

PEARSON EDEXCEL A-LEVEL BIOLOGY B • 9B10

BIOLOGY



EXAM QUESTION PACK

TOPIC 5: ENERGY FOR BIOLOGICAL PROCESSES
LINK REACTION AND KREBS CYCLE

SCORE

/241

PERCENTAGE

%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions and mark schemes in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question or mark scheme material in this pack. Pearson has not endorsed, approved or been involved in the production of it. Pearson, Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

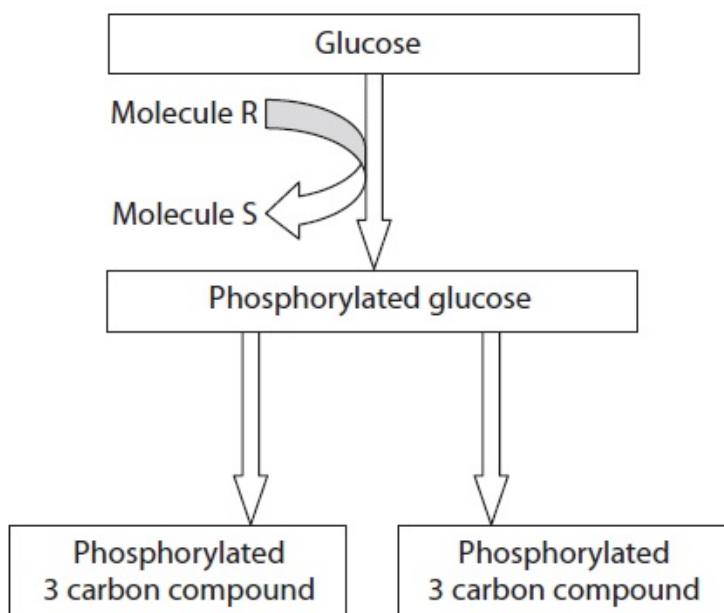
Pearson publishes its past papers and mark schemes free of charge. Always check the current specification at [qualifications.pearson.com](https://www.pearson.com/qualifications) before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

Respiration is a vital process in living organisms. All organisms carry out glycolysis. The Krebs cycle also occurs in some organisms.

(a) The diagram below shows some of the stages in glycolysis, using the hexose sugar glucose.



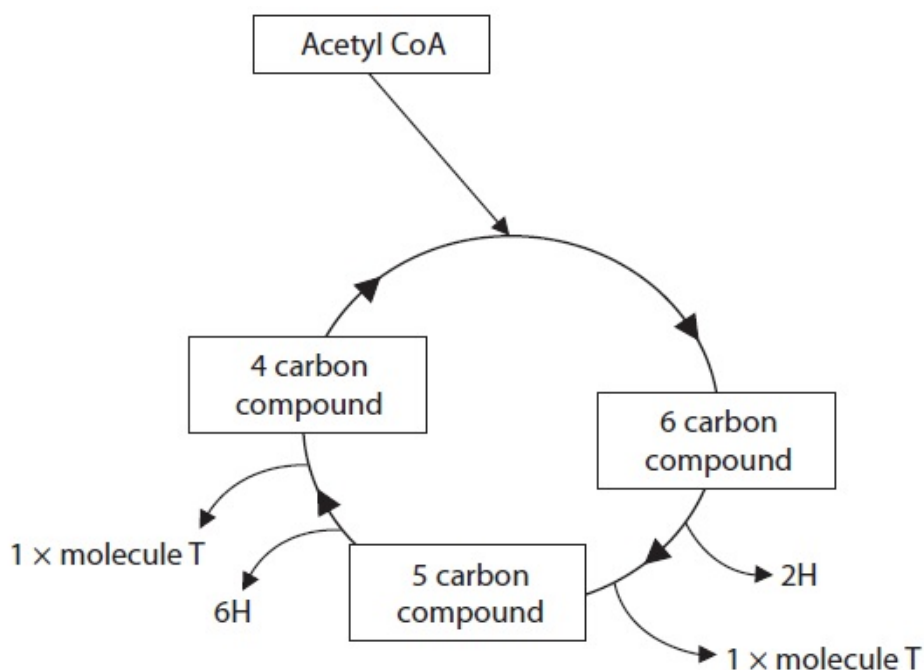
Name the molecules R and S shown in the diagram.

(2)

Molecule R

Molecule S

(b) The diagram below shows some of the stages in the Krebs cycle.



(i) Name molecule T and use the information in the Krebs cycle diagram to give a reason for your answer.

(2)

.....

.....

.....

.....

(ii) Using information in the diagram, suggest what would happen in the Krebs cycle if acetyl CoA became unavailable.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

(b) The hydrogen (H) from the Krebs cycle enters the electron transport chain and oxidative phosphorylation occurs.

Explain what is meant by the term **oxidative phosphorylation**.

(3)

.....

.....

.....

.....

.....

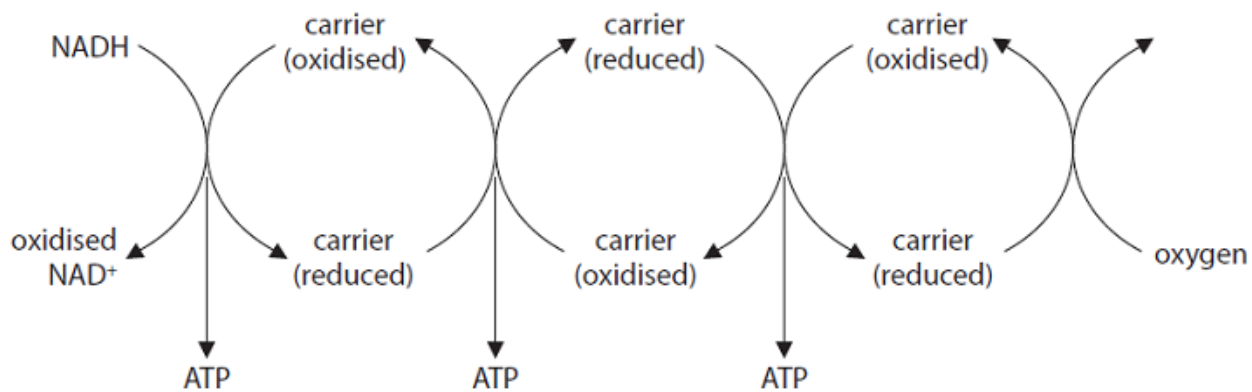
.....

(Total for question = 10 marks)

Q2.

Compare and contrast the way in which ATP is synthesised in mitochondria and in chloroplasts.

The diagram below shows part of the electron transport chain.



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

(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)

.....

.....

.....

.....

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

(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)

.....

.....

.....

(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)

.....

.....

.....

.....

.....

.....

(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)

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

The table shows the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

Membrane of mitochondrion	Protein : lipid ratio
inner	3:2
outer	1:1

Explain the difference in the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

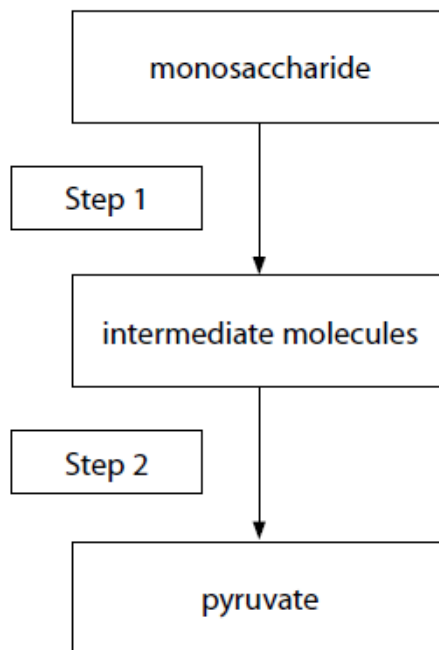
.....

.....

.....

(Total for question = 6 marks)

The diagram below shows a stage of the process of respiration in the cytoplasm of muscle cells.



(a) What is the name of this stage?

(1)

- ☐ **A** Calvin cycle
- ☐ **B** glycogenolysis
- ☐ **C** glycolysis
- ☐ **D** Krebs cycle

(b) Which other products are formed during this stage?

