Questions

Q1.

Acetyl CoA is produced in the link reaction when pyruvate is broken down.

The photograph shows a molecule of the enzyme acetyl CoA carboxylase.

This enzyme is involved in the conversion of acetyl CoA into fatty acids.

The enzyme is activated by citrate.

Citrate does not bind at the active site.

Citrate is produced in the Krebs cycle.

The enzyme is inhibited by long chain fatty acyl CoA molecules.

Fatty acyl CoA molecules have a longer carbon chain than acetyl CoA.

(i) Analyse the information to explain how the activity of the enzyme acetyl CoA carboxylase is controlled.

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(ii) Explain why inhibitors of this enzyme may be useful in treating obesity in humans.

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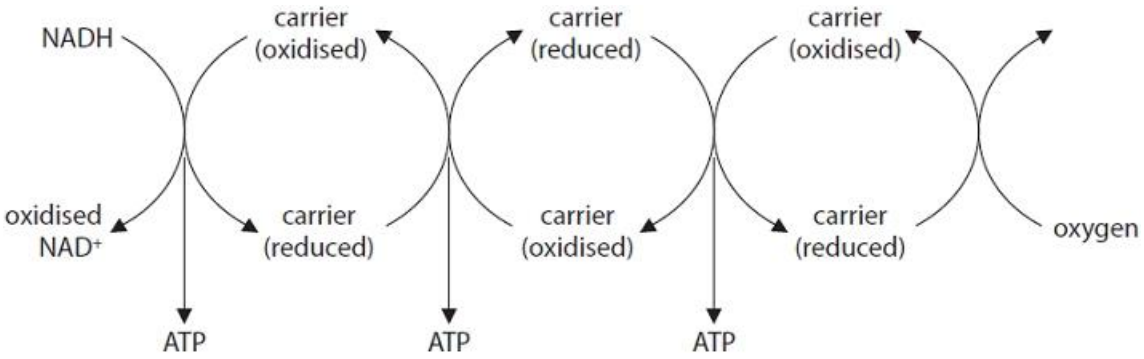
(Total for question = 7 marks)

Q2.

The electron transport chain requires oxygen and synthesises ATP.

The diagram below shows part of the electron transport chain.



Describe what happens to oxygen at the end of the electron transport chain.

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(Total for question = 2 marks)

Q3.

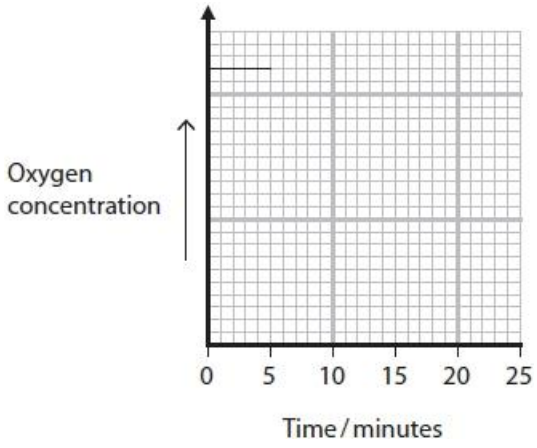
The effect of cyanide on oxygen uptake by mitochondria was investigated using the following method:

- suspend mitochondria in a flask containing a buffer solution
- measure the concentration of oxygen in the flask for the first five minutes
- then add a respiratory substrate and ADP to the flask
- measure the concentration of oxygen in the flask for the next 10 minutes
- then add cyanide solution to the flask
- measure the concentration of oxygen in the flask for the next 10 minutes.

The graph shows the results for the first five minutes.

Complete the graph to show the results for the next 20 minutes.

(2)



(Total for question = 2 marks)

Q4.

Hydrogen cyanide gas is a poison that can kill an animal if it is inhaled.

Cyanide is a non-competitive inhibitor of the enzyme cytochrome oxidase.

Cytochrome oxidase is the last carrier in the electron transport chain.

(i) Explain why hydrogen cyanide gas can kill an animal.

(5)

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(ii) A dose of 1.0 mg of hydrogen cyanide per kilogram of body mass is fatal.

