## Questions

**Q1.**

Yeast is a single-celled organism that can respire aerobically.

Mitochondria are the sites of aerobic respiration in yeast cells.

(i) Name two molecules needed for aerobic respiration that can move into the mitochondria.

**(2)**

1 .....

2 .....

(ii) The outer mitochondrial membrane is not permeable to hydrogen ions ($H^+$).

Explain the importance of this feature of the membrane.

**(4)**

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**(Total for question = 6 marks)**

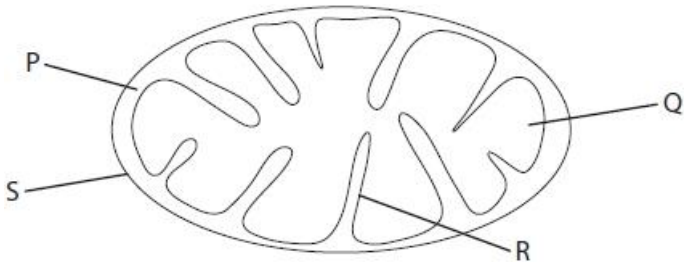
**Q2.**

**Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

Yeast is a single-celled organism that can respire aerobically.

Mitochondria are the sites of aerobic respiration in yeast cells.

The diagram shows a mitochondrion.




(i) Which labelled component in the diagram is the site of the Krebs cycle?

**(1)**

- ☐ **A** P
- ☐ **B** Q
- ☐ **C** R
- ☐ **D** S

(ii) Which labelled component in the diagram is the site of oxidative phosphorylation?

**(1)**

- ☐ **A** P
- ☐ **B** Q
- ☐ **C** R
- ☐ **D** S

(iii) Yeast cells can have many small mitochondria.

Calculate the magnification of the diagram if the maximum length of the mitochondrion is 0.5 μm.

**(2)**

Answer .....

**(Total for question = 4 marks)**

**Q3.**

**Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

Moving a limb involves the interaction of muscles, tendons and ligaments.

Tendons and ligaments are important structures in elbow and knee joints.

(i) Which of the following identifies the structures that join bones to bones in an elbow joint?

**(1)**

- ☒ **A** ligaments only
- ☒ **B** ligaments and tendons
- ☒ **C** tendons only
- ☒ **D** neither ligaments nor tendons

(ii) One type of joint injury is a torn ligament. This may be treated by adding a piece of tendon to the ligament. This is because after a period of time, the tendon tissue changes and responds in the same way as a ligament.

Which of the rows in the table correctly describe the changes in this piece of tendon?

**(1)**

| Row | Piece of tendon shows a change in its | The change is |
|---|---|---|
| 1 | genotype | an anatomical adaptation |
| 2 | genotype | a physiological adaptation |
| 3 | phenotype | an anatomical adaptation |
| 4 | phenotype | a physiological adaptation |

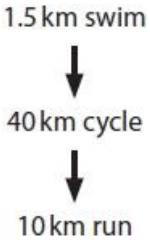
- ☒ **A** row 1 only
- ☒ **B** row 3 only
- ☒ **C** rows 1 and 2
- ☒ **D** rows 3 and 4

*(iii) The photograph shows athletes competing in the modern triathlon.


© Gonzalo Arroyo Moreno / Stringer

The modern triathlon involves three sports: swimming, cycling and running.
An investigation was carried out to compare the level of demand on the body of these

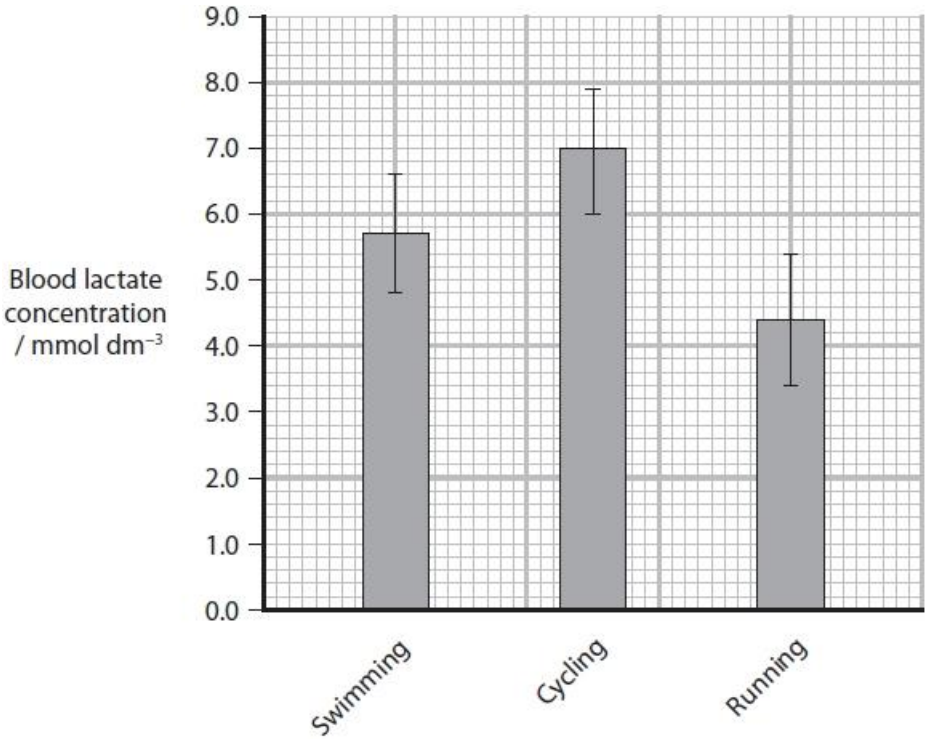
three sports during a triathlon.
The investigation involved 12 athletes who were all males of the same age.
Each athlete carried out the triathlon as shown in the flow diagram. There was no rest period between each sport.




The heart rate for each athlete was measured as they completed each sport.
The mean heart rate for each sport was then calculated and is shown in the table.

| Sport | Mean heart rate / bpm |
|---|---|
| Swimming | 163 |
| Cycling | 165 |
| Running | 159 |

The blood lactate level for each athlete was also measured as they completed each sport. Means for lactate level after each sport were calculated.
The results are shown in the graph.




It was concluded that cycling was the most demanding of the three triathlon sports. This was followed by swimming and then running.
Evaluate the validity of this conclusion.