(1)

- ☐ **A** ADP and carbon dioxide
- ☐ **B** ADP and oxidised coenzyme
- ☐ **C** ATP and carbon dioxide
- ☐ **D** ATP and reduced coenzyme

(c) What occurs in the first reaction of step 1?

(1)

- ☐ **A** condensation
- ☐ **B** hydrolysis
- ☐ **C** phosphorylation
- ☐ **D** photophosphorylation

(d) Describe what happens to the pyruvate when the muscle is supplied with oxygen.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 7 marks)

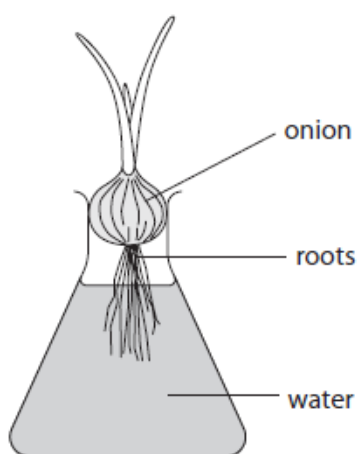
Q8.

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)

.....

.....

.....

.....

.....

.....

.....

.....

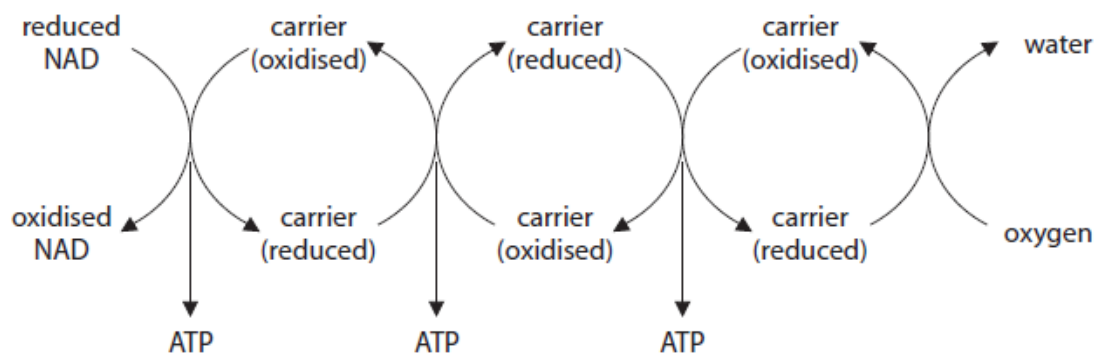
.....

(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)

.....

(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)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q11. The scientific article you have studied is adapted from several sources.

Use the information from the article and your own knowledge to answer the following questions.

(a) The sweet potato eaten by naked mole rats (paragraph 3) is very rich in starch. Starch can be a combination of amylose and amylopectin.

Give **two** structural differences between amylose and amylopectin.

(2)

.....

.....

.....

.....

.....

(b) Explain why a colony of naked mole rats is considered 'a eusocial society' (paragraph 4).

(2)

.....

.....

.....

.....

.....

(c) Naked mole rats show evidence of poikilothermy (paragraph 5).

(i) Explain what is meant by the term **poikilothermic**.

(1)

.....

.....

.....

(ii) Suggest how each of the following 'contribute to poikilothermic responses to changing temperature of this mammal'.

(2)

'Lack of an insulating layer'

.....

.....

.....

'A marked reduction in sweat glands'

.....

.....

.....

(d) Suggest a mechanism that could have been used to genetically modify cells from mice with cancer-causing genes (paragraph 13).

(2)

.....

.....

.....

.....

.....

*(e) Whilst naked mole rats are 'impervious to chemical pain' they do feel 'acute pain such as cuts and burns' (paragraph 31).

Touching something hot, which could lead to a burn, can cause nerve impulses to travel along myelinated sensory neurones very rapidly.

Explain how myelination increases the speed of transmission of nerve impulses in a sensory neurone.

(5)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(f) Explain how a heart attack can temporarily reduce the oxygen concentration in brain tissue (paragraph 36).

(3)

.....

.....

.....

.....

.....

.....

.....

(g) Using the information in paragraph 48, name **one** hormone **and** state its function.

(1)

Hormone:

.....

Function:

.....

.....

.....

(h) Suggest how a change in the mid region of the sperm may make it non-motile (paragraph 48).

(2)

.....

.....

.....

.....

.....

.....

.....

(i) Disperser naked mole rats 'are laden with fat' (paragraph 50).

Suggest why it may be advantageous for disperser naked mole rats to have high levels of fat.

(3)

.....

.....

.....

.....

.....

.....

.....

(j) Explain the statement that 'a preference by reproductively active females for unfamiliar males is interpreted as inbreeding avoidance' (paragraph 52).

(2)

.....

.....

.....

(4)

This image shows a single sheet of white paper with horizontal ruling lines. The lines are evenly spaced and run across the width of the page. There are no margins, text, or other markings on the paper.

Q12.

A student investigated the rate of uptake of nitrate ions (NO_3^-) into plant cells.

Discs of carrot were cut and half of them were immersed in a solution containing $10 \mu\text{mol dm}^{-3}$ nitrate ions. The other half were placed in the same nitrate ion solution to which 2,4-dinitrophenol (DNP) was added.

DNP inhibits the process of oxidative phosphorylation.

The nitrate ion concentration of the discs was determined every five minutes.

The student failed to pre-treat the carrot discs before placing them in the solution.

(a) Explain how the carrot discs should be pre-treated.

(3)

.....

.....

.....

.....

.....

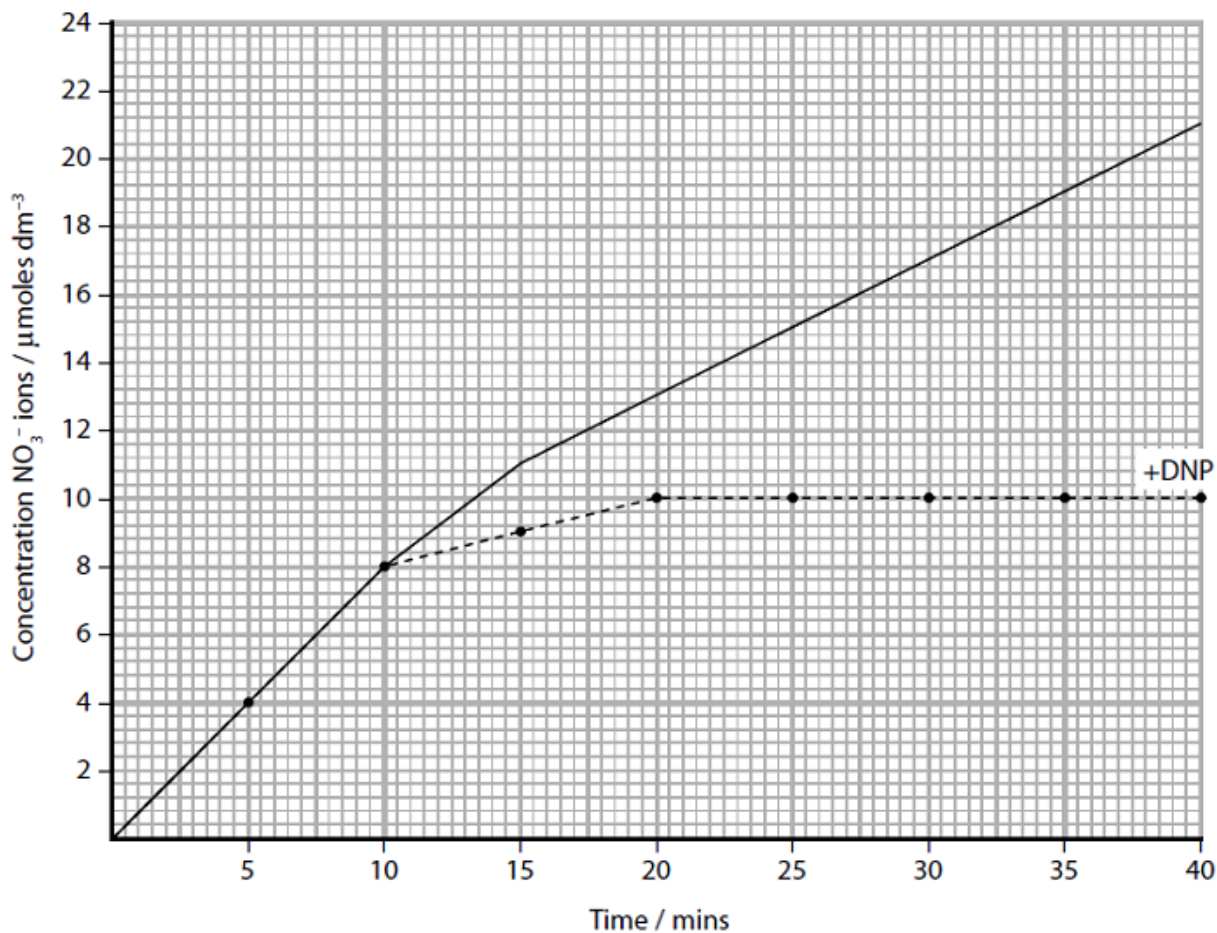
.....

