**Q1.**(a)     Describe the roles of calcium ions and ATP in the contraction of a myofibril.

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**(Extra space)** ................................................................................................

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**(5)**

(b)     ATP is an energy source used in many cell processes. Give **two** ways in which ATP is a suitable energy source for cells to use.

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2 .....................................................................................................................

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**(2)**

**(Total 7 marks)**

**Q2.**          (a)     Mitochondria in muscle cells have more cristae than mitochondria in skin cells. Explain the advantage of mitochondria in muscle cells having more cristae.

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**(2)**

(b)     Substance **X** enters the mitochondrion from the cytoplasm. Each molecule of substance **X** has three carbon atoms.

(i)      Name substance **X**.

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**(1)**

(ii)     In the link reaction substance **X** is converted to a substance with molecules effectively containing only two carbon atoms. Describe what happens in this process.

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**(2)**

(c)     The Krebs cycle, which takes place in the matrix, releases hydrogen ions. These hydrogen ions provide a source of energy for the synthesis of ATP, using coenzymes and carrier proteins in the inner membrane of the mitochondrion.

Describe the roles of the coenzymes and carrier proteins in the synthesis of ATP.

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**(3)**

**(Total 8 marks)**

**Q3.**          When one mole of glucose is burned, 2800 kJ of energy are released. However, when one mole of glucose is respired aerobically, only 40% of the energy released is incorporated into ATP. Each mole of glucose respired aerobically produces 38 moles of ATP.

(a)     (i)      Calculate how much energy is incorporated into each mole of ATP. Show your working.

Answer ................................................. kJ

**(2)**

(ii)     When glucose is respired what happens to the energy which is **not** incorporated into ATP?

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**(1)**

(b)     (i)      When one mole of glucose is respired anaerobically, only 2 moles of ATP are produced. Explain why less energy is released in anaerobic respiration.

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**(1)**

(ii)     At the end of a sprint race, a runner continues to breathe rapidly for some time. Explain the advantage of this.

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**(2)**

**(Total 6 marks)**

**Q4.**          (a)     Name the substance that muscles use as their immediate energy source.

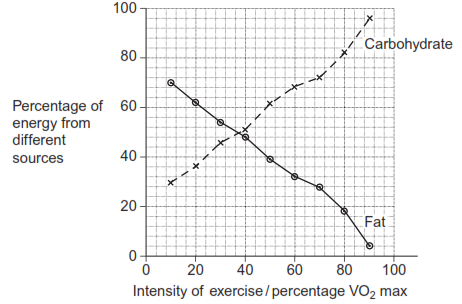
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**(1)**

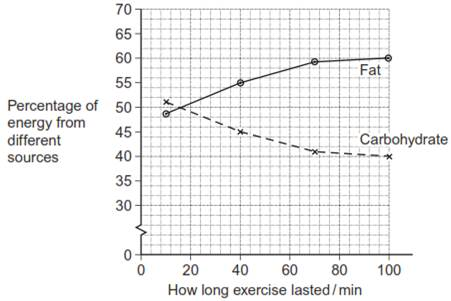
(b)     Sports scientists investigated the change in energy sources used during exercise.  
They measured the percentage of energy obtained from carbohydrate and the percentage of energy obtained from fat in two groups of athletes.  
•    **Group A** exercised at different intensities for the same time.  
•    **Group B** exercised at the same intensity for different times.  
They calculated the intensity of the exercise as a percentage of VO2 max.  
VO2 max is the maximum volume of oxygen the athletes can take in per minute.

The results for **Group A** are shown in **Figure 1** and the results for **Group B** are shown in **Figure 2**.

**Figure 1**

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**Figure 2**

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(i)      Calculate the ratio of the percentage of energy from carbohydrate to the percentage of energy from fat when the intensity of exercise is 70% VO2 max. Show your working.

Answer ..................................................................................................

**(2)**

(ii)     A person wishes to lose some body fat by exercising. What sort of exercise would be most effective? Use the information in **Figures 1** and **2** to explain your answer.

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(*Extra space*) .......................................................................................