**(6)**

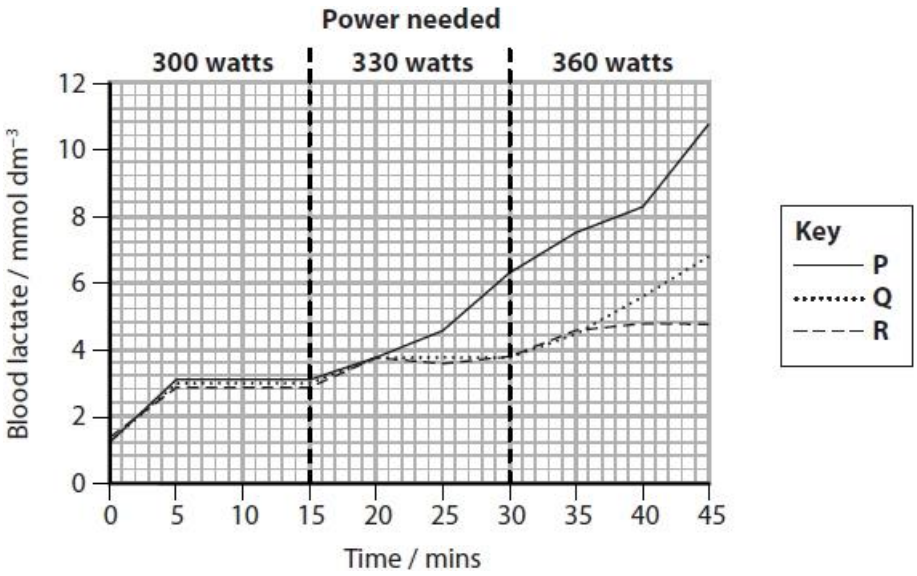
**(Total for question = 8 marks)**

**Q4.**

Athletes monitor the effect of different levels of exercise on their blood lactate concentration. This helps them to train effectively.

In a study, three athletes, **P**, **Q** and **R**, used an exercise bicycle for 45 minutes.
The power needed to maintain a constant speed was increased every 15 minutes.
Their blood lactate concentration was measured at 5-minute intervals.

The results are shown in the graph.




The most effective training involves the greatest power requirement over longer periods of time. Therefore, it is important to avoid high concentrations of blood lactate, which causes muscle fatigue, for as long as possible.

Analyse the data to deduce how each of these three athletes should plan their training.

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**(Total for question = 4 marks)**

**Q5.**

Nandrolone is an anabolic steroid, it is a molecule with a similar shape to testosterone. Nandrolone has been used as a performance-enhancing substance by athletes in the past.

A number of investigations with mice have been carried out to study the effect of nandrolone on the structure and function of the aorta.

In these investigations, all the mice were of one type and were all supplied with the same amount of food and water. These mice were placed into four groups.

Each group was treated differently for eight weeks. The treatments are shown in the table.

| Group | Treatment | |
|---|---|---|
| | Allowed to exercise | Given nandrolone |
| P | No | No |
| Q | No | Yes |
| R | Yes | No |
| S | Yes | Yes |

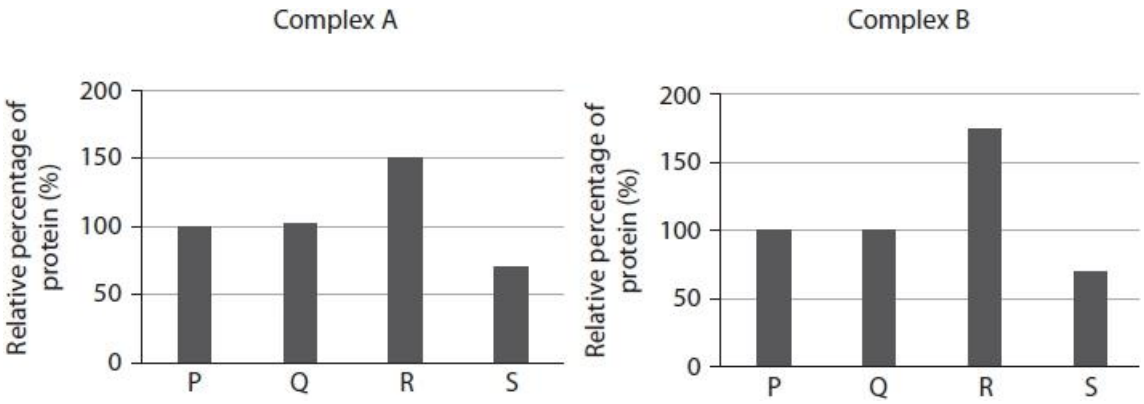
After eight weeks, the aorta of each mouse was studied.

In investigation 1, samples of aorta were put under tension to test elastic recoil.

The tension was removed and the mean maximum percentage recoil for each group was found.
The results are shown in the table.

| Group | Mean maximum percentage recoil (%) |
|---|---|
| P | 57 |
| Q | 38 |
| R | 80 |
| S | 53 |

In investigation 2, some of the cells from the middle layer of the aortas of the mice were removed.
Two protein complexes, A and B, are found in the cells of the middle layer.
These protein complexes are involved in the electron transport chain.
The graphs show the relative percentage of these two protein complexes in each group of mice.




The transcription factor Tfam is involved in the production of mitochondria.

In investigation 3, some of the cells from the middle layer of the aortas of the mice were removed. The quantity of mRNA per cell coding for Tfam was measured. The results are shown in the table.

| Group | Quantity of mRNA per cell coding for Tfam / a.u. |
|---|---|
| P | 100 ± 20 |
| Q | 75 ± 10 |
| R | 170 ± 25 |
| S | 85 ± 15 |

Analyse the data from these three investigations to discuss the advantages of an exercise programme without nandrolone.

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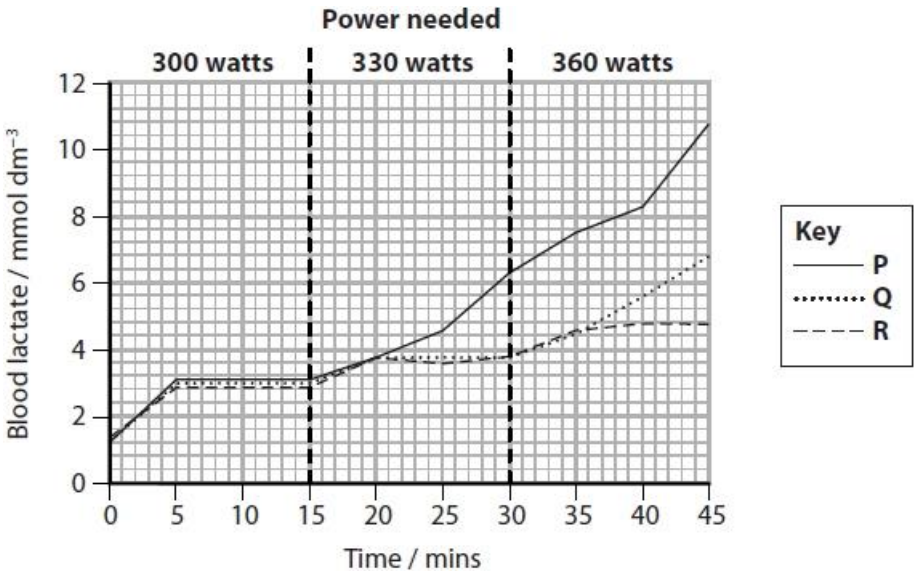
**(Total for question = 6 marks)**

**Q6.**

Athletes monitor the effect of different levels of exercise on their blood lactate concentration. This helps them to train effectively.