.....

.....

.....

The graph below shows the results of this investigation after the carrot discs were pre-treated.



(b) Calculate the mean rate of nitrate ion uptake of the carrot discs placed in the nitrate ion solution without DNP between 5 and 10 minutes.

(3)

Answer

(c) Analyse the data to explain the effect of DNP on the nitrate ion uptake of the carrot tissue between 0 to 10 minutes and 20 to 30 minutes.

(3)

.....

.....

.....

.....

.....

.....

(d) DNP acts by rapidly transferring protons (H^+ ions) across biological membranes.

Explain how this action will bring about the effect of DNP on oxidative phosphorylation.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 12 marks)

Q13.

The electron carriers in chloroplasts are inhibited by detergent.

Detergents dissolve lipids.

Explain how detergents inhibit the functioning of electron carriers in chloroplasts.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

Q14.

The photograph below shows a desert mammal.



(Source: <http://www.ardea.com>)

Some desert mammals do not drink water. They obtain water from the food they eat and from respiration.

(a) Explain how water is formed in respiration.

(2)

.....

.....

.....

.....

(b) The table below shows the percentage of plant roots and insects in the diet of two different species of desert mammal.

Food	Percentage of food in diet (%)	
	<i>M. hurrianae</i>	<i>T. indica</i>
Plant roots	40	20
Insects	10	25

(i) The desert mammals eat 8 g of food in one day. Calculate how many more grams of insects are eaten by *T. indica* than by *M. hurrianae*.

(2)

Answer g

(ii) Which species has kidneys that will produce the most concentrated urine?
Justify your answer.

(2)

.....

.....

.....

.....

(c) Which row of the table below shows the correct changes to the concentration of sodium ions as fluid moves along the descending and ascending loop of Henle?

(1)

	Concentration of sodium ions (Na ⁺) in descending loop of Henle	Concentration of sodium ions (Na ⁺) in ascending loop of Henle
☐ A	increases	increases
☐ B	increases	decreases
☐ C	decreases	increases
☐ D	decreases	decreases

(d) The concentration of urine is controlled by osmoreceptors and the secretion of ADH.

Which row of the table below shows the location of the osmoreceptors and the correct level of ADH secretion in a desert mammal that produces concentrated urine?

(1)

	Location of osmoreceptors	Level of ADH
☐ A	carotid body	high
☐ B	carotid body	low
☐ C	hypothalamus	high
☐ D	hypothalamus	low

(e) Explain how the nephrons of desert mammals enable them to survive in a dry environment.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 12 marks)

Q15.

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 mutations that affect proteins involved in the electron transport chain.

Explain why these mutations lead to a build-up of lactate.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 3 marks)

Q16.

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)

.....

.....

.....

.....

.....

.....

(Total for question = 2 marks)

Q17.

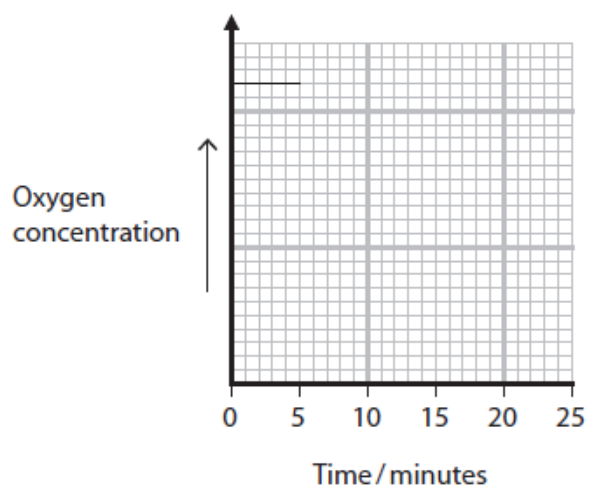
The effect of cyanide on oxygen uptake by mitochondria was investigated using the following method:

- 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)

Mark Scheme

Q1.

Question Number	Answer	Mark
(a)	molecule R - ATP / adenosine triphosphate ; molecule S - ADP / adenosine diphosphate ;	(2)

Question Number	Answer	Mark
(b)(i)	1. carbon dioxide / CO ₂ ; 2. idea that the C has been removed from C ₆ or C ₅ ;	(2)

Question Number	Answer	Mark
(b)(ii)	1. cycle would stop / eq ; 2. 4 carbon compound would accumulate / eq ; 3. 6 carbon compound would {run short / not be synthesised} / 5 carbon compound would run short / eq ; 4. idea that {molecule T / H} reduce ;	(3)

Question Number	Answer	Mark
(c)	1. idea of electrons being {passed along / eq} the electron transport chain ; 2. idea of {losing / eq} energy ; 3. (used to) add a phosphate to ADP to make ATP / eq ; 4. reference to ATPase ; 5. idea of chemiosmosis ; 6. idea of oxygen as the final acceptor ;	(3)

Q2.

Question Number	Acceptable Answer	Additional Guidance	Mark
	An answer that makes reference to the following: Similarities - both use an electron transport chain on membranes (1) - both use ATPase driven by { H^+ gradient / chemiosmosis / eq } (1) - in both, electrons passed from one carrier to another lose energy which drives ATP production (1)	At least one similarity and one difference must be given to gain full marks. Max 2 marks if only 3 similarities provided Max 1 marks if only 2 similarities provided	(5)

	Differences - energy is provided by light in chloroplasts but by { glucose / pyruvate / eq } in mitochondria (1) - ATP is made by photophosphorylation in chloroplasts but by { substrate level / oxidative phosphorylation } in mitochondria (1) - in chloroplasts, electrons are provided by chlorophyll but in mitochondria, electrons are brought by reduced { NAD / FAD } (1) - in chloroplasts, (some) electrons return to chlorophyll whereas in mitochondria, electrons are accepted by oxygen (1)	Max 3 marks if only 4 differences provided Max 2 marks if only 3 differences provided Max 1 marks if only 2 differences provided	
--	---	---	--

Q3.

