

AQA A-LEVEL • 7402

BIOLOGY



EXAM QUESTION PACK

3.1.6 ATP

SCORE

/104

PERCENTAGE

%

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Q1.

- (a) State **and** explain the property of water that can help to buffer changes in temperature.

(2)

- (b) Water is used to hydrolyse ATP.

Name the **two** products of ATP hydrolysis.

1. _____

2. _____

(1)

Hydrolysis of ATP is catalysed by the enzyme ATP hydrolase.

A student investigated the effect of ATP concentration on the activity of ATP hydrolase. She used shortening of strips of muscle tissue caused by contraction as evidence that ATP was being hydrolysed.

- She took four slides **A**, **B**, **C** and **D**, and added strips of muscle tissue of the same length to each slide.
- She then added the same volume of ATP solutions of different concentrations to the four slides and left each slide for five minutes.
- She then recorded the final length of each strip of muscle tissue.

Her results can be seen in the table.

Slide	Concentration of ATP solution added to slide / $\times 10^{-6} \text{ mol dm}^{-3}$	Final length of muscle tissue after 5 minutes / mm
A	2	36

B	4	31
C	6	29
D	8	26

- (c) Other than those given, name two variables the student should have controlled.

1. _____

 2. _____

(2)

- (d) Describe and explain the pattern shown by the data in the table.

Description

Explanation _____

(2)

- (e) The hydrolysis of 1 dm³ of a 1 mol dm⁻³ solution of ATP releases 30 500 J of energy.

60% of the energy released during the hydrolysis of 1 mol dm⁻³ of ATP is released as heat; the rest is used for muscle contraction.

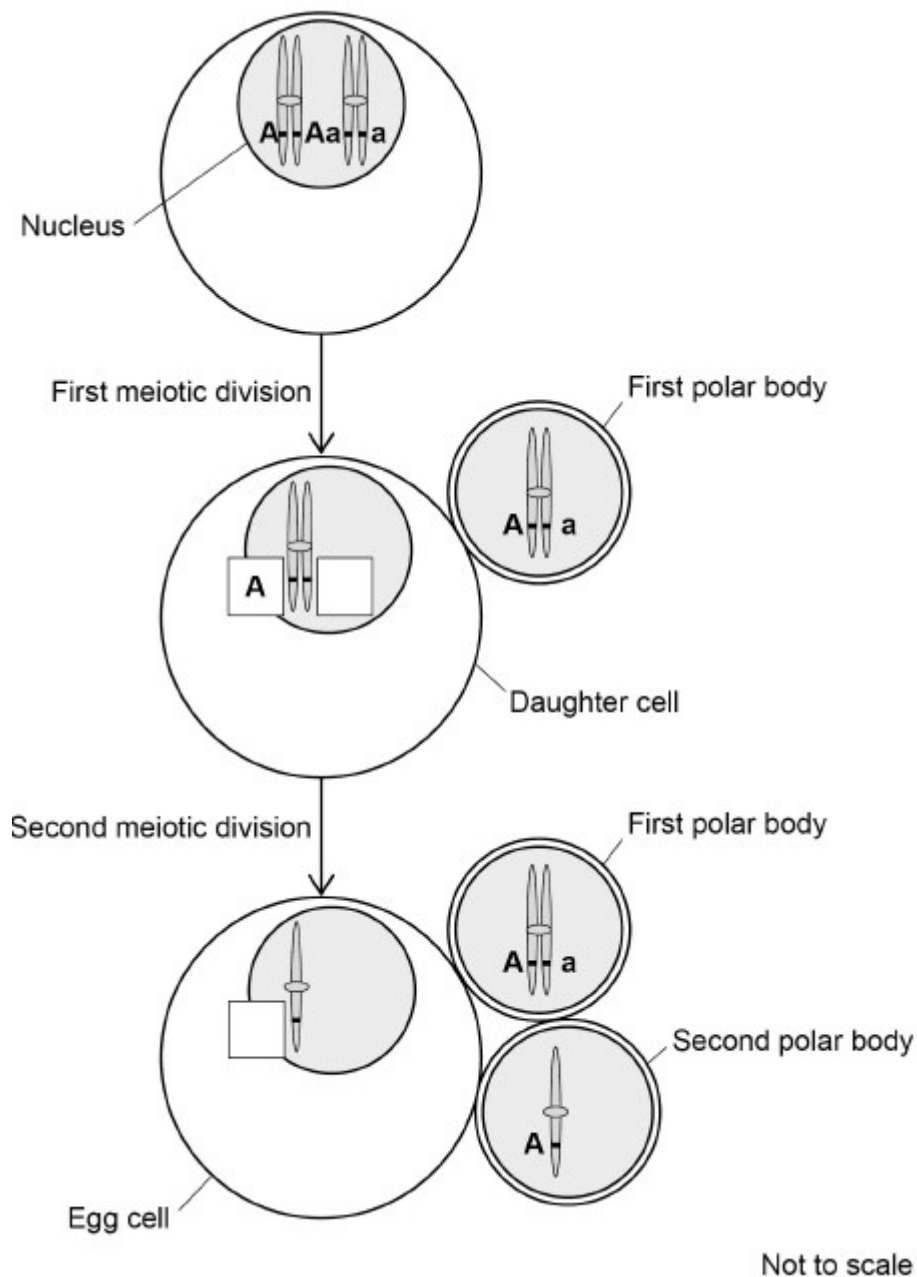
The student added 0.05 cm³ of ATP solution to slide **D**.