In a study, three athletes, **P**, **Q** and **R**, used an exercise bicycle for 45 minutes.
The power needed to maintain a constant speed was increased every 15 minutes.
Their blood lactate concentration was measured at 5-minute intervals.

The results are shown in the graph.




Explain the increase in blood lactate concentration observed between 0 and 5 minutes.

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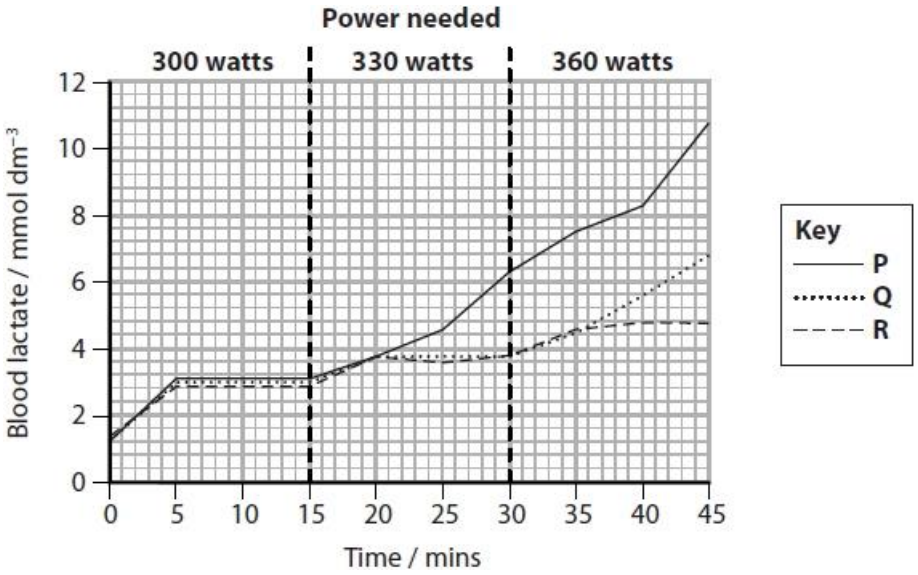
**(Total for question = 2 marks)**

**Q7.**

Athletes monitor the effect of different levels of exercise on their blood lactate concentration. This helps them to train effectively.

In a study, three athletes, **P**, **Q** and **R**, used an exercise bicycle for 45 minutes.
The power needed to maintain a constant speed was increased every 15 minutes.
Their blood lactate concentration was measured at 5-minute intervals.

The results are shown in the graph.




Give reasons why blood lactate concentration remains constant between 5 and 15 minutes.

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**(Total for question = 3 marks)**

**Q8.**

**Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

Each liver cell carries out respiration.

During respiration, ATP is formed and broken down.

(i) During which of the following processes is ATP formed?

**(1)**

- ☐ **A** glycolysis and the electron transport chain only
- ☐ **B** glycolysis and the Krebs cycle only
- ☐ **C** glycolysis, the Krebs cycle and the electron transport chain only
- ☐ **D** glycolysis, the link reaction, the Krebs cycle and the electron transport chain

(ii) Explain why some ATP is broken down during glycolysis.

**(2)**

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(iii) The electron transport chain occurs in the cristae of mitochondria. The electron transport chain involves a number of carrier molecules.
Explain the role of these carrier molecules in the electron transport chain.

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**(Total for question = 6 marks)**

**Q9.**

Nandrolone is an anabolic steroid, it is a molecule with a similar shape to testosterone. Nandrolone has been used as a performance-enhancing substance by athletes in the past.

A number of investigations with mice have been carried out to study the effect of nandrolone on the structure and function of the aorta.

In these investigations, all the mice were of one type and were all supplied with the same amount of food and water. These mice were placed into four groups.

Each group was treated differently for eight weeks. The treatments are shown in the table.

| Group | Treatment | |
|---|---|---|
| | Allowed to exercise | Given nandrolone |
| P | No | No |
| Q | No | Yes |
| R | Yes | No |
| S | Yes | Yes |

After eight weeks, the aorta of each mouse was studied.

(i) In investigation 1, samples of aorta were put under tension to test elastic recoil.

The tension was removed and the mean maximum percentage recoil for each group was found.
The results are shown in the table.

| Group | Mean maximum percentage recoil (%) |
|---|---|
| P | 57 |
| Q | 38 |
| R | 80 |
| S | 53 |

The use of nandrolone has been linked to a variety of cardiovascular conditions.
Explain how the use of nandrolone could lead to atherosclerosis.

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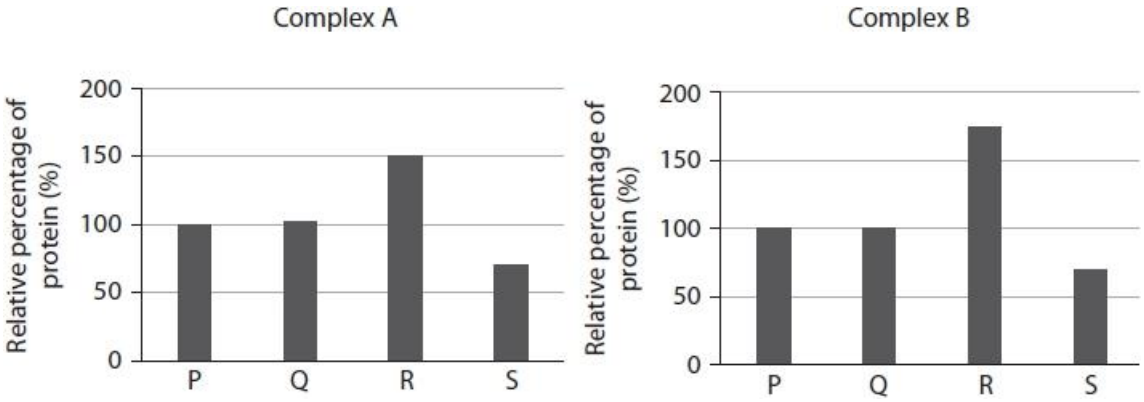
(ii) In investigation 2, some of the cells from the middle layer of the aortas of the mice were removed.
Two protein complexes, A and B, are found in the cells of the middle layer.
These protein complexes are involved in the electron transport chain.
The graphs show the relative percentage of these two protein complexes in each group of mice.