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)

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)	$1 \times 10 = 10 \text{ mg}$ $0.24 \text{ mg dm}^{-3} \times 15 = 3.6 \text{ (mg per minute)}$ $10 \div 3.6 = \mathbf{2.78} \text{ minutes (3sf)}$ $1 \times 10 = 10 \text{ mg}$ $10 \div 0.24 = 41.67 \text{ (dm}^3\text{)}$ $41.67 \div 15 = \mathbf{2.78} \text{ minutes (3sf)}$	(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	Indicative content
*	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. 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. Indicative content: • membranes both made of phospholipid bilayer with embedded proteins • lipid content is the phospholipid bilayer • phospholipids needed for {fluidity / compartmentalisation} • higher protein : lipid ratio in the inner membrane / more protein compared to lipid in the inner membrane • protein content equals lipid content in outer membrane • role of inner membrane is oxidative phosphorylation / chemiosmosis / synthesise ATP • inner membrane contains proteins involved in electron transport • inner membrane contains ATPase channels • movement of protons through ATPase channels results in ATP formation • proteins in outer membrane to allow pyruvate to pass through

Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain description of membrane structure 1 mark = 2 points 2 marks = 3 points
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages between the two membranes and their lipid and protein content 3 marks = explanation of ATPase or electron transport proteins or outer membrane 4 marks = explanation of two from ATPase, electron transport proteins, outer membrane
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which relates named protein molecules to the high protein content of the inner membrane 5 marks = explanation of ATPase, electron transport proteins and outer membrane 6 marks = clear, accurate account of oxidative phosphorylation

Q7.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	B		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(d)	A description that makes reference to the following: - it is transported into the (matrix) mitochondria (1) - link reaction oxidises pyruvate to form NADH + H⁺ (1) - carbon dioxide is removed (1) - molecule combines with acetyl CoA to form coenzyme A (1)		(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 <i>A is not correct because an insertion adds an additional base</i> <i>B is not correct because monosomy is a chromosome mutation</i> <i>D is not correct because translocation is a chromosome mutation</i>	(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 Comments	Mark
(a)	1. only (alpha) 1-4 glycosidic bonds in amylose / (alpha) 1-6 only found in amylopectin ; 2. only amylopectin has side branches / only amylose is {coiled / eq} ; 3. Amylopectin is a {larger / eq} molecule than amylose ;	1. ACCEPT 1-6 and 1-4 in amylopectin	(2)

Question Number	Answer	Additional Comments	Mark
(b)	1. Different individuals in the {colony / eq} take on specific {roles / jobs / eq} ; 2. Example given e.g. queen produces offspring ;	1. Accept division of labour 2. Accept dominance by queen, {few of the males / kings} involved in breeding	(2)

Question Number	Answer	Additional Comments	Mark
(c) (i)	Idea that body temperature of animal mimics the ambient temperature ;	Accept body temp follows environmental temperature	(1)

Question Number	Answer	Additional Comments	Mark
(c) (ii)	1. Lack of insulating layer: Idea that does not impede transfer of heat energy / allows exchange of heat energy more easily ; 2. A marked reduction in sweat glands: Idea that they do not need to cool down OR less water lost ;	1. Accept enables heat transfer between environment and NMR	(2)

Question Number	Answer	Additional Comments	Mark
(d)	1. (Cancer causing) gene identified / eq ; 2. Gene {cut / isolated / eq} from DNA / eq ; 3. Using a {restriction / eq} enzyme / eq ; 4. Gene in {vector / named vector} ; 5. Mechanism for getting {gene/vector} into host cells (of mice) / eq ;	1. Accept screen for the gene 2. Accept extracted 3. Accept correctly named restriction enzyme e.g. EcoR1 4. Accept Named <u>egs</u> – retrovirus, virus, liposome, plasmid, bacteria 5. Accept reference to (micro)injection, <u>microprojectiles</u> , electroporation, gene gun, inhaler, transduction	(3)

Question Number	Answer	Additional Comments	Mark
* (e)	QWC – Spelling of technical terms (<i>shown in italics</i>) must be correct and the answer must be organised in a logical sequence 1. {<i>neurone</i> (cell) surface membrane exposed / no <i>myelination</i> / eq} at nodes of <i>Ranvier</i> ; 2. Nodes are the site of clusters of {<i>sodium-gated channel proteins</i> / <i>potassium channels</i>} ; 3. Which {open / close} when <i>impulse</i> arrives / eq ; 4. Allowing <i>depolarisation</i> at nodes / eq ; 5. idea that <i>myelin</i>/eq acts as an (electrical) <i>insulator</i> (on <i>neurone</i> surface between nodes) ; 6. reference to <i>Schwann</i> cell ; 7. idea that <i>impulse/depolarisation</i> 'jumps' to next node ; 8. Reference to this being <i>saltatory conduction</i> ; 9. idea that this happens between the <i>myelin</i> layers of the <i>Schwann</i> cell ;	QWC emphasis on spelling 3. Accept influx of sodium ions	(5)

Question Number	Answer	Additional Comments	Mark
(f)	1. idea of heart working less efficiently ; 2. idea of less oxygen absorbed at lungs / eq ; 3. less blood pumped to brain ; 4. concentration gradient (for oxygen) at brain reduced / eq ; 5. less oxygen in blood (in brain) diffuses into brain tissue / eq ; 6. idea of less oxygen in brain tissue due to continual (aerobic) respiration ;		(3)

Question Number	Answer	Additional Comments	Mark
(g)	~~gonadotrophin~~-releasing (hormone) stimulates ~~gonadotrophin~~ release / ~~gonadotrophin~~ stimulates ovulation / testosterone stimulates {sperm production / (male) secondary sexual characteristics / other named example} ;		(1)

Question Number	Answer	Additional Comments	Mark
(h)	1. Idea of effect on mitochondria ; 2. (therefore) reduced {energy / ATP / eq} for flagellum movement ;	1. Accept less efficient/fewer/ none 2. Accept tail for flagellum	(2)

Question Number	Answer	Additional Comments	Mark
(i)	1. idea that fat is an energy store ; 2. reduces dependence on external food source / eq ; 3. enables disperser to travel / eq ; 4. (metabolic) water is released (on oxidation) / eq ; 5. acts as a thermal insulator / eq ;	Accept energy-rich	(3)

Question Number	Answer	Additional Comments	Mark
(j)	1. idea that unfamiliar males are likely to be genetically different ; 2. idea that this is outbreeding ; 3. idea that this increases genetic diversity ;	3. Accept producing offspring that are genetically different	(2)

Question Number	Answer	Additional Comments	Mark
(k)	the order of the {bases / genes and non-coding sequences / eq} in the DNA (of the naked mole rats) is found / eq ;	Accept exons and introns Ignore genes unqualified	(1)

Question Number	Answer	Additional Comments	Mark
(l)	Paired responses: 1. reduced sensitivity to chemical pain / disconnection of 'pain nerves' ; 2. Idea of pain relief e.g. dealing with post traumatic pain, post surgical pain, joint pain after a knee operation ; 3. haemoglobin has higher affinity for oxygen ; 4. Idea of dealing with reduced oxygen situations such as due to a heart attack or stroke ; 5. Naked mole rat {incisors / eq} grow through skin (of lip) without damage ; 6. Idea of better prosthesis e.g. new {coatings / permanent seal} at {skin / bone / metal} interface, soft tissue not damaged, avoid infection ; 7. High protein stability / does not (easily) lose 3D shape ; 8. (so) reduced effect of oxidative {damage / stress} / reduced effect of oxygen-containing free radicals / live healthily into old age ; 9. Cell overcrowding early warning gene / ref. to two tiered contact inhibition / presence of gene p16 ; 10. Idea of cancer prevention e.g. cancer resistance, future cancer therapy ; 11. Naked mole rat neurones display immature {characteristics / physiological properties} / brain cells that cope with {low oxygen / hypoxia} ; 12. To treat people with temporary loss of oxygen to brain e.g. heart attack, stroke, drowning / to prevent permanent brain damage ; 13. High levels of oxytocin receptors in {brain / nucleus <u>accumbens</u> } ; 14. Idea of links to autism ; 15. Naked mole rats do not experience menopause ; 16. Ref to osteoporosis {treatment / prevention} (without side effects) ; 17. circadian rhythms / sleep patterns of naked mole rats ; 18. Idea that may help with sleep disorders ;	9. Accept anticancer mechanism	

Q12.