Calculate the energy available from ATP for contraction of the muscle on this slide.

Q2.

In women, the first division of meiosis produces one daughter cell that has almost all of the cytoplasm. The other daughter cell consists of a nucleus surrounded by a very small amount of cytoplasm and a cell-surface membrane. This very small daughter cell is called a polar body. Polar bodies do not usually divide. The same process occurs in the second division of meiosis, resulting in one egg cell and two polar bodies.

The diagram shows the formation of an egg cell and two polar bodies during meiosis. It also shows what happens to one pair of homologous chromosomes. This pair carries two alleles of gene A.



- (a) Complete the diagram by putting **A** or **a** in the boxes. One box has been completed

for you with **A**.

(1)

- (b) Put a tick (✓) in the box next to the name of the process that produced the combination of alleles on the chromosome in the first polar body in the diagram.

Anaphase

☐

Crossing over

☐

Independent assortment

☐

Semi-conservative replication

☐

(1)

- (c) A scientist measured the diameter of a polar body and the diameter of the nucleus inside it. The diameter of the polar body was $10.4\text{ }\mu\text{m}$ and the diameter of the nucleus was $7.0\text{ }\mu\text{m}$. The density of mitochondria in the cytoplasm of the polar body (outside of the nucleus) was $0.08\text{ mitochondria per }\mu\text{m}^3$.

Calculate the number of mitochondria in the polar body. You should assume polar bodies and nuclei are spherical.

The formula for the volume of a sphere is $\frac{4}{3}\pi r^3$ where $\pi = 3.14$

Show your working.

Number of mitochondria = _____

(2)

- (d) Mitochondrial diseases are caused by faulty mitochondria. All of a person's mitochondria are inherited from their mother via the egg cell. An egg cell contains approximately 3×10^5 mitochondria.

One proposed treatment to prevent passing on faulty mitochondria involves

- removing the nucleus from an egg cell donated by a woman with healthy mitochondria
- replacing this nucleus with the contents of the polar body from a woman whose egg cells are affected by mitochondrial disease.

Suggest how this treatment prevents inheritance of mitochondrial diseases.

(2)

- (e) If most of the mitochondria in a cell are faulty, this prevents many important enzyme-catalysed reactions taking place or slows them down.

Suggest and explain **one** reason why.