Comment on the effects of nandrolone on the production of ATP.

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(iii) The transcription factor Tfam is involved in the production of mitochondria.

In investigation 3, some of the cells from the middle layer of the aortas of the mice were removed. The quantity of mRNA per cell coding for Tfam was measured. The results are shown in the table.

| Group | Quantity of mRNA per cell coding for Tfam / a.u. |
|---|---|
| P | 100 ± 20 |
| Q | 75 ± 10 |
| R | 170 ± 25 |
| S | 85 ± 15 |

A student concluded that nandrolone affects the quantity of mRNA per cell coding for Tfam.
Explain why this conclusion is not valid for all the mice.

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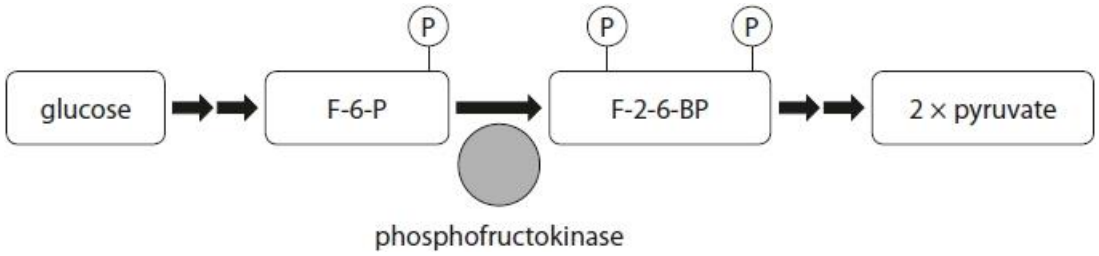
**(Total for question = 8 marks)**

**Q10.**

Phosphofructokinase is an enzyme that uses ATP to convert fructose-6-phosphate (F-6-P) into fructose-2,6-bisphosphate (F-2,6-BP).

The conversion of F-6-P by this enzyme is a rate-determining step in glycolysis. This is shown in the diagram.




(i) Explain why ATP is required for this reaction.

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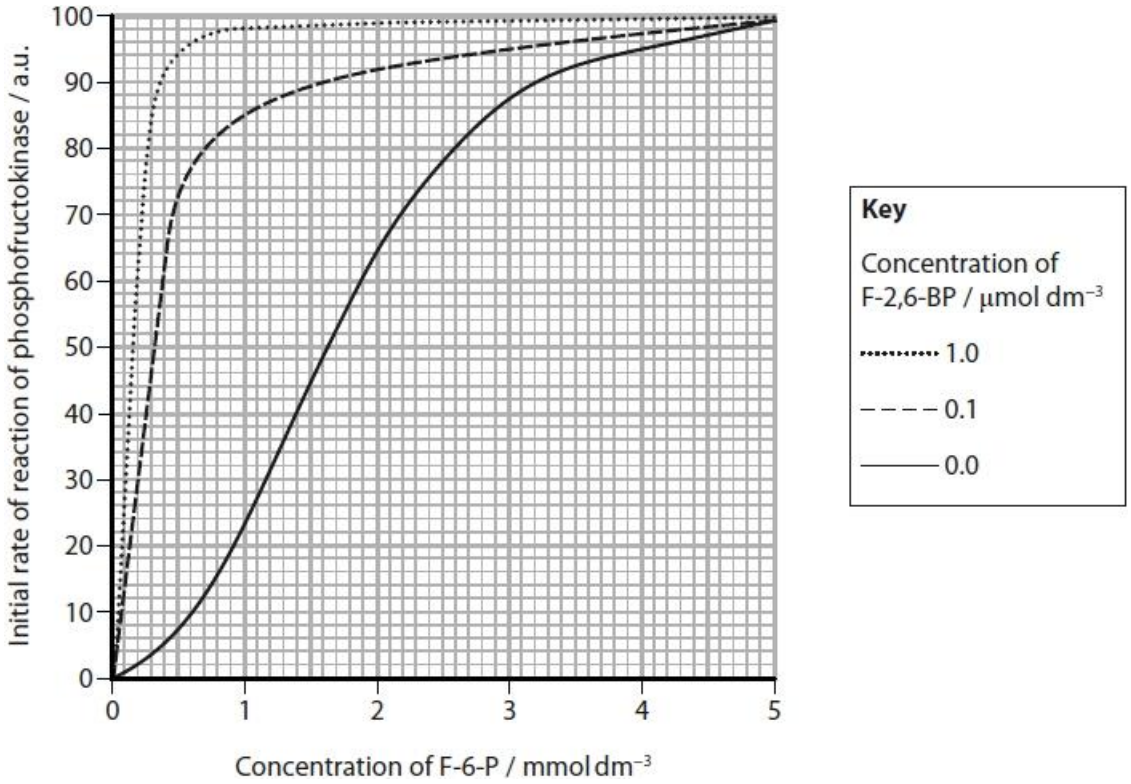
The effect of substrate concentration on the initial rate of reaction of phosphofructokinase was investigated.

This investigation was repeated with the addition of two concentrations of F-2,6-BP.

The graph shows the results of this investigation.




Comment on the effects of F-6-P and F-2,6-BP concentrations on the rate of glycolysis.

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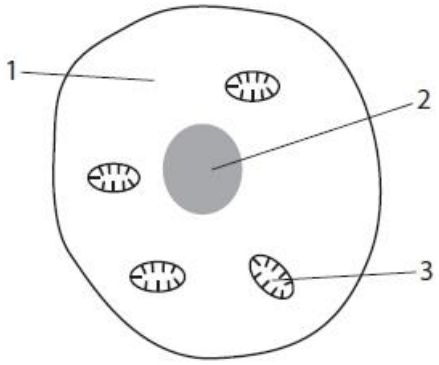
**(Total for question = 6 marks)**

**Q11.**

**Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

The diagram shows some of the features of a human liver cell.




(i) Which of the labelled features in the liver cell contain RNA?

**(1)**

- ☒ **A** 1 only
- ☒ **B** 1 and 3 only
- ☒ **C** 2 and 3 only
- ☒ **D** 1, 2 and 3

(ii) Cells produce lactate during anaerobic respiration. Lactate travels in the blood to the liver.

Liver cells can absorb lactate from the blood.
Deduce what happens to the lactate in these cells.

**(2)**

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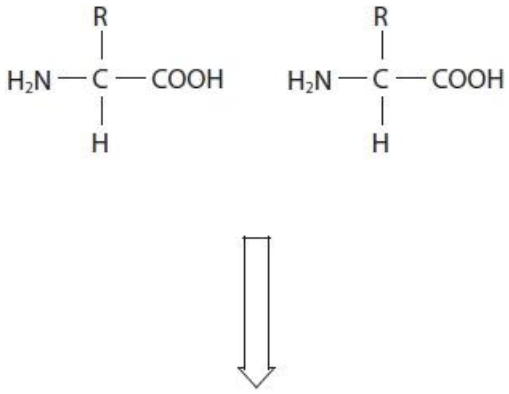
(iii) During protein synthesis, two amino acids are joined together to form a dipeptide.

