AQA A-LEVEL · 7402

BIOLOGY



MARK SCHEME

3.1.6 ATP

SCORE	PERCENTAGE
/104	%

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Q1.

(a) 1. (water has a relatively) high (specific) heat capacity;
Ignore numbers relating to heat capacity

2. Can gain / lose a lot of heat / energy without changing temperature;
OR
Takes a lot of heat / energy to change temperature;
Accept due to H bonding between water molecules

2

(b) Adenosine diphosphate and (inorganic) phosphate;
Accept ADP for adenosine diphosphate
Accept Pi / PO_4^{3-} / P in a circle for inorganic phosphate
Reject adenine diphosphate
Reject phosphorus / P for phosphate

1

(c) 1. Species / organism the muscle tissue came from;
OR
Thickness / type / source of the muscle tissue;
Ignore surface area of muscle tissue

2. Temperature of the muscle tissue / ATP solution / slides;
Need to be qualified

3. pH of the ATP solution;
Need to be qualified
Reject concentration / volume of ATP hydrolase

2 max

(d) Description
1. As concentration of ATP increases, length of muscle decreases;
Accept negative correlation

Explanation
2. More ATP (hydrolysed by ATP hydrolase), **so** more energy released, **so** more muscle contraction / shortening of muscle;
Accept more ATP available for correct/named aspect of muscle contraction
Idea of more is required once.
Reject energy produced

2

(e) 4.88×10^{-6} ;;;

If answer incorrect

EITHER

Allow 1 mark for 0.244

Allow 1 mark for 1.22×10^{-5}

OR

Allow 1mark for 12200 / 1.525

Allow 1 mark for 0.61

Accept 5×10^{-6}

Accept correct answer however expressed

Max 2 for incorrect final answer

3

[10]

Q2.

(a) Lowercase a in both boxes

1

(b) Tick in box next to 'Crossing over';

1

(c) 32.73 / 32.7 / 32 / 33;;

Award 1 max for either

409 (409.2) for difference in volume (but incorrect number of mitochondria);

OR

Answer of 262 (261.9) (using diameter, rather than radius);

2

(d) 1. Egg (created) has nucleus / DNA / genes of (affected) woman / mother;

Accept ref. to zygote / embryo / child for egg

Accept genetic information

Ignore references to alleles

Reject if nucleus from wrong egg / woman

2. It has mostly / many / lots of normal mitochondria (of unaffected woman)
OR
There are few faulty mitochondria;

*Reject ref. to **production** of healthy mitochondria as result of treatment*

2

(e) 1. Not enough / little ATP produced;

One reason asked for, so list rule applies

Ignore ref. to no ATP produced

2. ATP provides **energy** for (enzyme) reactions
OR
ATP phosphorylates substrates / enzymes, **so** making them (more) reactive;

Accept (leads to) lower activation energy for reaction

Reject if mention energy produced

2 max

[8]

Q3.

(a)

$ATP \longrightarrow ADP + P_i + H_2O$	
$ATP + H_2O \longrightarrow ADP + P_i$	
$ADP + P_i \longrightarrow ATP + H_2O$	✓
$ADP + P_i + H_2O \longrightarrow ATP$	

1

(b) 1. Human ATP synthase has a different tertiary structure to bacterial ATP synthase
OR
Human ATP synthase has a different shape active site to bacterial ATP synthase
OR
Antibiotic cannot enter human cells/mitochondria
OR
Antibiotic not complementary (to human ATP synthase);

1

(c) 0.75;
One mark for showing 30 g = 0.03 kg;
One mark for showing 0.025 mg g^{-1}

2

(d) Answer in range 97.0 − 97.8%;
OR
Answer in range 3288 − 4368%;

2. 1 mark for correct log_{10} readings from graph converted to actual numbers

*(16.98 − 19.50 **and** 660.7 − 758.6)*

2

(e) 1. (From the graph in part c) New / old antibiotic does not kill all bacteria;
OR
(From the graph in part c) Some bacteria are resistant to the new / old antibiotic;
2. Resistant bacteria will reproduce to produce (more) resistant bacteria;
3. (Use of both) one antibiotic will kill bacteria resistant to the other antibiotic;
OR
Unlikely that bacteria are resistant to both the new and the old antibiotic;
OR
Use of both antibiotics (likely to) kill all / most bacteria;

*Accept use of '**A**' for 'new antibiotic' and '**R**' for 'old antibiotic'.*

1. Must relate to the bacteria that are still present – 'some

bacteria are killed' or 'the bacteria number is reduced ' is insufficient.

2. *Accept 'resistant bacteria reproduce to pass on resistance gene / allele'*
3. *'Use of both antibiotics will be more effective' is insufficient.*

3

[9]

Q4.

(a) 1. A = β glucose;

B = Adenosine triphosphate;

do not accept ATP

2

(b) 1. Saturated;

1

2. Fatty acid;

1

(c) 1. Peptide bond shown correctly;

2. Rest of dipeptide structure shown correctly;

2

(d) Water;

1

[7]

Q5.