(2)

(Total 8 marks)

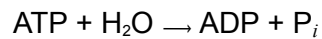
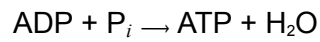
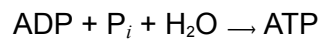
Q3.

Scientists investigated treatment of a human bladder infection caused by a species of bacterium. This species of bacterium is often resistant to the antibiotics currently used for treatment.

They investigated the use of a new antibiotic to treat the bladder infection. The new antibiotic inhibits the bacterial ATP synthase enzyme.

- (a) Place a tick (✓) in the appropriate box next to the equation which represents the

reaction catalysed by ATP synthase.

☐☐☐☐

(1)

- (b) The new antibiotic is safe to use in humans because it does **not** inhibit the ATP synthase found in human cells.

Suggest why human ATP synthase is not inhibited and bacterial synthase is inhibited.

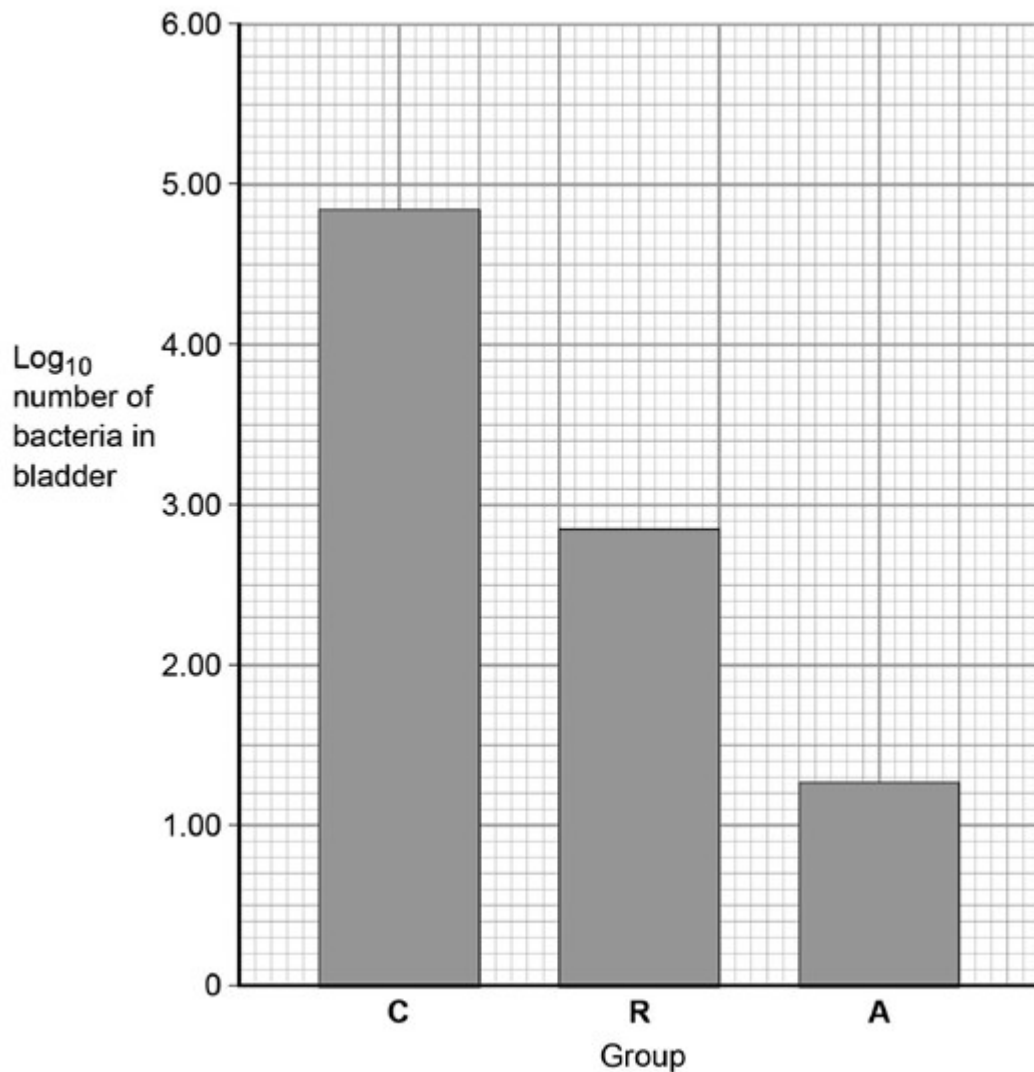
(1)