The diagram shows two identical amino acids.
Complete the diagram to show how the dipeptide is formed from these two amino acids.

**(2)**




**(Total for question = 5 marks)**

**Q12.**

**Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

Glycolysis occurs during germination. One of the products is adenosine triphosphate (ATP).

Which of the following is another product of glycolysis?

**(1)**

- ☐ **A** carbon dioxide
- ☐ **B** glucose
- ☐ **C** oxygen
- ☐ **D** pyruvate

**(Total for question = 1 mark)**

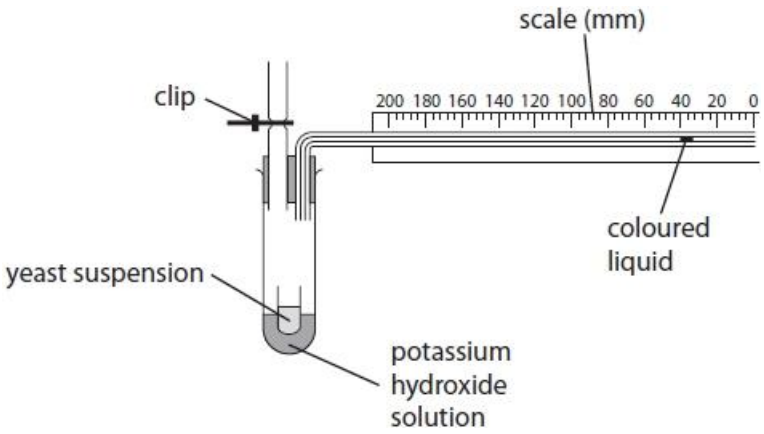
**Q13.**

Yeast is a single-celled organism that can respire aerobically.

Mitochondria are the sites of aerobic respiration in yeast cells.

It has been stated that if the temperature of yeast is raised by 10 °C, the rate of respiration will double.

The diagram shows some apparatus that can be used to measure the rate of respiration in yeast.




Devise an investigation using this apparatus to determine whether an increase of 10 °C doubles the rate of respiration in yeast.

**(4)**

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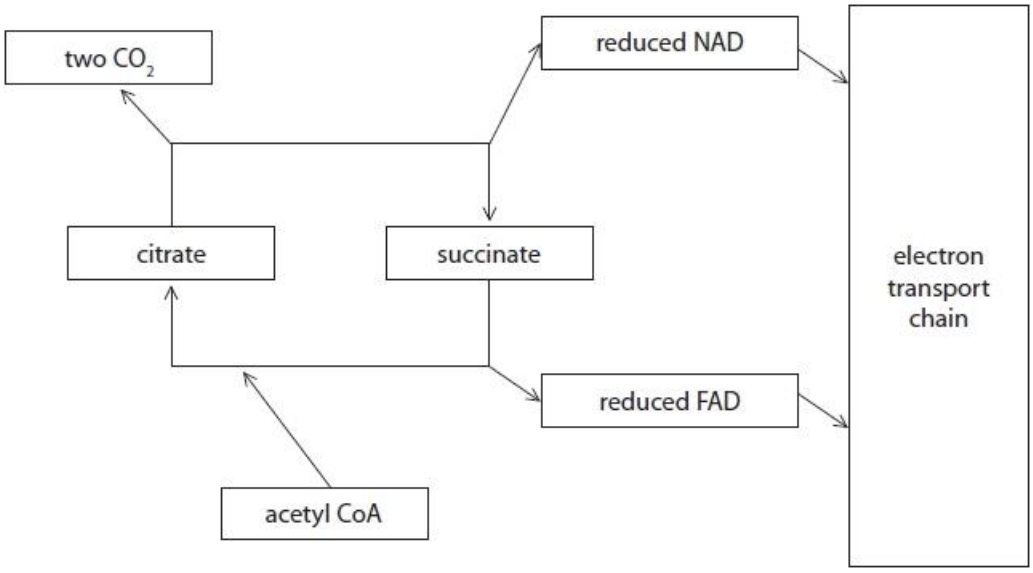
**(Total for question = 4 marks)**

**Q14.**

**Answer the questions with a cross in the boxes you think are correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

Respiration occurs in all healthy living cells.

The diagram shows part of the Krebs cycle and the electron transport chain.




(i) Which row shows the number of carbon atoms in citrate and succinate?

**(1)**

| | | Number of carbon atoms in | |
|---|---|---|---|
| | | **citrate** | **succinate** |
| ☒ | **A** | 2 | 4 |
| ☒ | **B** | 5 | 4 |
| ☒ | **C** | 6 | 4 |
| ☒ | **D** | 6 | 8 |

(ii) Which of the following is transferred to a molecule of FAD to form reduced FAD?

**(1)**

☒ **A** two oxygen atoms
☒ **B** two hydrogen atoms
☒ **C** one oxygen atom and one hydrogen atom
☒ **D** one water molecule

(iii) Explain the need for reduced NAD to be oxidised in a mitochondrion.

**(2)**

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(iv) A mutation in the gene that codes for the enzyme succinate dehydrogenase stops the conversion of succinate into citrate.
Which row states the change in concentration of citrate and reduced FAD as a result of this mutation?

**(1)**

| | Concentration of citrate | Concentration of reduced FAD |
|---|---|---|
| ☒ **A** | decreases | decreases |
| ☒ **B** | decreases | increases |
| ☒ **C** | increases | decreases |
| ☒ **D** | increases | increases |

**(Total for question = 5 marks)**

**Q15.**

The arctic ground squirrel (*Spermophilus parryii*) lives in Alaska. It has small ears, a cylindrical body and a shorter tail than other species of ground squirrel.

The arctic ground squirrel can survive cold winters by hibernating for up to eight months per year. When hibernating, arctic ground squirrels use stored fat supplies as an energy source.

www.sciencephoto.com

During hibernation, the core body temperature of an arctic ground squirrel can fall from 37 °C to −3 °C.

The table shows the effect of air temperature on the metabolic rate in the arctic ground squirrel.

| Air temperature / °C | Metabolic rate / $cm^3$ oxygen $g^{-1}$ $hour^{-1}$ |
|---|---|
| −16 | 0.18 |
| −8 | 0.08 |
| −4 | 0.04 |
| 0 | 0.02 |
| 4 | 0.02 |
| 8 | 0.02 |
| 12 | 0.02 |

(i) Calculate the change in metabolic rate for an arctic ground squirrel, with a body mass of 850g, as the air temperature increases from −16 °C to 4 °C.