An animal with a body mass of 10 kg inhaled air containing 0.24 mg dm^{-3} of hydrogen cyanide.
The animal breathed at a rate of 15 dm^3 of air per minute.
Calculate how many minutes it would take for this animal to obtain a fatal dose.
Give your answer to three significant figures.

(3)

Answer ..... minutes

(Total for question = 8 marks)

Q5.

Some antibiotics work by inhibiting the production of ribosomes in bacteria.

The structure of ribosomes in bacteria is similar to the structure of ribosomes in mitochondria.

These antibiotics can destroy cancer cells in humans.

The diagram shows the membranes of a mitochondrion from a cancer cell treated with these antibiotics.

(i) Give one difference in the membranes of this mitochondrion compared with the membranes of a mitochondrion from an untreated cancer cell.

(1)

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(ii) Some cancer cells depend on oxidative phosphorylation for ATP production.

Explain why the antibiotics that inhibit the production of ribosomes prevent oxidative phosphorylation when used to treat cancer cells.

(2)

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(iii) Some scientists suggested that inhibiting both glycolysis and mitochondrial respiration may be an effective way of treating cancer cells.

Explain why this suggestion may be an effective way of treating cancer cells.

(2)

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(Total for question = 5 marks)

Q6.

Hypoxia is an inadequate supply of oxygen to tissues and cells that restricts their function.

The body responds to hypoxia by releasing hypoxia-inducible transcription factors (HIF).

Investigations have shown that one effect of HIF is an increase in the rate of glycolysis in the affected cells.

(i) Explain how HIF could result in an increase in the rate of glycolysis.

(2)

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(ii) Explain why cells need to respond to hypoxia with an increase in the rate of glycolysis.

(4)

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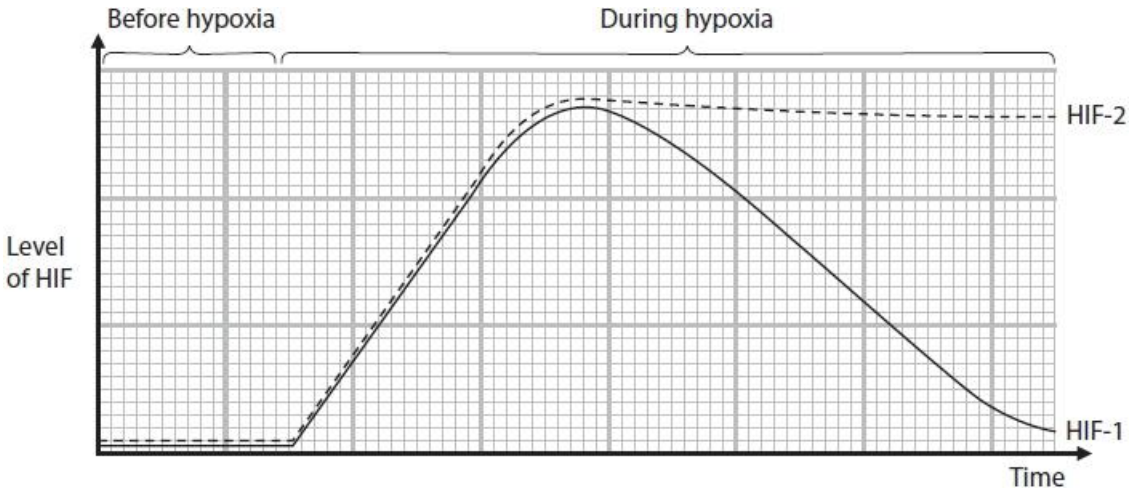
(iii) The graph shows the changes in levels of two HIFs, HIF-1 and HIF-2, before and during hypoxia.



Compare and contrast the changes in the levels of HIF-1 and HIF-2 during hypoxia.

(2)

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(iv) Explain the changes in levels of HIF-1 and HIF-2 during hypoxia.