- (c) The scientists tested the new antibiotic on mice with the same bladder infection. They divided these mice into three groups, **C**, **R** and **A**.

- Group **C** was the control (untreated).
- Group **R** was treated with an antibiotic currently used against this bladder infection.
- Group **A** was treated with the new antibiotic.

They removed samples from the bladder of these mice after treatment and estimated the total number of bacteria in the bladder.

Their results are shown in the graph.



The antibiotics were given to the mice at a dose of 25 mg kg⁻¹ per day.

Calculate how much antibiotic would be given to a 30 g mouse each day.

Show your working.

Answer = _____ mg

(2)

- (d) Calculate the percentage difference in actual numbers of bacteria in group **A** compared with group **R**. The actual number of bacteria can be calculated from the log₁₀ value by using the 10^x function on a calculator.

Show your working.

Answer = _____ %

(2)

- (e) The scientists suggested that people newly diagnosed with this bladder infection should be treated with both the current antibiotic and the new antibiotic.

Explain why the scientists made this suggestion.

Use information from the graph in part (c) and your knowledge of evolution of antibiotic resistance in bacteria in your answer.

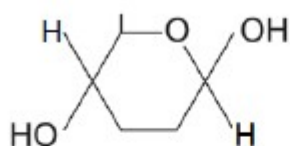
(3)

(Total 9 marks)

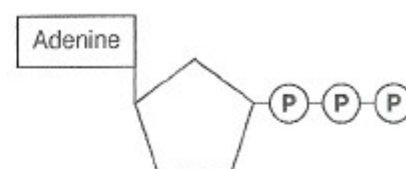
Q4.

The diagram shows four biological molecules.

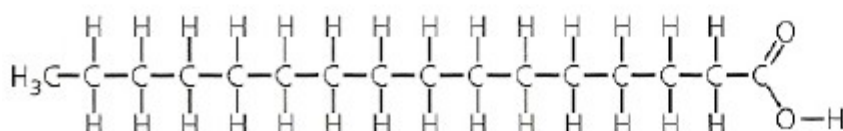
Molecule A



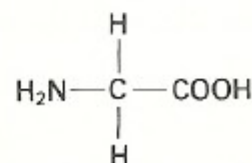
Molecule B



Molecule C



Glycine



- (a) Give the **full** name of:

Molecule A _____

Molecule **B** _____

(2)

- (b) What type of molecule is molecule **C**?

(2)

- (c) Glycine, shown in the diagram, is an amino acid.

In the space below, draw a diagram to show the dipeptide produced when two molecules of glycine are joined together.

(2)

- (d) Name the other molecule formed when two molecules of glycine are joined together.

(1)

(Total 7 marks)

Q5.

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

(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.

1. _____

2. _____

(2)

(Total 7 marks)

Q6.

Cells constantly hydrolyse ATP to provide energy.

(a) Describe how ATP is resynthesised in cells.