Give your answer in $dm^3$ oxygen $day^{-1}$.

**(3)**

..... $dm^3$ oxygen $day^{-1}$

(ii) When the air temperature was −4 °C, the respiratory quotient (RQ) for the arctic ground squirrel was calculated as 0.77.

The RQ value can indicate the respiratory substrate as shown in the table.

| RQ value | Respiratory substrate |
|---|---|
| 1.0 | Carbohydrate |
| 0.9 | Protein |
| 0.7 | Lipid |

Intermediate values indicate a mixture of respiratory substrates.
Which of the following respiratory substrates were used by the arctic ground squirrel when the air temperature was −4 °C?

**(1)**

☒ **A** carbohydrate and protein

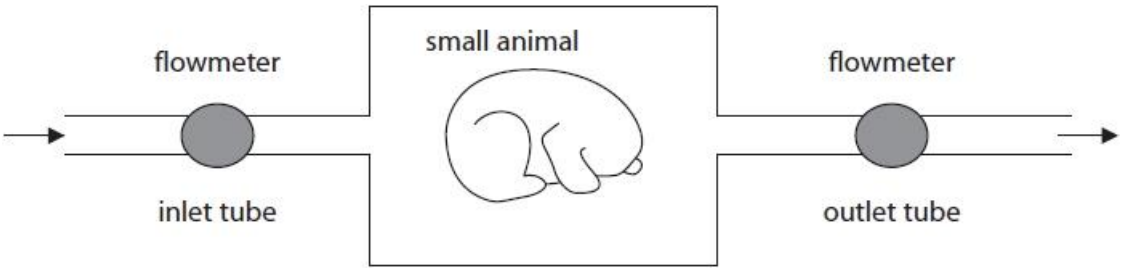
☒ **B** lipid only

☒ **C** lipid and protein

☒ **D** protein only

(iii) The data for calculating metabolic rate are collected using a respirometer.

The rate of respiration for small mammals can be measured using a continuous flow respirometer. A continuous flow respirometer circulates air through a chamber containing the animal. The rate of air flow can be measured using flowmeters on the inlet and outlet tubes.




Devise a procedure using a continuous flow respirometer to collect the data required to calculate the metabolic rate of an arctic ground squirrel.

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**(Total for question = 8 marks)**

## Mark Scheme

Q1.

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (i) | An answer that makes reference to two of the following:<br>• pyruvate (1)<br>• oxygen (1)<br>• reduced NAD / ADP (1) | | (2) |

| Question Number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (ii) | An explanation that makes reference to four of the following:<br>• to stop $H^+$ diffusing out (of mitochondrion) / into cytoplasm (1)<br>• (therefore) maintaining a high concentration (of $H^+$) in the intermembrane space (1)<br>• so {hydrogen ions / protons / $H^+$} can move down {concentration / electrochemical} gradient (1)<br>• (by) chemiosmosis (1)<br>• to synthesise ATP (1) | ALLOW moves out for diffuses out<br>ALLOW enabling/allowing/establishing formaintaining | (4) |

**Q2.**

| Question Number | Answer | Mark |
|---|---|---|
| (i) | **The only correct answer is B Q – the Krebs cycle occurs in the matrix**<br>***A*** *is not correct because the Krebs cycle does not occur in the intermembrane space*<br>***C*** *is not correct because the Krebs cycle does not occur on the crista*<br>***D*** *is not correct because the Krebs cycle does not occur at the outer mitochondrial membrane* | (1) |

| Question Number | Answer | Mark |
|---|---|---|
| **(ii)** | **The only correct answer is C – R which labels a crista**<br><br>***A*** *is not correct because oxidative phosphorylation does not occur in the intermembrane space*<br><br>***B*** *is not correct because oxidative phosphorylation does not occur in the matrix*<br><br>***D*** *is not correct because oxidative phosphorylation does not occur at the outer mitochondrialmembrane* | **(1)** |

| Question Number | Answer | Additional guidance | Mark |
|---|---|---|---|
| **(iii)** | An answer that makes reference to the following:<br><br>• length measured and units (converted correctly)(1)<br><br>• image size divided by actual size to calculate magnification (1) | Example of calculation<br><br>e.g. 70mm – 70 000 µm<br><br>e.g. 70 000 ÷ 0.5 = 140 000<br><br>x 140 000<br><br>Correct answer with no working gains full marks | **(2)** |

**Q3.**

| Question Number | Answer | Mark |
|---|---|---|
| **(i)** | **The only correct answer is A - ligaments only**<br><br>***B*** *is not correct because the tendons do not join bones to bones in the elbow joint*<br><br>***C*** *is not correct because the tendons do not join bones to bones in the elbow joint*<br><br>***D*** *is not correct because the ligaments do join bones to bones in the elbow joint* | **(1)** |

| Question Number | Answer | Mark |
|---|---|---|
| **(ii)** | **The only correct answer is D rows 3 and 4**<br><br>***A*** *is not correct because the tendons showing a change is not a change in genotype*<br><br>***B*** *is not correct because the tendons also show a physiological adaptation*<br><br>***C*** *is not correct because the tendons showing a change is not a change in genotype* | **(1)** |

| Question Number | Answer | |
|---|---|---|
| * (iii) | Answers will be credited according to candidates' deployment of knowledge and understanding of materialin relation to the qualities and skills outlined in the generic mark scheme.<br><br>The indicative content below is not prescriptive and candidates are not required to include all the materialwhich is relevant. Additional content included in the response must be scientific and relevant.<br><br>**Indicative content Valid because:**<br>• {sufficient replicates / 12 individuals} used and a mean calculated<br>• All same gender<br>• Means of both heart rate and blood lactate agree with conclusion<br>• Spread of data (standard deviation / error bars) between cycling and running does not overlap<br><br>**Not valid because:**<br>• Insufficient / only 12 individuals involved<br>• Insufficient detail relating to the athletes e.g. they maybe athletes that focus on different sports/have done more than one previous triathlon / more experienced<br>• The three disciplines are always done in the same order / different distances covered<br><br>• Spread of cycling data (standard deviation / error bars) for blood lactate overlaps with swimming<br>• As no time allowed to recover between sports, some of blood lactate shown for cycling could havebeen produced during swimming<br><br>• Agree or not agree with conclusion | **(6)** |

| | | | Additional Guidance |
|---|---|---|---|
| **Level 0** | Marks | No awardable content | |
| **Level 1** | 1-2 | Limited scientific judgement made with a focus on mainlyjust one method, with a few strengths/weaknesses identified.<br><br>A conclusion may be attempted, demonstrating isolatedelements of biological knowledge and understanding butwith limited evidence to support the judgement being made. | Considers one area only e.g. comparingmean data or spread of data only<br><br>Conclusion based on only one set of data or only one sport considered e.g. cycling ismost demanding |
| **Level 2** | 3-4 | A scientific judgement is made through the application of relevant evidence, with strengths and weaknesses of each method identified.<br><br>A conclusion is made, demonstrating linkages to elements of biological knowledge and understanding, with occasionalevidence to support the judgement being made. | Considers both a valid and an invalid aspect e.g. relevance of spread of data forlactate concentrations overlap in some cases or elements of the study<br><br>Conclusion given that takes both valid andinvalid aspects into account |
| **Level 3** | 5-6 | A scientific judgement is made which is supported throughout by sustained application of relevant evidencefrom the analysis and interpretation of the scientific information.<br><br>A conclusion is made, demonstrating sustained linkages tobiological knowledge and understanding with evidence to support the judgement being made. | Considers both a range of valid and invalidaspects<br><br>A conclusion based on a range of considered evidence |