(2)

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(Total for question = 10 marks)

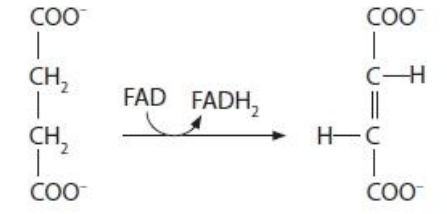
Q7.

Mitochondria can be extracted from liver cells.

In order to monitor the purification of a sample of mitochondria,
a protein concentration : enzyme activity ratio can be determined.

The enzyme used to monitor the purification of mitochondria is succinate dehydrogenase.

This enzyme is involved in the Krebs cycle and converts succinate into fumarate in this reaction.



Succinate Fumarate

(i) When succinate is converted into fumarate, succinate is

(1)

- ☒ **A** hydrolysed
- ☒ **B** oxidised
- ☒ **C** phosphorylated
- ☒ **D** reduced

(ii) Explain the role of the Krebs cycle.

(4)

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(Total for question = 5 marks)

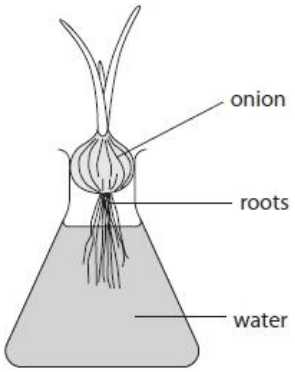
Q8.

A student read that some plants do not grow well in waterlogged soil.

The student formed the following hypothesis:

Adding water.

To test this hypothesis, the student grew onion roots in the apparatus shown.



The tips of the onion roots were removed and observed for stages of mitosis.

The photomicrograph shows a preparation from one onion root tip.

Waterlogged soil lacks oxygen.

Explain why a lack of oxygen in waterlogged soil could reduce the growth of a plant.

(4)

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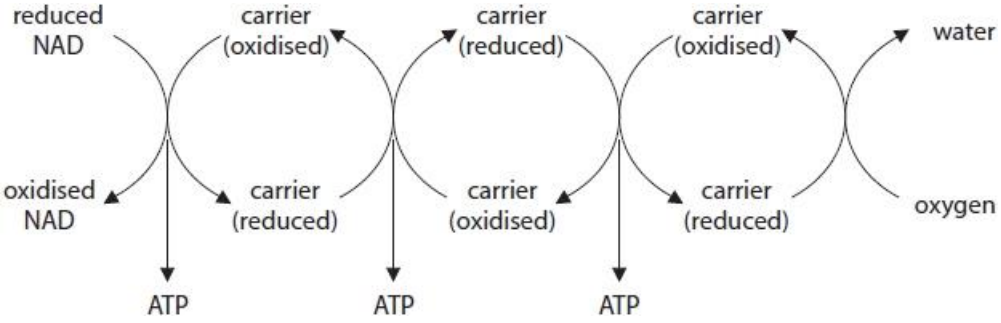
(Total for question = 4 marks)

Q9.

The electron transport chain generates ATP.

The diagram shows the electron transport chain.



State the location of the electron transport chain in a mitochondrion.

(1)

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(Total for question = 1 mark)

Q10.

Mitochondrial disorders may be caused by mutations in the genes coding for mitochondrial components. Some of these genes are found in mitochondrial DNA (mtDNA) and some are found in nuclear DNA.

Leigh syndrome is an example of a mitochondrial disorder. In this syndrome, a number of different proteins involved in respiration are affected.

These mutations may be inherited or may occur when DNA replicates.

Some people with Leigh syndrome have a mutation in the MT-ATP6 gene.
This gene codes for ATP synthase.

This is a point mutation at nucleotide 8993 that changes thymine to guanine.

(i) What type of mutation is this?

(1)

- ☒ **A** insertion
- ☒ **B** monosomy
- ☒ **C** substitution
- ☒ **D** translocation

(ii) Explain how this mutation could affect oxidative phosphorylation.

(3)

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(Total for question = 4 marks)

Q11.