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**(3)**

**(Total 6 marks)**

**Q5.**(a)     ATP is useful in many biological processes. Explain why.

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**(4)**

(b)     Describe how ATP is made in mitochondria.

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**(6)**

(c)     Plants produce ATP in their chloroplasts during photosynthesis. They also produce ATP during respiration. Explain why it is important for plants to produce ATP during respiration in addition to during photosynthesis.

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**(5)**

**(Total 15 marks)**

**Q6.**(a)     The table contains statements about three biological processes.

Complete the table with a tick if the statement in the first column is true, for each process.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | **Photosynthesis** | **Anaerobic respiration** | **Aerobic respiration** |
|  | ATP produced |  |  |  |
|  | Occurs in organelles |  |  |  |
|  | Electron transport chain involved |  |  |  |

**(3)**

(b)     Write a simple equation to show how ATP is synthesised from ADP.

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**(1)**

(c)     Give **two** ways in which the properties of ATP make it a suitable source of energy in biological processes.

1 ...................................................................................................................

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2 ...................................................................................................................

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**(2)**

(d)     Humans synthesise more than their body mass of ATP each day. Explain why it is necessary for them to synthesise such a large amount of ATP.

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**(2)**

**(Total 8 marks)**

**Q7.**          (a)     Describe the part played by the inner membrane of a mitochondrion in producing ATP.

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**(3)**

(b)     A scientist investigated ATP production in a preparation of isolated mitochondria. He suspended the mitochondria in an isotonic solution and added a suitable respiratory substrate together with ADP and phosphate. He bubbled oxygen through the preparation.

(i)      Why was the solution in which the mitochondria were suspended isotonic?

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(ii)     Explain why the scientist did **not** use glucose as the respiratory substrate.

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**(2)**

(iii)     Explain why the oxygen concentration would change during this investigation.

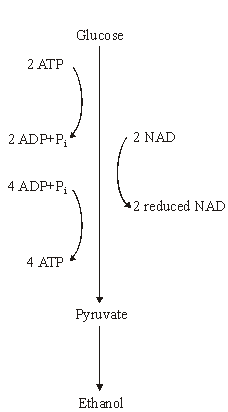
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**(1)**

**(Total 7 marks)**

**Q8.**          The diagram summarises the process of anaerobic respiration in yeast cells.



(a)     (i)      In anaerobic respiration, what is the net yield of ATP molecules per molecule of glucose?

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**(1)**

(ii)     Give **two** advantages of ATP as an energy-storage molecule within a cell.

1 ..........................................................................................................

.............................................................................................................

2 ..........................................................................................................

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**(2)**

(b)     Describe how NAD is regenerated in anaerobic respiration in yeast cells.

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**(1)**

**(Total 4 marks)**

**M1.**(a)     1.      Calcium ions diffuse into myofibrils from (sarcoplasmic) reticulum;

2.      (Calcium ions) cause movement of tropomyosin (on actin);

3.      (This movement causes) exposure of the binding sites on the actin;

4.      Myosin heads attach to binding sites on actin;

5.      Hydrolysis of ATP (on myosin heads) causes myosin heads to bend;

6.      (Bending) pulling actin molecules;

7.      Attachment of a new ATP molecule to each myosin head causes myosin heads to detach (from actin sites).

**5 max**

(b)     1.      Releases relatively small amount of energy / little energy lost as heat;

*Key concept is that little danger of thermal death of cells*

2.      Releases energy instantaneously;

*Key concept is that energy is readily available*

3.      Phosphorylates other compounds, making them more reactive;

4.      Can be rapidly re-synthesised;

5.      Is not lost from / does not leave cells.

**2 max**

**[7]**

**M2.**          (a)     (more cristae / larger surface area) for electron transport chain /   
more enzymes for ATP production / oxidative phosphorylation;  
muscle cells use more ATP (than skin cells)(not just more respiration);

**2**

(b)     (i)      pyruvate;

**1**

(ii)     carbon dioxide formed / decarboxylation;  
hydrogen released / reduced NAD formed;  
acetyl coenzyme A produced;

