Relevant terminology is occasionally used. The answer occasionally demonstrates substantiated reasoning, but may lack clarity, structure and/or focus at times.
Level 3	7-9	Knowledge is generally accurate and sometimes detailed. Application of breadth or depth of knowledge is sometimes evident. Some analysis and/or evaluation are made between different relevant factors and their impact, but may sometimes lack coherence. Relevant terminology is used but may sometimes be missing. The answer sometimes demonstrates substantiated reasoning, clarity, structure and focus.
Level 4	10-12	Knowledge is usually comprehensive, accurate and detailed. Application of breadth or depth of knowledge is often evident. Analysis and/or evaluation are often made between different relevant factors and their impact, and is usually coherent. Relevant terminology is usually used. The answer usually demonstrates substantiated reasoning, clarity, structure and focus.
Level 5	13-15	Knowledge is consistently comprehensive, accurate and well detailed. Application of breadth or depth of knowledge is clearly evident. Analysis and/or evaluation is coherently and consistently made between different relevant factors and their impact. Relevant terminology is almost always used. The answer demonstrates a high level of substantiated reasoning, clarity, structure and focus.

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 systems part one

Practice questions - text book pages 23 - 25

- 1) Which of the following reactions would liberate the most energy?
- complete oxidation of a molecule of glucose to carbon dioxide and water.
 - conversion of a molecule of ADP to ATP.
 - respiration of molecule of glucose to lactic acid.
 - 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?
- walking for 30 minutes.
 - jogging for 50 minutes.
 - taking part in an 400 m race.
 - 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?
- Mary's aerobic system has been her predominant energy pathway during this bout of physical exertion.
 - 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.
 - ATP is being produced by the breakdown of fats and protein and her aerobic conditioning is inadequate to meet the demands of this exercise.
 - 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?
- four 30 second print intervals (total time = 2 minutes).
 - six 30 second endurance intervals at 100% $\dot{V}O_{2max}$.
 - 4 minutes of continuous exercise at 100% $\dot{V}O_{2max}$.
 - 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?
- an increase in muscle glycogen concentration.
 - an increase in phosphocreatine (PC) concentration.
 - an increase in muscle Na⁺/K⁺ pump capacity.
 - 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?
- basketball.
 - 100 metres track event.
 - high jump.
 - 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: $ATP \rightarrow ADP + P_i + \text{energy}$.

- 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 $ADP + P_i + \text{energy} \rightarrow ATP$.

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) 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.

8 marks

Answer:

An elite swimmer performs a flat-out 100 metre freestyle:

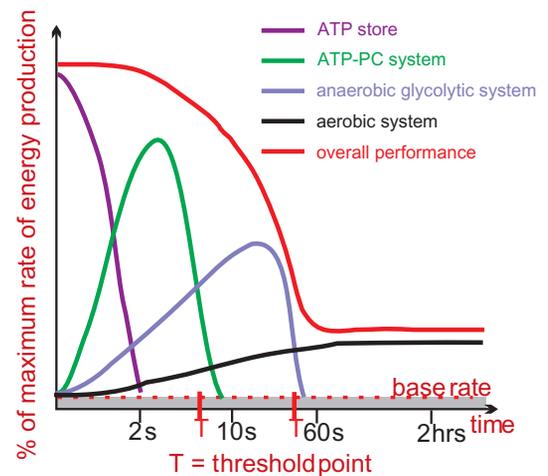
- Via the **anaerobic glycolytic (lactic acid) system**.
- Process called **glycolysis** or the incomplete breakdown of sugar.
- Glycolytic enzymes (for example, phosphofructokinase **PFK**) assist breakdown of glucose.
- **Without oxygen** being present.
- Takes place in the muscle cell sarcoplasm.
- 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



10) 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.
- **CO₂** 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 **O₂** 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.

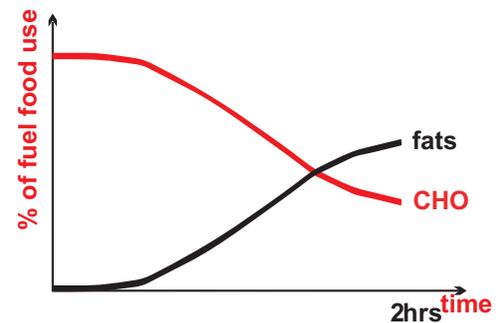
b) Construct a graph, which illustrates the food fuel usage against time during a triathlon race lasting 2 hours.

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



11) 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**.

12) 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 1.3 – 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

13) Figure 1.21 illustrates the contribution of the anaerobic and aerobic energy systems to the total energy requirements for four different track events: 200 m, 400 m, 800 m and 1500 m.

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

Answer:

- Grey.