Question Number	Correct Answer	Additional guidance	Mark
(a)	An explanation that makes reference to the following: - wash immerse in water / water without nitrate ions (1) - at a suitable temperature / stated temperature (less than 25 °C) (1) - reference to sterile water (1)		(3)

Question Number	Correct Answer	Additional guidance	Mark
(b)	An answer that makes reference to the following: - reading from graph 5 mins = 4 $\mu\text{mol dm}^{-3}$ 30 mins = 8 $\mu\text{mol dm}^{-3}$ (1) - mean rate = increase $\div$ time (4 $\div$ 5) (1) - correct answer with units = 0.8 $\mu\text{mol dm}^{-3} \text{ min}^{-1}$ (1)	Candidate must state units for full marks	(3)

Question Number	Correct Answer	Additional guidance	Mark
(c)	An explanation that makes reference to the following: - rate the same for both solutions between 0–10 minutes because initial uptake in both by (passive) diffusion (1) - rate with DNP zero between 20–30 minutes because uptake requires {energy / ATP} for active transport (1) - DNP prevents formation of ATP by chemiosmosis (1)		(3)

Question Number	Correct Answer	Additional guidance	Mark
(d)	An explanation that makes reference to the following: - DNP transports protons across the inner mitochondrial membrane (1) - therefore preventing the establishment of a gradient across the membrane (1) - which prevents the formation of ATP (1)	cristae Accept inhibits interaction between protons and ATP synthase	(3)

Q13.

Question Number	Acceptable Answer	Additional guidance	Mark
	An explanation that makes reference to the following: - electron carrier components are on chloroplast membranes (1) - detergents disrupt the phospholipid bilayer in the membranes (1) - therefore electrons can no longer move along the chain (1)		(3)

Q14.

Question Number	Correct Answer	Additional guidance	Mark
(a)	An explanation that makes reference to the following: - reference to electron transport chain (1) - oxygen as final proton and electron acceptor (1)		(2)

Question Number	Correct Answer	Additional guidance	Mark
(b)(i)	25% of 8 g = 2 g and 10% of 8 g = 0.8 g (1) 2 g – 0.8 g = 1.2 g (1)		(2)

Question Number	Correct Answer	Additional guidance	Mark
(b)(ii)	An answer that makes reference to the following: <i>T. indica</i> because eats fewer plant roots (1) - plant roots contain more water than insects (1)		(2)

Question Number	Correct Answer	Additional guidance	Mark
(c)	B		(1)

Question Number	Correct Answer	Additional guidance	Mark
(d)	C		(1)

Question Number	Correct Answer	Additional guidance	Mark
(e)	An explanation that makes reference to the following: - desert mammals have long loops of Henle (1) - which allows for a greater counter current multiplier effect (1) - therefore a higher concentration of solute / sodium chloride at base of the medulla (1) - which causes greater amounts of water to be reabsorbed from collecting ducts (1)		(4)

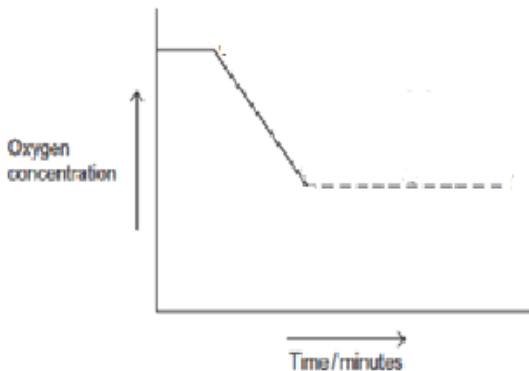
Q15.

Question Number	Answer	Additional Guidance	Mark
	An explanation that makes reference to three of the following: • mutation may prevent {electrons being passed down the electron transport chain / ATPase from working properly} (1) • therefore {NADH / reduced NAD} cannot be oxidised (1) • therefore pyruvate and {NADH / reduced NAD} will produce lactate (1) • lactate produced at a faster rate than it can be removed (1)	Accept reformed / converted back	(3)

Q16.

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 / FADH₂	(2)

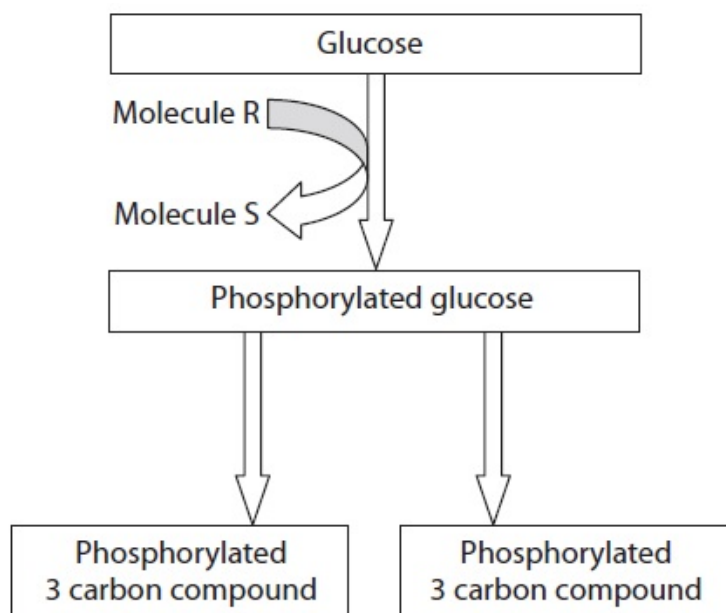
Q17.

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)	 The graph shows a line that is horizontal at the start, then decreases linearly, and finally becomes horizontal again at a lower level. The y-axis is labeled 'Oxygen concentration' and the x-axis is labeled 'Time/minutes'.	(2)

Q1.

Respiration is a vital process in living organisms. All organisms carry out glycolysis. The Krebs cycle also occurs in some organisms.

(a) The diagram below shows some of the stages in glycolysis, using the hexose sugar glucose.



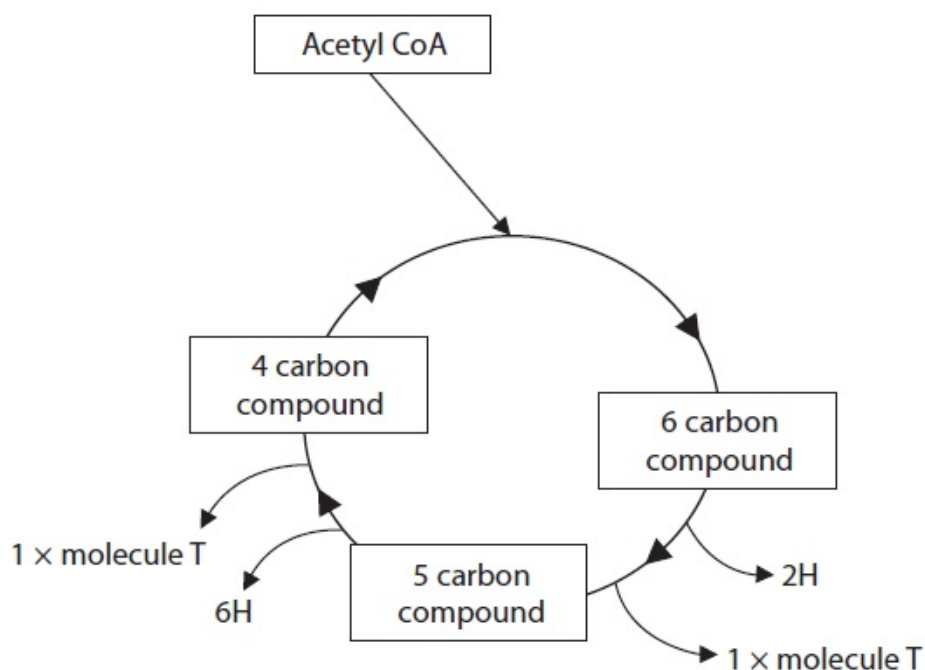
Name the molecules R and S shown in the diagram.

(2)

Molecule R

Molecule S

(b) The diagram below shows some of the stages in the Krebs cycle.



(i) Name molecule T and use the information in the Krebs cycle diagram to give a reason for your answer.

(2)

.....

.....

.....

.....

(ii) Using information in the diagram, suggest what would happen in the Krebs cycle if acetyl CoA became unavailable.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

(b) The hydrogen (H) from the Krebs cycle enters the electron transport chain and oxidative phosphorylation occurs.

Explain what is meant by the term **oxidative phosphorylation**.

(3)

.....

.....

.....

.....

.....

.....

(Total for question = 10 marks)

Q2.

The scientific article you have studied is adapted from articles in New Scientist.

Use the information from the article and your own knowledge to answer the following questions.