**Q4.**

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| | An answer that makes reference to the following points:<br><br>• (athlete) P should exercise at an intensity of 300 watts (1)<br><br>• (athlete) Q should exercise at an intensity of 330 watts (1)<br><br>• (athlete) R should exercise at an intensity of 360 watts (1)<br><br>• as there would be an increase in lactate at the next level of intensity of exercise (1) | | (4) |

**Q5.**

| Question Number | Answer |
|---|---|
| * | Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.<br><br>The indicative content below is not prescriptive and candidates are not required to include all the material which is indicated as relevant. Additional content included in the response must be scientific and relevant.<br><br>Indicative content<br><br>Investigation 1<br>• comparison of data for no exercise/exercise without nandrolone: maximum recoil of {aorta / artery} is {higher / 23% greater}<br>• discuss outcome of this difference as an advantage: so (oxygen-rich) blood can flow more rapidly (at the correct pressure) {from the heart / to the muscles}<br>• less likely to get atherosclerosis / CVD / strokes<br><br>Investigation 2<br>• comparison of data for P and R for both protein complexes: more present due to exercise<br>• discuss advantageous outcome: so more {oxidative phosphorylation / ATP synthesis / chemiosmosis} so more ATP for muscle contraction / breaking of the bond between actin and myosin (in aorta wall)<br><br>Investigation 3<br>• compare P and Q for mRNA coding for Tfam: more Tfam per cell<br>so more<br>mitochondria produced<br>so more {respiration / ATP formed } |

| Level | Marks | Descriptor | Additional Guidance |
|---|---|---|---|
| 0 | 0 | No awardable content | |
| 1 | 1-2 | Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made.<br><br>Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures.<br><br>The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context. | Results of one investigation described e.g. comparing P and R groups<br><br>General comments about production of ATP or respiration |
| 2 | 3-4 | Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts.<br><br>Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures.<br><br>The discussion shows some linkages and lines of scientific reasoning with some structure. | Results of at least two investigations considered<br><br>Discussion of results of one of these investigations in terms of consequences |
| 3 | 5-6 | Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts.<br><br>Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures.<br><br>The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured. | Results of all three investigations discussed<br><br>Discussion of the consequences of the data from the investigations in terms of respiration / ATP synthesis<br><br>Links the consequences to muscle contraction |

**Q6.**

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| | An explanation that makes reference to the following points:<br><br>• (muscles cells release lactate into blood) due to anaerobic respiration (1)<br><br>• insufficient oxygen for aerobic respiration / aerobic respiration cannot meet the demand for energy (1) | | (2) |

**Q7.**

| Question number | Answer | Additional guidance | Mark |
|---|---|---|---|
| | A description that makes reference to three of the following points:<br>• { increased / sufficient } oxygen supply (1)<br>• for aerobic respiration (1)<br>• because { heart rate / breathing rate } increases (1)<br>• lactate is broken down by the liver / rate of lactate production is balanced by rate of lactate breakdown (1) | ALLOW lactic acid for lactate | (3) |

**Q8.**

| Question Number | Answer | Mark |
|---|---|---|
| (i) | ***The only correct answer C*** glycolysis, the Krebs cycle and the electron transport chain only<br>*A is incorrect because ATP is also made in the Krebs cycle*<br>*B is incorrect because ATP is also made in the electron transport chain*<br>*D is incorrect because ATP is not made in the link reaction* | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (ii) | An explanation that makes reference to two of the following:<br>• (because the breakdown of ATP) {donates phosphate to / phosphorylates} the glucose (1)<br>• (ATP) supplies energy to break down the glucose (1)<br>• to produce (phosphorylated) 3-carbon compounds (1) | ALLOW 'hexose' for 'glucose'.<br>ALLOW production of fructose diphosphate<br>ALLOW to make the glucose more reactive, activate the glucose<br>e.g. for 3-carbon compounds: GALP / glyceraldehyde-3-phosphate / glycerate-3phosphate / GP/ PGAL / G3P / GA3P / GADP / GAP / TP / triose phosphate | **(2)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (iii) | An explanation that makes reference to three of the following:<br>• receive hydrogen from reduced { NAD / FAD } / to allow reduced { NAD / FAD } to be oxidised (1)<br>• break hydrogen into { protons / $H^+$ / hydrogen ions } and electrons (1)<br>• electrons transferred by a series of redox reactions (1)<br>• energy released is used to pump { hydrogen ions / protons / $H^+$ } into intermembranal space (1) | ALLOW NAD red / NADH + $H^+$ for reduced<br>NAD and NAD or $NAD^+$ for oxidised NAD<br>ALLOW $e^-$ for electrons<br>ALLOW a series of reduction and oxidation reactions<br>ALLOW 'actively transported / moved into / moved up the concentration gradient' for 'pump' | (3) |

**Q9.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (i) | An explanation that makes reference to following:<br>• the use of nandrolone reduces the (mean maximum percentage) recoil of the { aorta / artery } (1)<br>and two from:<br>• increased risk of damage to the endothelium of arteries (1)<br>• inflammatory response / white blood cells accumulate (1)<br>• build-up of { cholesterol / calcium salts / fibrous tissue } leads to formation of { atheroma / plaque } (1) | | (3) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (ii) | An answer that makes reference to three of the following:<br>• nandrolone reduces the production of (both) proteins when exercise is allowed (1)<br>• these proteins are involved in { ATP production / oxidative phosphorylation } (1)<br>• nandrolone has no effect on ATP production if there is no exercise (1)<br>• nandrolone reduces ATP production if exercise takes place (1) | ALLOW nandrolone has no effect on the production of the proteins in absence of exercise | (3) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (iii) | An explanation that makes reference to the following:<br>• without exercise the values for mRNA for Tfam overlap for groups with and without nandrolone (1)<br>• as when exercise is carried out and nandrolone taken, the values for mRNA for Tfam overlap with no exercise and no nandrolone (1) | ALLOW overlap between groups P and Q<br>ALLOW overlap between groups P and S | (2) |