**2 max**

(c)     NAD / FAD reduced / hydrogen attached to NAD / FAD;  
H+ ions / electrons transferred from coenzyme to coenzyme /   
carrier to carrier / series of redox reactions;  
energy made available as electrons passed on;  
energy used to synthesise ATP from ADP and phosphate /   
using ATPase;  
H+ / protons passed into intermembrane space;  
H+ / protons flow back through stalked particles / enzyme;

**3 max**

**[8]**

**M3.**          (a)     (i)      29.47(29.5);

*(2 marks for correct answer)*

40% / 0.4 of 2800 / 38;

**2**

(ii)     released as heat;

**1**

(b)     (i)      glucose only partly broken down / only broken down to lactate;

**1**

(ii)     lactate / lactic acid has built up / been produced;  
oxygen used to break down lactate / convert it back to  
pyruvate / glucose / glycogen;

**2**

**[6]**

**M4.**          (a)     ATP

**1**

(b)     (i)      2.57:1/2.6:1/18:7;Correct answer however derived scores two marks72:28 scores one markCorrect working from wrong figures scores 1 mark

*Accept*

*0.4 / 0.39 / 0.389 / 0.3889*

**2 max**

(ii)     Low intensity;At low intensity/below 40% mainly fat used / at high intensity/  
above 40% mainly carbohydrate used;Long duration exercise;Percentage fat used increases with time / percentage  
carbohydrate used decreases with time;

**3**

**[6]**

**M5.**          (a)     1.      Releases energy in small / manageable amounts;

*1. Accept less than glucose*

2.      (Broken down) in a one step / single bond broken immediate energy compound / makes energy available rapidly;

*2. Accept easily broken down*

3.      Phosphorylates / adds phosphate makes (phosphorylated substances) more reactive / lowers activation energy;

*3. Do not accept phosphorus or P on its own*

4.      Reformed / made again;

*4. Must relate to regeneration*

**4**

(b)     1.      Substrate level phosphorylation / ATP produced in Krebs cycle;

*Accept alternatives for reduced NAD*

2.      Krebs cycle / link reaction produces reduced coenzyme / reduced NAD / reduced FAD;

*2. Accept description of either Krebs cycle or link reaction*

3.      Electrons released from reduced / coenzymes / NAD / FAD;

4.      (Electrons) pass along carriers / through electron transport chain / through series of redox reactions;

5.      Energy released;

*5. Allow this mark in context of electron transport or chemiosmosis*

6.      ADP / ADP + Pi;

*6. Accept H+ or hydrogen ions and cristae*

7.      Protons move into intermembrane space;

*7. Allow description of movement through membrane*

8.      ATP synthase;

*8. Accept ATPase. Reject stalked particles*

**6 max**

(c)     1.      In the dark no ATP production in photosynthesis;

*1. In context of in photosynthetic tissue / leaves*

2.      Some tissues unable to photosynthesise / produce ATP;

3.      ATP cannot be moved from cell to cell / stored;

4.      Plant uses more ATP than produced in photosynthesis;

5.      ATP for active transport / synthesis (of named substance);

**5**

**[15]**

**M6.**(a)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  | Photosynthesis | Anaerobic respiration | Aerobic respiration |
|  | ATP produced |  |  |  |
|  | Occurs in organelles |  |  |  |
|  | Electron transport chain involved |  |  |  |

*1 mark per column*

*Mark ticks only. Ignore anything else if different symbols such as crosses are used as well.*

*If crosses are used instead of ticks allow cross as equivalent to a tick.*

*Reject tick with a line through*

**3**

(b)     ADP + Pi → ATP;

*Both sides correct, but allow other recognised symbols or words for phosphate ion. Reject P unless in a circle.*

*Accept = as equivalent to arrow*

*Accept reversible arrow*

*Ignore any reference to kJ / water*

**1**

(c)     1.      Energy released in small / suitable amounts;

2.      Soluble;

3.      Involves a single / simple reaction;

*1. In context of release, not storage. Ignore producing energy / manageable amounts.*

*2. Reject "broken down easily / readily". Reject "quickly / easily resynthesised".*