(a) Suggest why 'incredibly efficient cellular mechanisms' can increase the chance of obesity (paragraphs 4 and 5).

(2)

.....

.....

.....

.....

.....

.....

(b) A larger VO₂max means more oxygen can enter a mitochondrion and therefore more energy can be released from fuel (paragraph 8).

Name **two** substances, other than oxygen, that need to enter the mitochondrion to enable energy to be released from fuel.

(2)

.....

.....

(c) Describe the structure of glycogen (paragraph 11).

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(d) Using the information in paragraphs 12 to 14, explain how lowered testosterone levels may help a cyclist to race harder on successive days.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

(e) Explain why Coyle suggests that greater muscle efficiency may be linked to an increase in the percentage of **slow twitch** muscle fibres (paragraph 20).

(2)

.....

.....

.....

.....

.....

.....

*(f) Suggest how 'the development of a leak in a specific class of calcium channel in muscle cells' can lead to muscle fatigue (paragraph 23).

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(g) The ACE gene codes for the synthesis of angiotensin converting enzyme (ACE) (paragraph 25).

Complete the table by naming two nucleic acids involved in each of the processes described.

(2)

Process	Two nucleic acids involved in the process
Transcription of the ACE gene	1 2
Synthesis of ACE at a ribosome	1 2

(h) A variant of the APOE gene could put individuals at increased risk in contact sports. DNA profiling is a technique that can be used in genetic screening.

Suggest how DNA profiling could be carried out to identify this variant of the APOE gene (paragraph 27).

(4)

.....

.....

.....

.....

.....

.....

.....

.....

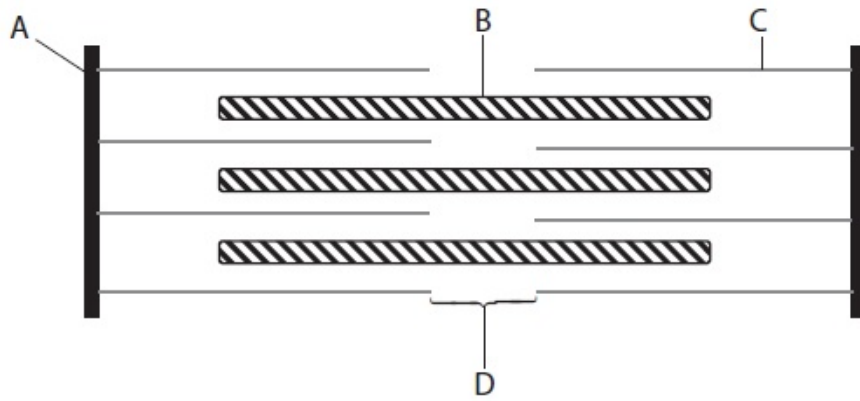
.....

.....

.....

.....

(i) The titin gene produces a protein that attaches to myosin in a sarcomere (paragraph 30).



Place a cross (☒) in the box that identifies myosin shown in the diagram.

(1)

☒ A

☒ B

☐ C

☐ D

(j) The colder the water Japanese Ama divers swim in, the higher their resting metabolic rate (paragraph 50).

Suggest and explain why this might be an advantage to these divers.

(3)

.....

.....

.....

.....

.....

.....

(k) Pugh noticed the effects of climate change (paragraph 53).

Name **two** greenhouse gases that contribute to climate change. Give **one** source of each of these gases.

(2)

.....

.....

.....

.....

(I) Using the information in paragraph 55, calculate the percentage increase in Pugh's core body temperature due to his "anticipatory thermogenesis".

Show your working.

(2)

Answer = ... %

(Total for question = 30 marks)

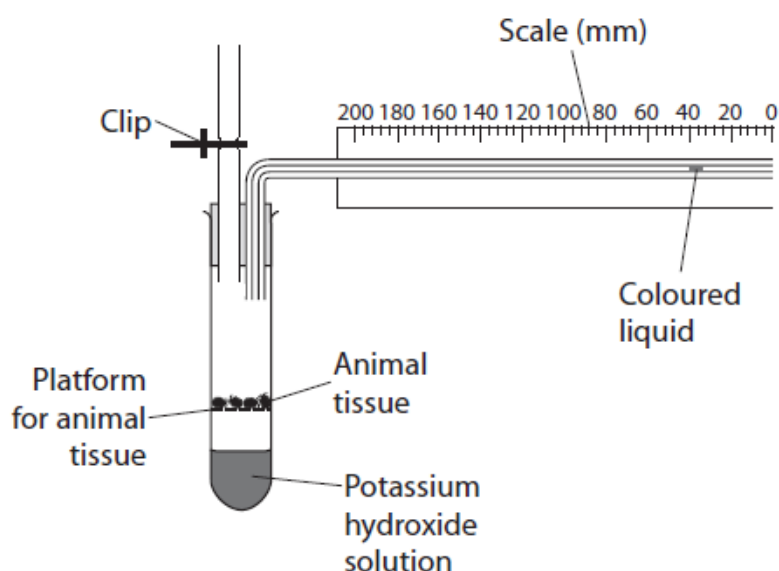
Q3.

The tissues of some animals can carry out anaerobic and aerobic respiration.

Three investigations were carried out to study respiration in an animal tissue, using the apparatus shown below.

The tissue used glucose as the respiratory substrate.

All other variables were kept constant.



The table below shows the three investigations that were carried out and the result for investigation 1.

Investigation	Type of respiration	Potassium hydroxide solution absent or present	Coloured liquid moved to the left	Coloured liquid moved to the right	Coloured liquid did not move
1	Anaerobic	Absent	☐	☐	☒
2	Aerobic	Absent	☐	☐	☐
3	Aerobic	Present	☐	☐	☐

(i) Complete the table by placing a cross in one box ☒ for each of investigations 2 and 3 to show the response of the coloured liquid.

(2)

(ii) Explain why the coloured liquid did not move in investigation 1.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(iii) Reduced NAD ($\text{NADH} + \text{H}^+$) would be formed in investigations 2 and 3.

Describe the fate of reduced NAD in aerobic respiration.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

Q4.

The table shows the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

Membrane of mitochondrion	Protein : lipid ratio
inner	3:2
outer	1:1

Explain the difference in the protein : lipid ratio of the inner and outer membrane of a mitochondrion.

(6)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

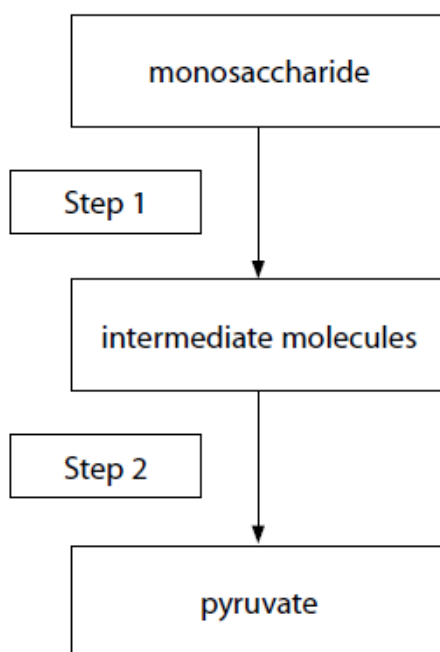
.....

.....

(Total for question = 6 marks)

Q5.

The diagram below shows a stage of the process of respiration in the cytoplasm of muscle cells.



(a) What is the name of this stage?

(1)

- ☐ **A** Calvin cycle
- ☐ **B** glycogenolysis
- ☐ **C** glycolysis
- ☐ **D** Krebs cycle

(b) Which other products are formed during this stage?

(1)

- ☐ **A** ADP and carbon dioxide
- ☐ **B** ADP and oxidised coenzyme
- ☐ **C** ATP and carbon dioxide
- ☐ **D** ATP and reduced coenzyme

(c) What occurs in the first reaction of step 1?

(1)

- ☐ **A** condensation
- ☐ **B** hydrolysis
- ☐ **C** phosphorylation
- ☐ **D** photophosphorylation

(d) Describe what happens to the pyruvate when the muscle is supplied with oxygen.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 7 marks)

Q6.