(2)

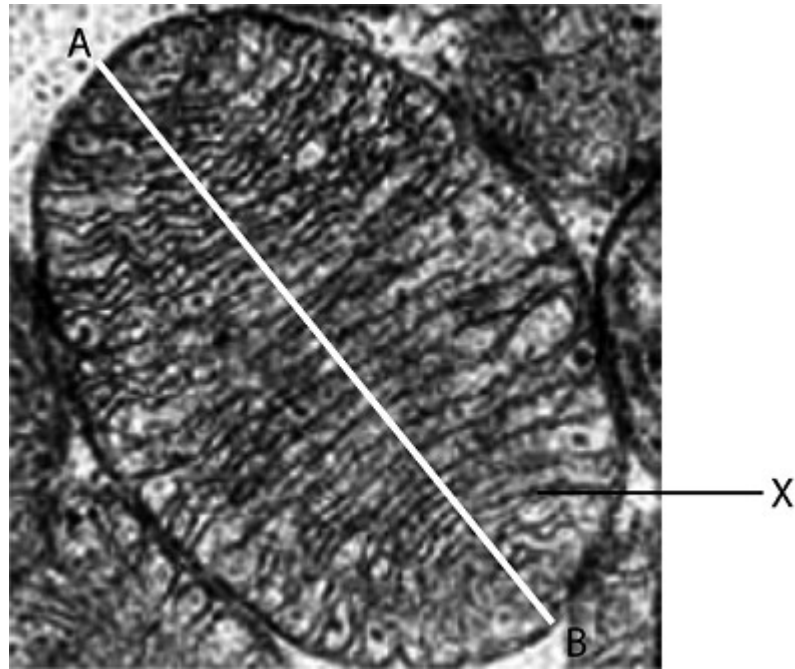
(b) Give **two** ways in which the hydrolysis of ATP is used in cells.

1. _____

2. _____

(2)

(c) This is a photograph (micrograph) of a mitochondrion taken using a scanning electron microscope.



What is the evidence that a scanning electron microscope was used to take this photograph?

(1)

- (d) Name the part of the mitochondrion labelled **X** in the photograph.

(1)

- (e) The actual length of the mitochondrion between points **A** and **B** in the photograph is 4 μm .

What is the magnification of the mitochondrion in the photograph?

Show your working.

Magnification _____

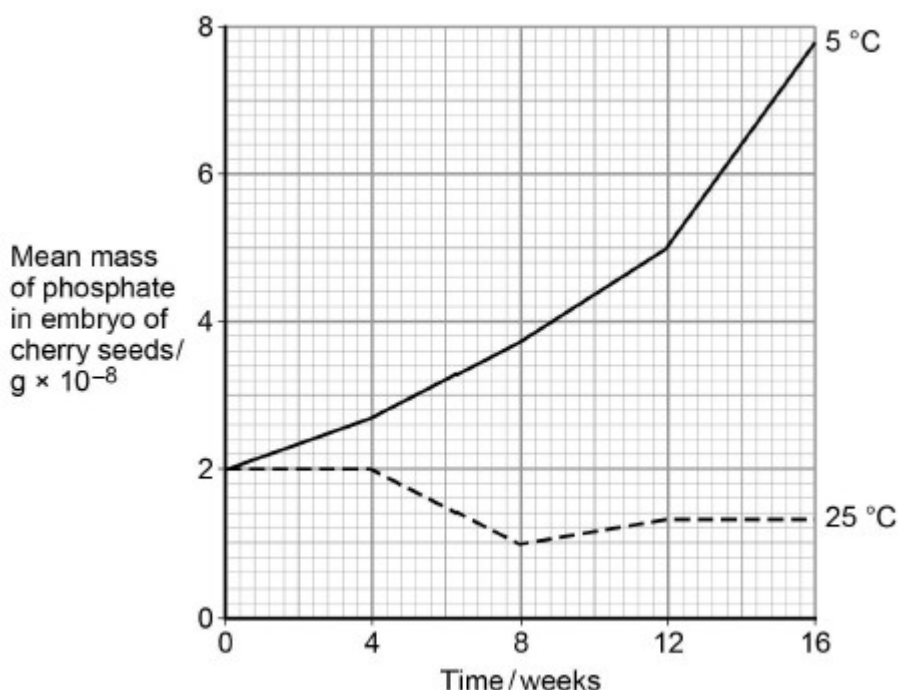
(2)

(Total 8 marks)

Q7.