**2 max**

(d)     1.      ATP cannot be stored / is an immediate source of energy;

2.      ATP only releases a small amount of energy at a time;

**2**

**[8]**

**M7.**          (a)     Electrons transferred down electron transport chain;

Provide energy to take protons / H+ into space between membranes;

Protons / H+ pass back, through membrane / into matrix / through  
ATPase;

Energy used to combine ADP and phosphate / to produce ATP;

*Accept: alternatives for electron transport chain.*

**3 max**

(b)     (i)      Prevent damage to mitochondria caused by  
water / osmosis / differences in water potential;

*Accept: other terms that imply damage e.g. shrink / burst*

**1**

(ii)     Glucose is used / broken down during glycolysis in cytoplasm / not in mitochondria;

*Accept: ‘glucose is converted to pyruvate’ for description of breakdown*

Glucose cannot cross mitochondrial membrane / does not  
enter mitochondria;

*Accept: only pyruvate can*

**2**

(iii)    Terminal / final acceptor (in electron transport chain) / used to  
make water;

*Could be shown by symbols*

**1**

**[7]**

**M8.**         (a)     (i)      2 (molecules)

**1**

(ii)     Cannot pass out of cell;  
Quickly / easily broken down (hydrolysed) / broken  
down in a on-step reaction / immediate source of energy;  
Stores / releases small amounts of energy;  
*Do not credit “producing energy”*

**max 2**

(b)     Formed when reduced NAD used to reduce / donate H ions  
to pyruvate / convert pyruvate to ethanol;

**1**

**[4]**

**E2.**          (a)     Many candidates could relate the cristae to the electron transport chain. Some of these failed to complete the answer by going on to explain that this would satisfy the greater requirement for ATP for muscle activity. Weaker candidates often just gave vague answers about there being a greater surface area or the mitochondria providing more energy.

(b)     Again, there were many good answers gaining full marks. The formation of acetyl coenzyme A was mentioned by most, but carbon dioxide and reduced NAD formation were quite often omitted. Weaker candidates often showed a dubious grasp of chemistry, with carbon atoms being ‘lost’ and hydrogen ‘picked up’, while many referred to pyruvate forming ‘acetyl’ which combined with coenzyme A.

(c)     More able candidates clearly understood this well and often gave comprehensive answers easily gaining maximum marks. Quite often candidates referred to the reduction of the coenzymes and transfer of electrons from carrier to carrier, but failed to link this to energy being made available for the synthesis of ATP from ADP and phosphate. Frequently there was no mention of energy at all, or energy was described as being ‘created’. Some candidates, who were obviously aware that movements across the inner membrane were involved, omitted basic points and gave confusing or inaccurate accounts which were difficult to credit.

**E3.**          Whilst many candidates scored maximum marks on this question, there was a surprising number of very weak answers.

(a)     Many candidates gained maximum marks in part (i) and were able to calculate the energy released from one mole of ATP. A common error was to calculate the energy released from one mole of glucose (40% of 2800) and to fail to divide this by the number of moles of ATP produced from one mole of glucose (38).

In part (ii) many correctly identified that the energy not incorporated into ATP is released as heat, but references to food storage were common errors.

(b)     In part (i) better candidates were able to explain the low ATP production in anaerobic respiration in terms of the partial breakdown of glucose. Although there were many excellent answers to part (ii), clearly explaining how oxygen is used to breakdown lactate, there were many vague and often incorrect references to oxygen debt.

**E4.**          In (a), nearly everyone knew ATP was the energy source, although a few did suggest glucose and one or two, rather disappointingly, suggested oxygen. In (b)(i), a surprising number of candidates were unaware of what is meant by a ratio and gave an answer based on percentage. Although some tolerance was allowed in reading the figures from the graph, too many were simply not careful enough in carrying out this task. Part (b)(ii) was a good discriminator. A good number noticed that fat usage was greatest at low intensity exercise and also after longer durations, but failed to put the two together to suggest low intensity, long- lasting exercise.