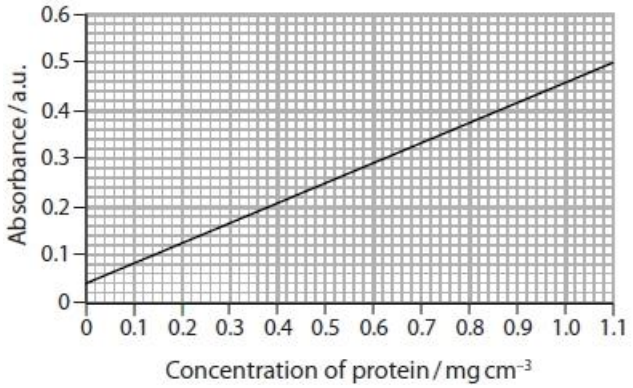
Mitochondria can be extracted from liver cells.

In order to monitor the purification of a sample of mitochondria,
a protein concentration : enzyme activity ratio can be determined.

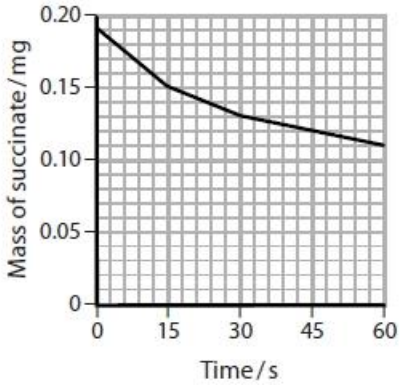
Protein concentrations can be determined by using a calibration curve, shown in graph 1.

The initial rate of activity of succinate dehydrogenase, from a sample of mitochondria, can be determined using graph 2.

Graph 1



Graph 2



(i) This sample of mitochondria had an absorbance of 0.28 when the protein concentration was measured.

Determine the protein concentration of this sample of mitochondria.

(1)

Answer .....

(ii) Determine the initial rate of enzyme activity to obtain the protein : enzyme activity ratio for this sample of mitochondria.

(2)

Ratio .....

(Total for question = 3 marks)

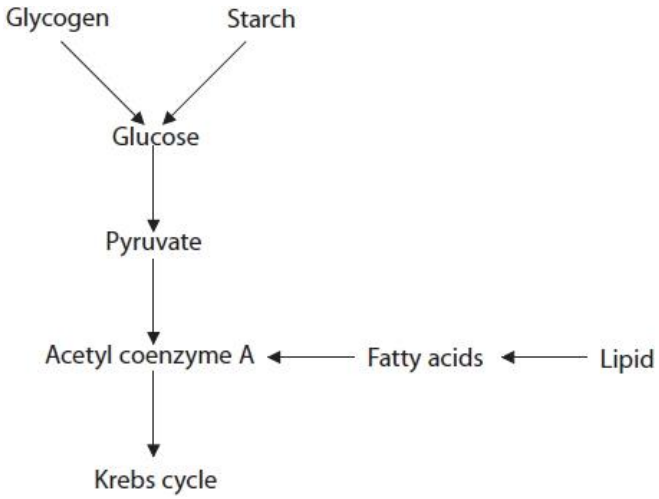
Q12.

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 ☒.

Lipids and carbohydrates are used as respiratory substrates.

The respiration of lipids generates more ATP than the respiration of carbohydrates.

The diagram shows some steps in the respiration of carbohydrates and lipids.



(i) Where in a cell does the conversion of pyruvate to acetyl coenzyme A take place?

(1)

- ☒ **A** cytoplasm
- ☒ **B** matrix
- ☒ **C** stroma
- ☒ **D** tonoplast

(ii) Explain why lipids can be respired only in aerobic conditions.

(3)

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(Total for question = 4 marks)

Q13.

Lipids and carbohydrates are used as respiratory substrates.

The respiration of lipids generates more ATP than the respiration of carbohydrates.

The electron transport chain uses hydrogen ions to generate ATP.

Explain why the respiration of lipids generates more ATP than the respiration of carbohydrates.

(2)

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(Total for question = 2 marks)

Q14.

Lipids and carbohydrates are used as respiratory substrates.

The respiration of lipids generates more ATP than the respiration of carbohydrates.

The respiratory quotient (RQ) can indicate which substrate is being used in respiration.