(i) Which of the following stages of aerobic respiration produces four molecules of carbon dioxide for each glucose molecule?

(1)

- ☐ **A** glycolysis

- ☐ **B** Krebs cycle
- ☐ **C** link reaction
- ☐ **D** oxidative phosphorylation

(ii) Which of the following is the approximate percentage of total ATP produced, directly from the Krebs cycle?

(1)

- ☐ **A** 0%
- ☐ **B** 5%
- ☐ **C** 63%
- ☐ **D** 100%

(iii) Describe how glucose is converted to pyruvate in glycolysis.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

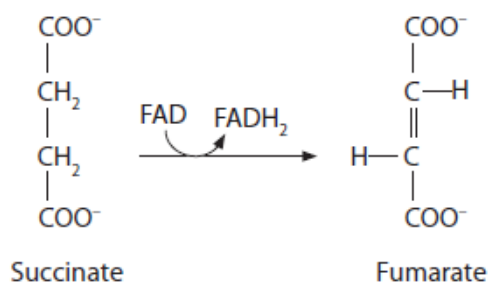
Q7.

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.



(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)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 5 marks)

Q8. The scientific article you have studied is adapted from several sources.

Use the information from the article and your own knowledge to answer the following questions.

(a) The sweet potato eaten by naked mole rats (paragraph 3) is very rich in starch. Starch can be a combination of amylose and amylopectin.

Give **two** structural differences between amylose and amylopectin.

(2)

.....

.....

.....

.....

.....

(b) Explain why a colony of naked mole rats is considered 'a eusocial society' (paragraph 4).

(2)

.....

.....

.....

.....

.....

(c) Naked mole rats show evidence of poikilothermy (paragraph 5).

(i) Explain what is meant by the term **poikilothermic**.

(1)

.....

.....

.....

(ii) Suggest how each of the following 'contribute to poikilothermic responses to changing temperature of this mammal'.

(2)

'Lack of an insulating layer'

.....

.....

'A marked reduction in sweat glands'

.....

.....

.....

.....

.....

Touching something hot, which could lead to a burn, can cause nerve impulses to travel along myelinated sensory neurones very rapidly.

Explain how myelination increases the speed of transmission of nerve impulses in a sensory neurone.

This image shows a full page of white paper with ten horizontal dashed lines, typical of primary school handwriting practice paper. The lines are evenly spaced and extend across the entire width of the page. There is no text or other markings on the paper.

.....

(f) Explain how a heart attack can temporarily reduce the oxygen concentration in brain tissue (paragraph 36).

(3)

.....

.....

.....

.....

.....

.....

.....

.....

(g) Using the information in paragraph 48, name **one** hormone **and** state its function.

(1)

Hormone:

.....

Function:

.....

.....

.....

(h) Suggest how a change in the mid region of the sperm may make it non-motile (paragraph 48).

(2)

.....

.....

.....

.....

.....

.....

(i) Disperser naked mole rats 'are laden with fat' (paragraph 50).

Suggest why it may be advantageous for disperser naked mole rats to have high levels of fat.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

(j) Explain the statement that 'a preference by reproductively active females for unfamiliar males is interpreted as inbreeding avoidance' (paragraph 52).

(2)

.....

.....

.....

.....

(k) 'The naked mole rat hasn't yet had its genome sequenced' (paragraph 53).

Explain what is meant by the term **genome sequenced**.

(1)

.....

.....

.....

(l) 'With so much to offer science, it is no surprise that naked mole rats are becoming more common in labs' (paragraph 53).

Using information from the article, describe **two** adaptations of naked mole rats. For each adaptation, explain why it could be of interest in a medical research laboratory.

(4)

.....

.....

.....

[illegible]

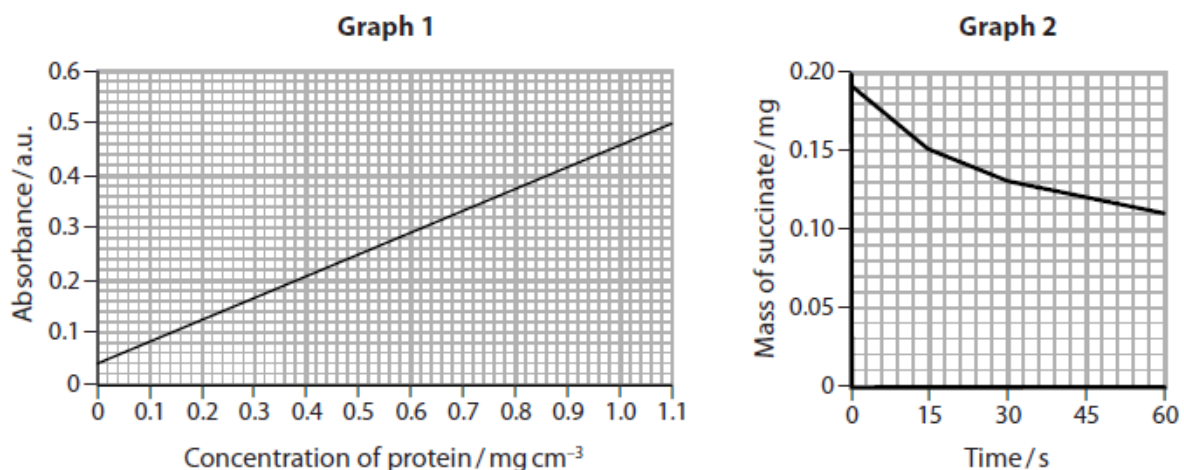
Q9.

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.



(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)

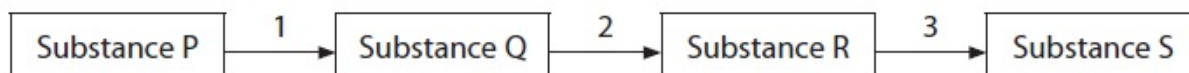
Ratio

(Total for question = 3 marks)

Q10. Respiration is a metabolic process which consists of many steps.

(a) The diagram below shows a metabolic process consisting of three steps.

Each letter represents a different substance and each number a different enzyme.



Describe and explain the functions of enzymes in this metabolic process.

(4)

.....

.....

.....

.....

.....

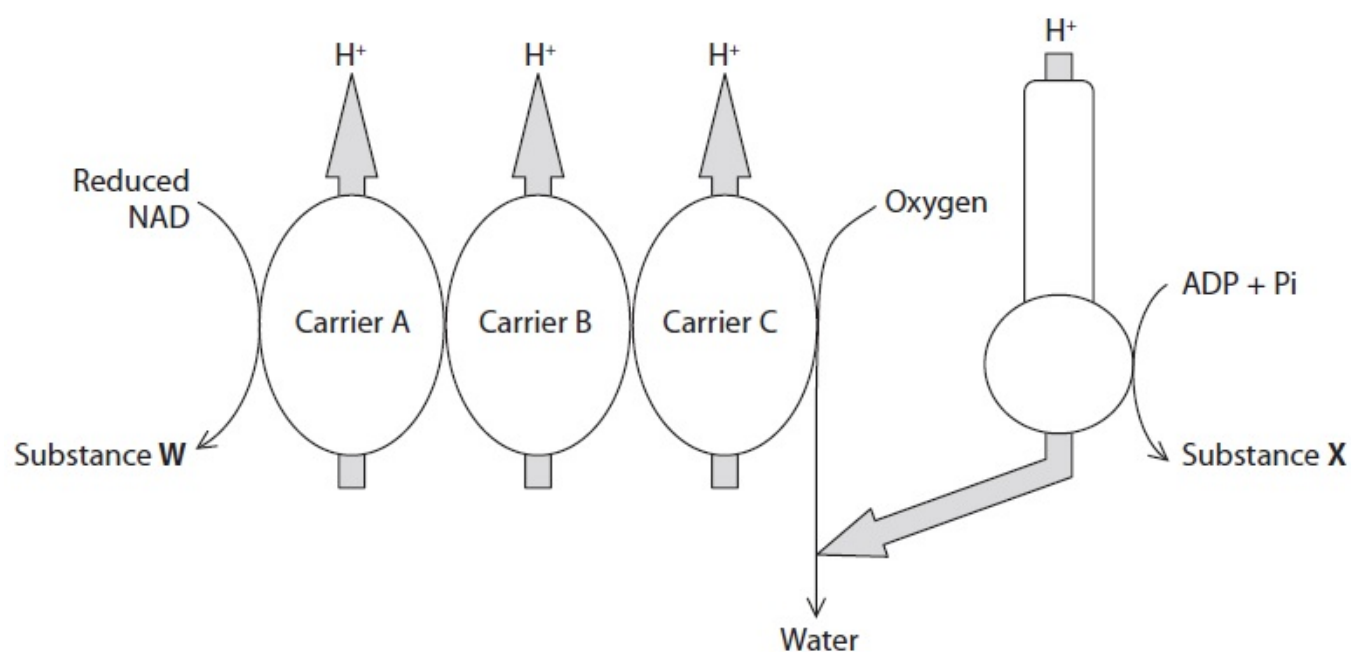
.....