**E5.**          (a)     Some good answers were given to this question, with candiates being confident in their understanding of the way in which ATP rapidly releases small, manageable amounts of energy in a single hydrolytic reaction. Marking points 5 and 6 were the least often seen, and the use of ATP to lower activation energy was very rarely seen, although answers frequently referred to activation of glucose in glycolysis.

(b)     Many excellent answers were given in this section that included six or more of the marking points and showed excellent understanding of the processes involved in ATP formation, including chemiosmosis. A significant number gave an account of the whole process of respiration, including glycolysis, using up the space provided and indicating that the answer continued on a separate sheet. One or two included the digestion and absorption of carbohydrates. Weaker students often gained marking points 1, 2 and 6. There was confusion over protons and electrons and hydrogen ions/atoms and molecules. Some students confused the processes of respiration and the light-independent reaction of photosynthesis. Glycerate 3-phosphate (GP) and triose phosphate (TP) were sometimes said to be involved in the Krebs cycle, as was NADP. The movement of protons through the inner mitochondrial membrane into the intermembrane space was often only loosely described, with protons passing into the membrane, along the membrane, or out of the mitochondrion.

(c)     Many students did not appear to have any real understanding of the relationship between photosynthesis and respiration. Statements such as ‘plants have to respire so they can make the carbon dioxide so they can photosynthesise’ were not atypical. The weakest students completely reversed the roles of the two processes. Most commonly, students gained two marks, for referring to the uses of ATP in active transport and synthesis. Marking points 1 and 4 were seen rather less often and marking points 2 and 3 were fairly rarely made. Some students demonstrated good knowledge but not the ability to be selective, giving accounts in some detail of both photosynthesis and respiration which failed to address the question fully.

**E6.**(a)     The column for aerobic respiration was usually correct, but the other two contained a variety of errors that suggested that these processes were less well understood.

(b)     Most candidates gained this mark, but a number did not through the use of P, the symbol for the element phosphorus, rather than one of the many accepted abbreviations for phosphate.

(c)     There were some good answers here where candidates showed a sound understanding of ATP releasing energy in small amounts in a single reaction. However, a large number of responses were very vague, simply stating that the production of ATP was quick or easy.

(d)     Few candidates understood the significance of ATP being too unstable to be stored within cells. A larger number understood that a high turnover of ATP balances its continuous use within cells. Weaker candidates gained one of the marks by showing that they knew of specific processes that required ATP, such as active transport or muscle contraction. Marks were not given for imprecise terms such as growth.

**E7.**          (a)     This question separated candidates into those who had a general idea about electron transfer and those who appreciated the role of membranes in this process. A common error was to describe protons as moving into or out of the membrane, rather than across it. Although this question was largely based on factual recall, a significant proportion showed a lack of adequate preparation or clearly did not appreciate the level of detail expected.

(b)     (i)      A large proportion of candidates appeared not to understand what was meant by ‘isotonic’. Many believed the term to be associated with control of pH. Where answers were related to the control of water movement, many erroneously related osmotic damage to the cell rather than the organelles in question.

(ii)     Mitochondria were under investigation so glucose was not used as the respiratory substrate since it does not enter mitochondria. Glycolysis occurs in the cytoplasm. Surprisingly few candidates were able to explain this adequately.

(iii)     It was to be expected that rather more candidates would appreciate the role of oxygen as the terminal acceptor in the electron transfer chain than was the case. Many failed to make the necessary link suggesting that it was required for ATP production in some way.

**E8.**          (a)     (i)      Nearly all candidates either knew or were able to calculate the net yield of ATP molecules per molecule of glucose (2) in anaerobic respiration. A few candidates, of varying abilities, did not read the question, or the flowchart, carefully and produced an answer of 38.

(ii)     Although most candidates knew that ATP is readily hydrolysed, fewer were able to give a second advantage, although good candidates knew that the energy is released in small amounts and that the molecule cannot pass out of a cell.

(b)     Only good candidates knew that NAD is regenerated when molecules of reduced NAD are oxidised by molecules surrendering pyruvate, reducing it to form ethanol. Some exceptional candidates actually knew that it is, in fact, ethanal that is reduced, rather than pyruvate itself, but the specification does not insist on this level of understanding.