The formula used to calculate RQ is

$$\text{RQ} = \frac{\text{volume of carbon dioxide produced}}{\text{volume of oxygen used}}$$

Explain why an insect has an RQ of 1.0 at rest and an RQ of 0.7 during flight.

(3)

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(Total for question = 3 marks)

Q15.

Lipids and carbohydrates are used as respiratory substrates.

The respiration of lipids generates more ATP than the respiration of carbohydrates.

The respiratory quotient (RQ) can indicate which substrate is being used in respiration.

The formula used to calculate RQ is

$$RQ = \frac{\text{volume of carbon dioxide produced}}{\text{volume of oxygen used}}$$

(i) State why the RQ for carbohydrate is 1.0.

(1)

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(ii) The table shows the formula for calculating the volume of oxygen used and the volume of carbon dioxide produced in the respiration of lipids.
The number of carbon atoms in the lipid is represented by n.

Volume of oxygen used / a.u.	Volume of carbon dioxide produced / a.u.
4.5n + 3.75	3n + 6

Calculate the RQ for a lipid containing 21 carbon atoms.

(2)

Answer .....

(Total for question = 3 marks)

Mark Scheme

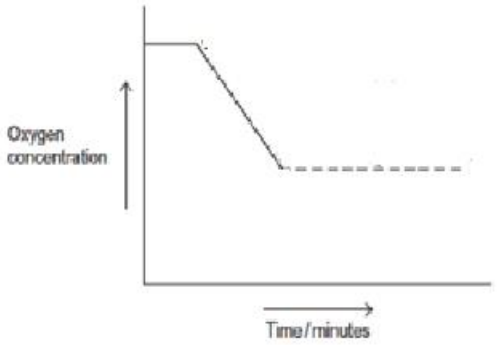
Q1.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to the following: • citrate binds to another site on the enzyme, activating theenzyme (1) • so that the structure of the enzyme is changed (1) • so that active site binds more effectively to the substrate (1) • an increase in fatty acyl CoA molecules inhibits the substratebinding to the active site (1) • due to competitive inhibition (1)	Accept citrate and fatty acyl CoAmolecules act together to regulate the activity of the enzyme	(5)
(ii)	An explanation that makes reference to two of thefollowing: • fewer fatty acids will be made (1) • so that less fat is stored (1) • because the enzyme is being inhibited despite beingactivated by citrate (1)	Allow (less fat stored so) fatreserves used	(2)

Q2.

Question Number	Answer	Additional Guidance	Mark
	A description that makes reference to the following: • acts as an {electron / e^- / H^+ / proton} acceptor / becomes reduced (1) • forms water (1)	**DO NOT ACCEPT** hydrogen **ACCEPT** for 2 marks $2H^+ + O^{2-} \rightarrow H_2O$	(2)

Q3.

Question Number	Answer	Additional Guidance	Mark
	An answer that makes reference to the following: • line decreasing from 5 to 15 minutes (1) • line level from 15 to 25 minutes (1)		(2)

Q4.

Question Number	Answer	Additional guidance	Mark
(i)	An explanation that makes reference to five of the following: • (cyanide) changes tertiary structure / changes active site / substrate no longer fits {active site / enzyme} (1) • therefore transport of {electrons / hydrogen ions} stops (1) • carrier(s) cannot be reduced (1) • (so that) ATP manufacture stops / less ATP made (1) • muscles {cannot contract / go into spasm} / breathing stops / heart stops (1) • any other named biological process that requires ATP stops eg active transport (1)		(5)

Question Number	Answer	Additional guidance	Mark
(ii)	• mass of cyanide that kills = 10 mg (1) • mass of cyanide inhaled per minute • time taken to inhale lethal dose (1) OR • mass of cyanide that kills = 10 mg (1) • volume that provides lethal dose (1) • time taken to inhale lethal dose (1)	1 x 10 = 10 mg 0.24 mg dm^{-3} x 15 = 3.6 (mg per minute) 10 ÷ 3.6 = **2.78** minutes (3sf) 1 × 10 = 10 mg 10 ÷ 0.24 = 41.67 (dm^3) 41.67 ÷ 15 = **2.78** minutes (3sf)	**(3)**

Q5.