(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]

Q6.

(a) 1. From ADP and phosphate;

Accept Pi/PO_4^{3-} / (P)

Reject P/Phosphorus

Reject use of water in the reaction

2. By ATP synthase;
3. During respiration/photosynthesis;

2 max

(b) 1. To provide energy for other reactions/named process;

Reject 'produce' energy

2. To add phosphate to other substances **and** make them more reactive/change their shape;

2

(c) (Can see) 3D image;

1

(d) Crista/cristae;

Ignore matrix

1

(e) Value between 20,750 (83mm) and 21,250 (85mm) two marks;;
Formula given/used but calculation wrong, award 1 mark

Magnification = image size / Object size

(Large number divided by 4)

2

[8]

Q7.

(a) Hydrolysis (reaction);

1

(b) 1. (Phosphate required) to make RNA;
2. (Phosphate required) to make DNA;

1 and 2. If neither DNA or RNA are named allow one mark for nucleotide/nucleic acid/phosphodiester bonds/sugar-phosphate backbone.

3. (Phosphate required) to make ATP/ADP;
4. (Phosphate required) to make membranes;

Ignore: phospholipids without reference to membranes.

5. (Phosphates required) for phosphorylation;

Accept: as additional mark points any named biological molecule containing phosphate e.g. NADP, AMP, RuBP.

2 max

(c) Accept answer in range from 3.7 : 1 to 4.1 : 1;

Reject any ratio not : 1.

1

(d) 1. Seeds/embryo remain dormant/inactive in winter/cold

OR

Growth/development of seed/embryo during winter/cold;

Ignore: hibernate.

Accept: 'seed survives winter/cold'.

Reject: plant develops or seed germinates during winter/cold.

2. Seeds/plants develop in spring/summer

OR

Seeds/plants develop when temperature/light increases;

Accept: seeds/plants develop when more light or when temperature is higher.

Accept: seed germinates/'sprouts' during spring/summer or when temp/light increases.

3. Plant photosynthesise (in spring/when warm);
4. Produce (more) seeds/offspring in spring/growing season;

3 max

[7]

Q8.

(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]

Q9.

(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) $ADP + P_i \longrightarrow ATP$;

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]

Q10.

(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]

Q11.

(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]

Q12.

(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]

Q13.

(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]

Q1.

Answers to (a) showed good knowledge, but there was some confusion between heat capacity and the latent heat of vaporisation. Many students hedged their bets by referring to latent heat capacity. There were several students who stated that a high heat capacity was caused by strong hydrogen bonds, or that hydrogen bonds were between H^+ and O^{2-} in water, not between water molecules.

Question (b) was well answered; the most common mistake was stating *adenine* diphosphate instead of adenosine diphosphate.

In (c) many students did not consider the question and either gave variables whose control had already been given in the question, or gave unqualified answers of temperature and pH. Only 7% of students scored two marks. Many also stated the concentration of ATP hydrolase, again showing a failure to consider the question and realising that this cannot be controlled as it was produced by the muscle tissue.

In question (d), the description was well answered by the majority, however many students thought the muscle became shortened as the muscle tissue was being hydrolysed. Several also stated that ATP released more energy for respiration. References to energy being 'produced' negated otherwise good responses.

Students found (e) very difficult, with only 3.7% of them scoring all three marks. Many failed to use the table correctly and realise that the concentration of ATP added to the slide was $\times 10^{-6}$ mol dm^{-3}. Two marks were regularly awarded for incorrect responses, however, for including 12200 and 0.61 in the workings. 7.5% of students made no attempt whatsoever to answer this question.

Q2.

In question (a), it was pleasing to find that 83% of students managed to complete the diagram correctly.

In (b), only 68% correctly identified crossing over as the process that produced the alleles in the first polar body. This was a little surprising, given how many correctly answered (a).

The calculation in (c) discriminated well. Two marks were obtained by 30% of students. A further 17% obtained one mark for making some progress with the calculation. This included students who correctly calculated the difference in volume between the nucleus and the polar body, but could not then correctly calculate the number of mitochondria. Others used diameters instead of radii.

Question (d) was marred by the number of students who appeared not to have read the stem carefully enough. As in question 2, the information comes from a published scientific paper. The bullet points in the stem state that the nucleus is removed from a donor egg and this is replaced by the polar body from a woman affected by mitochondrial disease. Only 3% of students obtained both marks by noting that the egg produced by this process would contain a nucleus from the affected woman and very few faulty mitochondria. Very large numbers of students wrote about how the **nucleus from the donated egg** would not contain the genes to make faulty mitochondria and so this would be a cure. This would mean that the child produced would have the DNA of the donor, not the woman affected by mitochondrial disease. There would be little point in carrying out such a complex procedure to achieve this; a donor egg would suffice. Other students correctly spotted that the egg produced would contain the DNA of the affected woman but, having just

calculated the number of mitochondria in a polar body, stated that the polar body contained no faulty mitochondria. This accounted for the 21% of students who obtained one mark. Many students thought that mitochondria are contained within nuclei, or that they are synthesised along with proteins at ribosomes, using mRNA from genes in the nucleus.