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

Answer:

3 marks for three of:

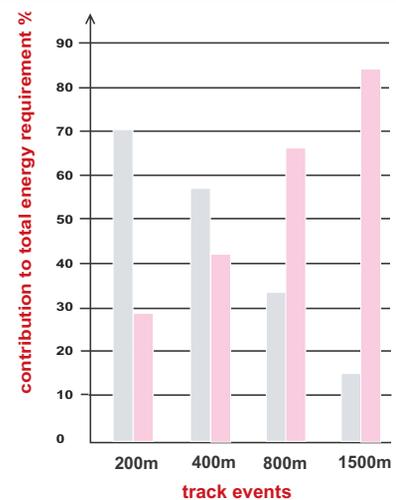
- Although **all anaerobic and aerobic energy systems contribute** to ATP regeneration during an activity, one or other of the energy systems usually provides the major contribution as illustrated in figure 1.21.
- Skeletal muscle can perform **work** in the absence of an adequate supply of oxygen for 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 m 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).

figure 1.21 – energy system contributions



- 14) 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.

15 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.
- **Stage 2: 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 resynthesise 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.

15) Figure 1.20 illustrates the relationship between blood lactate and $\% \dot{V}O_{2\max}$

a) What do you understand by the term lactate threshold?

2 marks

Answer:

- The highest oxygen uptake or exercise intensity achieved with less than 1.0 mmol increase in blood lactate level concentration above pre-exercise level.

b) Mark on the graph in figure 1.20 the point at which the onset of blood lactate accumulation (OBLA) occurs.

1 mark

Answer:

- Mark between 2 and 4 mmols

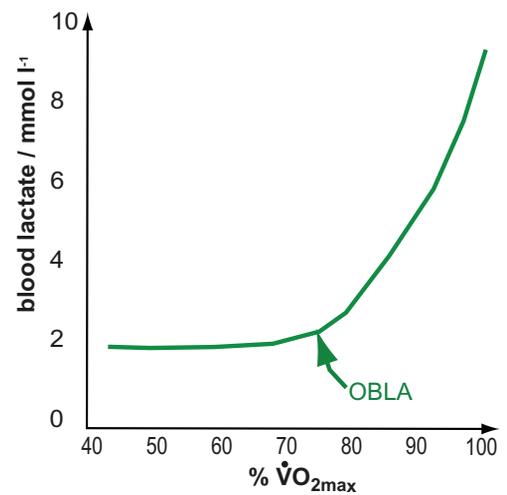
c) Explain why lactic acid tends to be produced when a player is exercising.

3 marks

Answer:

- When workload intensity increases during exercise, there is an inadequate oxygen supply and utilisation.
- All the hydrogens formed in rapid glycolysis fail to oxidise.
- And so pyruvic acid converts to lactic acid.

figure 1.20 – blood lactate and oxygen uptake



16) Figure 1.23 shows oxygen uptake of an elite games player undertaking exercise followed by a recovery period.

- 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: $\text{ATP} + \text{C} \rightarrow \text{ADP} + \text{PC}$.

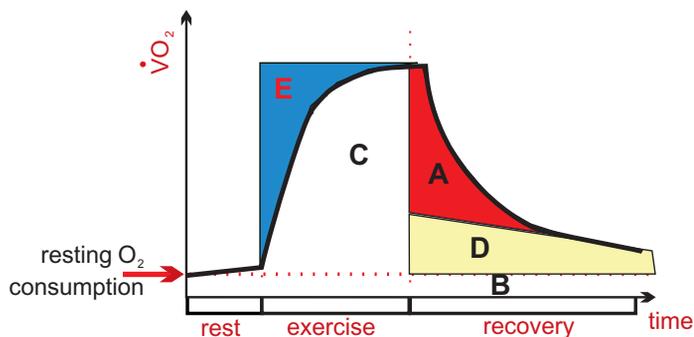
- d) Describe the process of ATP production that restores the oxygen debt or EPOC. 6 marks

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_2O) given off.
- Creates **32 or 34 ATPs** per molecule of glucose.

figure 1.23 – oxygen consumption during exercise and recovery



17) 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 1.3.

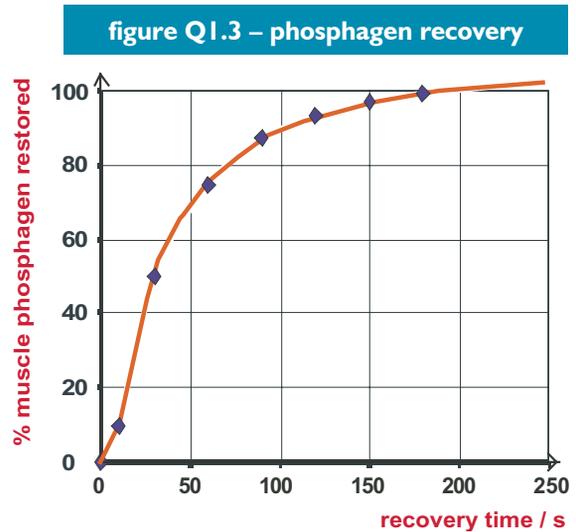
a) Using the results in table 1.3, plot a graph of recovery time against the percentage of muscle phosphagen restored. 3 marks

Table 1.3 – 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



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 .

18) 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.

19) 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.

3 marks

Answer:

3 marks for three 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**.