Question Number	Answer	Additional Guidance	Mark
(i)	• {fewer / smaller} cristae / less folding of the inner membrane / reduced surface area of inner membrane		(1)
(ii)	An explanation that makes reference to two of the following: • (fewer cristae / lower surface area) therefore reduced electrontransport chain (1) • because ribosomes prevented from synthesising {enzymes / ATPase / electron transport molecules} (1) • credit reason linked to protein not made (1)	e.g. no enzymes to catalyse steps in Krebs cycle, noATPase channels for {protons to pass through / phosphorylation of ADP}, no ETC so no redox reactions **ACCEPT** less intermembrane space foraccumulation of protons = 1 mark	(2)
(iii)	An explanation that makes reference to the following: • no ATP will be produced (if both inhibited / glycolysis inhibited) (1) • therefore no {energy / ATP} for metabolic process / named metabolic processes / cell division} (1)		(2)

Q6.

Question Number	Answer	Additional Guidance	Mark
(i)	An explanation that makes reference to two of the following: • because HIF can switch on gene (expression) (1) • bind to a promotor region / stimulate transcription / stimulate protein synthesis} (1) • for {enzymes / proteins} involved in glycolysis (1)	**ACCEPT** increased gene expression **ACCEPT** increase rate of transcription **IGNORE** enzymes **ACCEPT** named {enzyme / protein} involved in glycolysis e.g. enzyme that makes NAD **IGNORE** NAD otherwise	(2) EXP
Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to the following: • (because if conditions are hypoxic) there is not much oxygen available to act as a terminal electron acceptor (1) • therefore the electron transport chain will not operate (1) • therefore ATP production by oxidative phosphorylation will be reduced (1)	**ACCEPT** no oxygen **IGNORE** numbers of ATP molecules produced	(4) EXP
	• ATP is produced (directly / SLP) during glycolysis (during these anaerobic conditions) (1)		

Question Number	Answer	Additional Guidance	Mark
(iii)	An answer that makes reference to the following: • both HIF-1 and HIF-2 increase (during hypoxia) (1) • levels of HIF-2 remain high (after a small decrease) but levels of HIF-1 fall (1)	**DO NOT PIECE TOGETHER** **IGNORE** any explanations given	(2) EXP

Question Number	Answer	Additional Guidance	Mark
(iv)	An explanation that makes reference to two of the following: • HIF-1 and HIF-2 switch on different genes (1) • {products / transcription of genes} resulting from the presence of both HIF-1 and HIF-2 are needed in the early stages of hypoxia (1) • {products / transcription of gene} resulting from the presence of HIF-2 are needed {for longer periods of hypoxia / to sustain glycolysis} (1)	**ACCEPT** bind to different promotor regions **ACCEPT** converse for HIF-1	(2) EXP

Q7.

Question Number	Answer	Mark
(i)	**The only correct answer is B** ***A*** *is not correct because no bonds are being broken* ***C*** *is not correct because no phosphate group is being added* ***D*** *is not correct because if FAD is reduced to* $FADH_2$ *the succinate is being oxidised*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to four of the following: • completely oxidises {pyruvate / acetyl Co A} (1) • to release as much energy as possible (1) • to generate ATP (directly) (1) • to produce {reduced coenzyme / NADH} (1) • so that ATP can be produced {in the ETC / by oxidative phosphorylation} (1)	**ACCEPT** glucose **DO NOT ACCEPT** makes **ACCEPT** $FADH_2$ / FADH / reduced {NAD / NADH} / reduced {FAD / FADH / $FADH_2$}	**(4)**

Q8.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to four of the following: • aerobic respiration inhibited / anaerobic respiration occurs (1) • therefore {electron transport chain / oxidative phosphorylation} inhibited / therefore {glycolysis occurs / ethanol produced} (1) • less {ATP synthesis / reduced NAD} (1) • (less) active transport (of mineral ions) (1) • less {GP / GALP / IAA pumping / spindle fibre contraction / protein synthesis} (1)	**ACCEPT** valid substances / energy requiring processes **DO NOT ACCEPT** starch	**(4)**

Q9.