The seeds of some plant species require chilling (exposure to low temperatures) before the embryos they contain grow into plants. During chilling, storage molecules in the seed that contain phosphate are broken down and phosphates are transported to the embryo. Scientists investigated the change in the mass of phosphate in the embryos of cherry seeds exposed to two different temperatures for 16 weeks.

The following graph shows their results.



- (a) Phospholipids are one of the storage molecules found in cherry seeds.

Name the type of reaction used to break down phospholipids to release phosphate.

(1)

- (b) The scientists concluded that an increase in phosphate in the embryo was linked to growth of the embryo.

Suggest **two** reasons why an increase in phosphate can be linked to growth of the embryo.

1. _____

2. _____

(2)

- (c) Calculate the ratio of the mean mass of phosphate found at 5 °C to the mean mass of phosphate found at 25 °C after 9 weeks of chilling.

Ratio = _____

(1)

- (d) The chilling requirement of seeds of certain plant species is considered to be an adaptation for survival in countries with seasonal changes in environmental conditions.

Suggest how this adaptation may enable these plant species to survive and respond to seasonal changes.

(3)

(Total 7 marks)

Q8.

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

(4)

(6)

(5)

(Total 15 marks)

Q9.

- (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.

(1)

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

1. _____

2. _____

(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.

(2)

(Total 8 marks)

Q10.

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

(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?

(1)

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

(2)

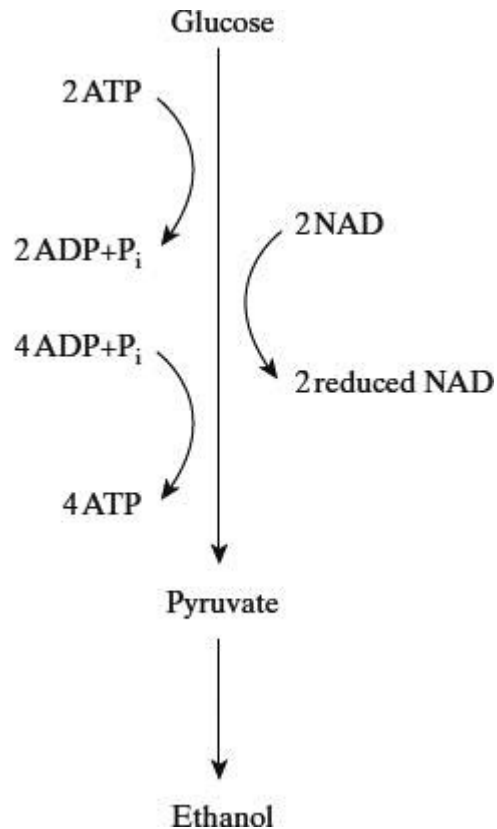
- (iii) Explain why the oxygen concentration would change during this investigation.

(1)

(Total 7 marks)

Q11.

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?

_____ (1)

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

1. _____

2. _____

_____ (2)

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

_____ (1)

(Total 4 marks)

Q12.

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

(2)

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

- (i) Name substance **X**.

(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.

(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.

(3)

(Total 8 marks)

Q13.

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?

(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.

(1)

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

(2)

(Total 6 marks)

Mark schemes

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 P_i / 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 1 mark 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;

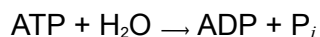
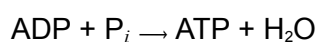
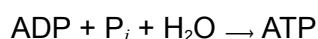
Accept (leads to) lower activation energy for reaction

Reject if mention energy produced

2 max

Q3.

(a)

☐☐☒☐

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 $30 \text{ g} = 0.03 \text{ kg}$;
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 $\text{P}_i/\text{PO}_4^{3-}$ / 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 = $\frac{\text{image size}}{\text{Object size}}$

(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
- (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

4

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) $\text{ADP} + \text{P}_i \rightarrow \text{ATP}$;

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]

Examiner reports

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 $\times 10^{-6} \text{ mol dm}^{-3}$. 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 candidates 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.