Question (d) produced an even spread of possible marks. About 40% of students obtained one mark for stating that the faulty mitochondria would produce less ATP. Some 29% obtained a second mark by linking ATP to the energy required for reactions. A few students did recall that ATP is used to phosphorylate substances, to make them more reactive, or helps to lower the activation energy for a reaction. There were pleasingly few references to 'making energy'. Some students drifted into accounts of how ATP is made in mitochondria, which was more than the question required.

Q3.

This question revealed some confusion between antibiotics and vaccines, with many answers discussing immune responses as a result of taking antibiotics.

(a) 72.5% of students gained this mark.

(b) Some good understanding was demonstrated of how this universal enzyme could be different in different species. Some students demonstrated understanding but their responses were insufficiently precise to fulfil the marking criteria; they failed to reference the 'tertiary' structure or the 'shape' of the active site. Some students successfully suggested that the human enzyme would be found in the mitochondria and so be inaccessible to the antibiotic.

(c) 67% of students scored 2 marks. Those who did not, usually could not convert 30 g to 0.03 kg.

(d) There were two ranges of correct answer here, crediting a percentage difference compared with either group A or group R. Ranges were calculated to allow for a tolerance of half a 2x2 mm square when reading from the graph, and for rounding at different stages. It was pleasing to note that 46% of students could correctly complete this calculation. Some clearly were unfamiliar with using the 10^x function on their scientific calculators. 14% of students could correctly read from the graph and convert these values into actual numbers of bacteria, but then could not calculate the percentage difference.

(e) Only 6% of students achieved all 3 marks here. Those who did were those who fully understood that the significant aspect of the data was that **neither** antibiotic killed all the bacteria and then went on to **explain** the consequences of this. As with question (b), some students wrote extensive descriptions of the data; this is not creditworthy in this 'explain' question. Those who wrote extensive descriptions often then forgot the instruction to use their knowledge of the evolution of antibiotic resistance. Mark point 3 was commonly achieved for the idea that bacteria resistant to one antibiotic would be killed by the other antibiotic. There was a disappointing number of references to 'immune' bacteria. Some students tried to evaluate the information (not requested here), with statements relating to this investigation being in mice rather than humans.

Q6.

The specification (section 3.1.6) requires students to know that ATP is resynthesised by a condensation reaction involving ADP and phosphate, catalysed by ATP synthase. The examiners did not require reference to 'a condensation reaction' but only 26% of students

obtained both marks in (a). About 40% obtained one mark for reference to ADP and phosphate. Some failed to score that mark because they wrote about phosphorus. Many wasted time writing about hydrolysis of ATP but often went on to describe the reaction between ADP and phosphate.

The same section of the specification (3.1.6) requires students to know that the hydrolysis of ATP can be coupled to energy-requiring reactions, or the phosphorylation of other compounds (often making them more reactive). In (b), 35% of students obtained one mark for reference to ATP providing energy for a reaction (usually named). Only 3% did this and then made reference to phosphorylation to obtain the second mark.

In (c), about 40% obtained the mark by noting that the image was 3-D. Many simply wrote that the evidence was the black and white nature of the image.

About 56% of students obtained both marks for the calculation in (e). Some (about 30%) had the right idea in terms of what to divide by what but couldn't handle the units and obtained one mark.

Q7.

(a) The vast majority of students correctly named the type of reaction as hydrolysis. Common errors were 'condensation' and 'phosphorylation'.

(b) Approximately 50% of students gained a mark in this question. The most common scoring points referred to phosphate being required for the formation of ATP, DNA, RNA or phospholipids in cell membranes. Many students stated that phosphate was used as a 'nutrient', 'for energy' or to 'form protein'.

(c) Approximately 40% of students were able to calculate a correct ratio. A significant number of students did not gain the mark as they provided the ratio the wrong way round or they simply transcribed their readings from the graph as a ratio, most commonly, 4.1:1.1.

(d) This question proved difficult for most students with almost 60% scoring zero. The most common misconception was that the chilling requirement of seeds would enable plants to grow during the winter so that they would be fully grown by spring and could outcompete other plants. Some students also referred to plants carry out photosynthesis and reproducing during the winter. A significant number of students misinterpreted the question and answered it in terms of natural selection for plants with a chilling requirement. Students who did gain credit often referred to growth of the seed/embryo during the winter followed by photosynthesis in the spring/summer. Very few students referred to seed production in the spring or summer.

Q8.

(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.

Q9.

(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.

Q10.

(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.

Q11.

(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.

Q12.

(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.

Q13.

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.