Question Number	Answer	Additional Guidance	Mark
	inner membrane / cristae		**(1)**

Q10.

Question Number	Answer	Mark
(i)	**The only correct answer is C** ***A*** *is not correct because an insertion adds an additional base* ***B*** *is not correct because monosomy is a chromosome mutation* ***D*** *is not correct because translocation is a chromosome mutation*	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: • it will change the {amino acid sequence / primary structure } of ATP synthase **(1)** • therefore the ATP synthase active site could be a different {structure / shape } so ADP cannot {bind / bind as well} **(1)** • therefore the {channel / ATP synthase} the wrong {structure / shape} so {hydrogen ions / protons} cannot {pass through / pass through as well} **(1)** . therefore { no / less} {ATP made / oxidative phosphorylation} **(1)**	**Accept** a stop codon could result changing the {length / shape / structure} of the protein	**(3)**

Q11.

Question Number	Answer	Additional Guidance	Mark
(i)	concentration of protein read from graph	0.58 / 0.57 (mg cm^{-3})	**(1)**

Question Number	Answer	Additional Guidance	Mark
(ii)	• initial rate of reaction calculated (1) • ratio calculated (1)	0.00267 / 0.0027 (mg sec^{-1}) / 0.16 (mg min^{-1}) 0.58 : 0.0027 = 214.81 : 1 or 3.63 : 1 21481 : 100 or 363 : 100 0.57 : 0.0027 = 211.11 : 1 or 3.56 : 1 21111 : 100 or 356 :100 **CE applies from both (i) and the value for initial rate of reaction**	(2)

Q12.

Question Number	Answer	Mark
(i)	The only correct answer is **B** matrix **A** is incorrect because only glycolysis takes place in the cytoplasm **C** is incorrect because stroma is in chloroplasts not mitochondria **D** is incorrect because tonoplasts are in plant cells only	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	An explanation that makes reference to three of the following: • in anaerobic conditions, the pyruvate is used to reoxidise NADH so no Krebs cycle (1) • no oxygen available to act as a (terminal) electron acceptor (1) • so reduced { NAD / FAD / coenzyme} cannot be reoxidised (1) • so no (oxidised) coenzyme to bind {hydrogen ions / protons / H^+/electrons} (1)	**ACCEPT** oxygen binds to electrons **ACCEPT** NADH / $FADH_2$	(3)

Q13.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to two of the following: • because a lipid molecule contains a higher proportion of hydrogen (than a carbohydrate molecule) (1) • therefore more reduced {NAD / FAD / coenzyme} (1) • therefore more hydrogen (ions) {to accumulate in the inter-membrane space / to produce a proton gradient / to pass through ATP synthase channels / for chemiosmosis / for oxidative phosphorylation} (1)	**ACCEPT** converse throughout **ACCEPT** NADH / $FADH_2$	(2)

Q14.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • insect is respiring carbohydrates at rest and lipid during flight (1) • respiration of carbohydrate provides enough energy for the insect at rest (1) • it requires more {energy / ATP} (for contraction) (1) • therefore the insect has to respire lipid to provide this energy (1)	**NB** uses for respires throughout but reference to respiration must be made at least once for full marks to be awarded **PIECE TOGETHER**	(3)

Q15.

Question Number	Answer	Additional Guidance	Mark
(i)	• when one molecule of carbohydrate is respired the number of carbon dioxide molecules produced is the same as the number of molecules of oxygen used	**ACCEPT** carbon dioxide produced = oxygen used	(1)

Question Number	Answer	Additional Guidance	Mark
(ii)	• volume of both gases calculated (1) • RQ value calculated to {1 / 2} decimal places (1)	Example of calculation: oxygen volume = 4.5 × 21 + 3.75 = 98.25 carbon dioxide volume = 3 × 21 + 6 = 69 69 ÷ 98.25 = 0.70 / 0.7 / 0.702 **ACCEPT** ecf	(2)