**Q10.**

| Question Number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (i) | An explanation that makes reference the following:<br>• hydrolysis of ATP (1)<br>• provides energy for the reaction (1)<br>• provides phosphate group for phosphorylation of F-6-P (1) | ALLOW as the reaction requires energy<br>ALLOW provides {phosphate / Pi} that is added to F-6-P | (3) |

| Question Number | Answer | Additional guidance | Mark |
|---|---|---|---|
| (ii) | An answer that makes reference to three of the following:<br>• as concentration of { F-6-P / F-2,6-BP } increases so does the (initial) rate of reaction of the phosphofructokinase (1)<br>• an increasing in the concentration of { F-6-P / F-2,6BP } will increase the rate of glycolysis (1)<br>• up to a maximum (rate) (1)<br>• increasing the concentration of F-2,6-BP reduces the concentration of F-6-P required to achieve the maximum rate of glycolysis (1) | ALLOW 'enzyme' for 'phosphofructokinase'<br>ALLOW F-2,6-BP provides positive feedback to the enzyme activity | (3) |

**Q11.**

| Question Number | Answer | Mark |
|---|---|---|
| (i) | ***The only correct answer is D because there is RNA in the cytoplasm, nucleus and mitochondria*** 1, 2 and 3<br>*A is incorrect because there is also RNA in the nucleus and mitochondria*<br>*B is incorrect because there is also RNA in the nucleus*<br>*C is incorrect because there is also RNA in the cytoplasm (as tRNA, mRNA or in ribosomes)* | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (ii) | An answer that makes reference to two of the following:<br>• (lactate is ) { oxidized to form / converted to } pyruvate (1)<br>• (pyruvate is) converted to { glucose / glycogen } (1)<br>• (pyruvate / glucose) used in respiration (1) | ALLOW glucose produced from the lactate<br>ALLOW correct named stage e.g.<br>glycolysis for glucose or link reaction for pyruvate | (2) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (iii) | An answer that makes reference to the following:<br>• dipeptide correctly drawn with peptide bond (1)<br>• water molecule released (1) | | (2) |

**Q12.**

| Question Number | Answer | Mark |
|---|---|---|
| | The only correct answer is **D** - pyruvate<br>***A*** *is incorrect because carbon dioxide is not a product of glycolysis*<br>***B*** *is incorrect because glucose is not a product of glycolysis*<br>***C*** *is incorrect because oxygen is not a product of glycolysis* | (1) |

**Q13.**

| Question Number | Answer | Additional guidance | Mark |
|---|---|---|---|
| | An answer that makes reference to four of the following:<br>• selection of two temperatures that are not above theoptimum temperature (1)<br>• named variable kept constant (1)<br>• record the distance travelled by the coloured liquid ina set time (1)<br>• description of how to calculate rates (1)<br>• data collected during the initial rate of reaction / before a factor (other than temperature) becomes limiting (1) | ALLOW: below a temperature that causes enzyme denaturing or not above optimum tempALLOW any two temperatures between 10 and 40°C<br>e.g. pH of solution, {sucrose/glucose} concentration, yeast {concentration / volume}<br>ALLOW time taken for coloured liquid to travel aset distance<br>e.g. by dividing distance travelled by time | (4) |

**Q14.**

| Question Number | Answer | Mark |
|---|---|---|
| (i) | The only correct answer is **C** – number of carbon atoms in citrate is 6 and in succinate is 4<br><br>***A*** *is incorrect because the number of carbons is not correct for either citrate or succinate*<br><br>***B*** *is incorrect because the number of carbons is not correct for either citrate or succinate*<br><br>***D*** *is incorrect because the number of carbons is not correct for either citrate or succinate* | (1) |

| Question Number | Answer | Mark |
|---|---|---|
| (ii) | The only correct answer is **B** – two hydrogen atoms<br><br>***A*** *is incorrect because oxygen is not transferred to FAD*<br><br>***C*** *is incorrect because oxygen is not transferred to FAD*<br><br>***D*** *is incorrect because water is not transferred to FAD* | (1) |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| (iii) | An explanation that makes reference to two of the following:<br><br>• so that hydrogen can be delivered to the electron transport chain (1)<br><br>• to allow { ATP synthesis / chemiosmosis } (1)<br><br>• to regenerate NAD (1) | ALLOW supply of { hydrogen ions / protons / electrons } to ETC<br><br>ALLOW description of chemiosmosis<br><br>ALLOW to keep Krebs cycle going / to allow conversion of citrate to succinate | (2) |

| Question Number | Answer | Mark |
|---|---|---|
| (iv) | The only correct answer is **A** – concentration of citrate and reduced FAD decreases<br><br>***B*** *is incorrect because the concentration of reduced FAD decreases rather than increases*<br><br>***C*** *is incorrect because the concentration of citrate decreases rather than increases*<br><br>***D*** *is incorrect because the concentration of citrate and reduced FAD decrease rather than increase* | (1) |

**Q15.**

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **(i)** | • change in metabolic rate calculated for the ground squirrel<br><br>• difference calculated for one day<br><br>• value correctly converted from $cm^3$ to $dm^3$ | <u>Example of calculation</u><br><br>0.18 at -16 ºC and 0.02 at 4 ºC =0.16<br>0.16 x 850 = 136<br><br>136 x 24 = 3264<br><br>3.264 / 3.26 / 3.3<br><br>Correct answer with no working gains full marks<br><br>ALLOW 2 marks for 0.136 (if not calculated for one day) | **(3)** |

| Question Number | Answer | Mark |
|---|---|---|
| **(ii)** | **C** - lipid and protein<br><br>*The only correct answer is **C***<br><br>***A** is incorrect because RQ value is too low for carbohydrate*<br><br>***B** is incorrect because RQ value is too high for lipid only*<br><br>***D** is incorrect because RQ value is too low for protein only* | **(1)** |

| Question Number | Answer | Additional Guidance | Mark |
|---|---|---|---|
| **(iii)** | An answer that makes reference to four of the following:<br><br>• use of {potassium hydroxide / sodium hydroxide / soda lime} to remove carbon dioxide<br><br>• measure volumes of air entering and leaving the chamber<br><br>• decrease in volume of air represents oxygen taken up (by ground squirrel for respiration )<br><br>• control the temperature / measure mass of squirrel / measure for a stated period of time<br><br>• divide volume of oxygen used in a unit of time by the body mass of the ground squirrel to calculate its metabolic rate | ALLOW a sensible specified time<br><br>ALLOW volume of oxygen ÷ (mass × time) | **(4)** |