.....

.....

.....

(b) The diagram below shows the electron transport chain, which is part of aerobic respiration.



(i) Using the information in the diagram, name substance **W** and explain how it is formed.

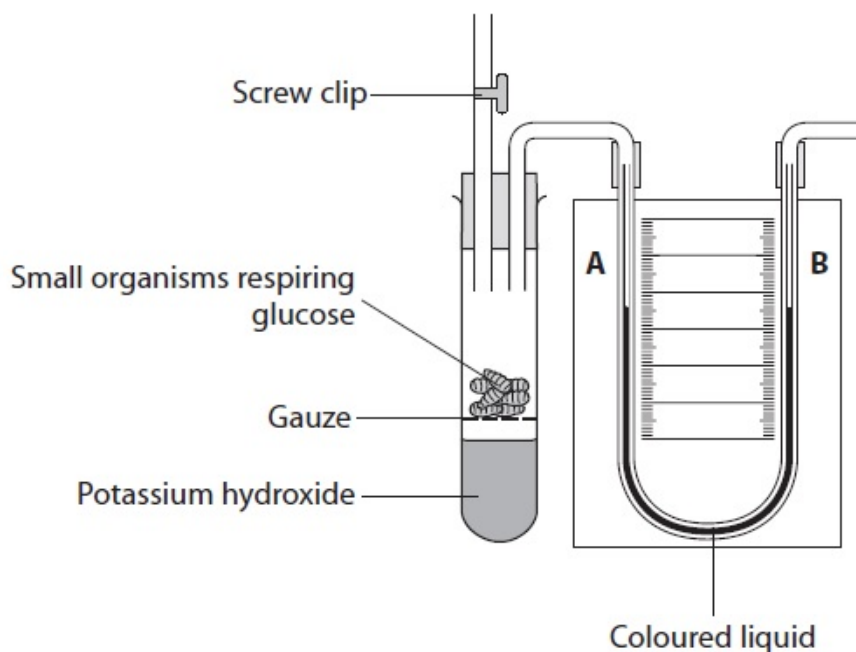
(3)

(ii) Name substance **X**.

Explain the link between the formation of substance **X** and the H^+ shown on the diagram.

(3)

(c) The diagram below shows a respirometer used to measure the rate of aerobic respiration in small organisms.



Potassium hydroxide absorbs carbon dioxide.

The table below describes three different situations.

Place a cross in the box ☐ that correctly shows the movement of the coloured liquid in the U-shaped tube for each situation.

(3)

Situation	Movement of coloured liquid		
	towards A	towards B	does not move
Screw clip is open	☐	☐	☐
Screw clip is closed	☐	☐	☐
Potassium hydroxide is replaced with water and screw clip is closed	☐	☐	☐

(Total for Question = 13 marks)

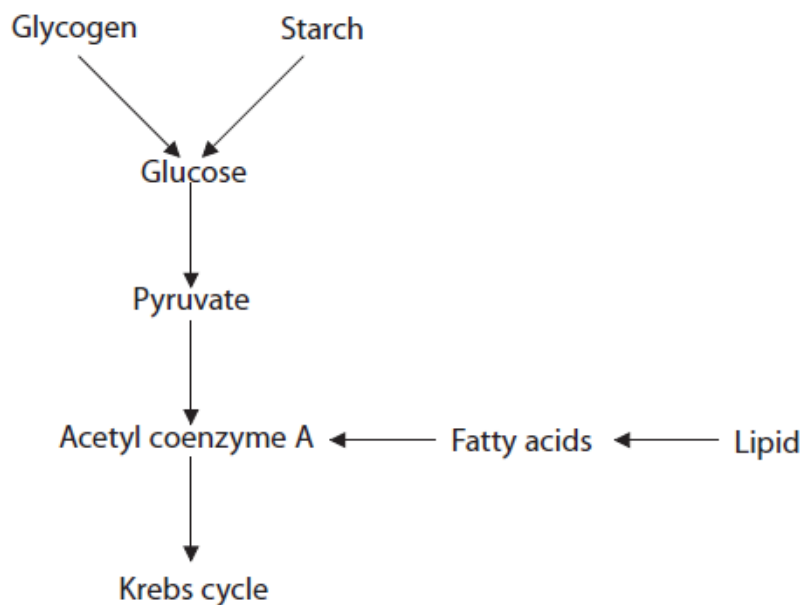
Q11.

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 ☐.

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)

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for question = 4 marks)

Q12.

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)

.....

.....

.....

(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	Mark
(a)	molecule R - ATP / adenosine triphosphate ; molecule S - ADP / adenosine diphosphate ;	(2)

Question Number	Answer	Mark
(b)(i)	1. carbon dioxide / CO ₂ ; 2. idea that the C has been removed from C ₆ or C ₅ ;	(2)

Question Number	Answer	Mark
(b)(ii)	1. cycle would stop / eq ; 2. 4 carbon compound would accumulate / eq ; 3. 6 carbon compound would {run short / not be synthesised} / 5 carbon compound would run short / eq ; 4. idea that {molecule T / H} reduce ;	(3)

Question Number	Answer	Mark
(c)	1. idea of electrons being {passed along / eq} the electron transport chain ; 2. idea of {losing / eq} energy ; 3. (used to) add a phosphate to ADP to make ATP / eq ; 4. reference to ATPase ; 5. idea of chemiosmosis ; 6. idea of oxygen as the final acceptor ;	(3)

Q2.

Question Number	Answer	Mark
(a)	1. idea that less {food /eq} required to deliver energy requirement ; 2. (so) more likely to have extra food not respired / {extra/surplus} energy ; 3. which could be laid down in body as fat / eq ;	(2)

Question Number	Answer	Mark
(b)	Any two from: 1. ADP 2. Pi / inorganic phosphate 3. pyruvate / pyruvic acid / lactate 4. fatty acids 5. NAD / eq 6. acetyl CoA / eq 7. water ; ;	(2)

Question Number	Answer	Mark
(c)	1. many {alpha / eq} glucose monomers ; 2. joined by glycosidic bonds ; 3. detail of glycosidic bonds e.g. 1-4 ; 4. reference to side branches present / 1-6 glycosidic bonds ;	(3)

Question Number	Answer	Mark
(d)	1. more gonadotropins ; 2. {use / muscle uptake} of (excess) fatty acids ; 3. respired to release (much) energy / increased fat metabolism ; 4. idea of reduced requirement to replenish glycogen stores ;	(3)

Question Number	Answer	Mark
(e)	1. (slow twitch muscles) carry out aerobic respiration / full oxidation / eq ; 2. which produces more ATP (than anaerobic) / eq ; 3. 'energy' not locked up in lactate / eq ; 4. idea that it takes longer for lactate levels to build up ;	(2)

Question Number	Answer	Mark
* (f)	QWC – Spelling of technical terms (<i>shown in italics</i>) must be correct and the answer must be organised in a logical sequence) 1. Ca^{2+} leaks out of {cell / <i>cytoplasm</i> / <i>sarcoplasmic reticulum</i>} ; 2. idea of change in Ca^{2+} binding to <i>troponin</i> ; 3. causes displacement of <i>tropomyosin</i> / eq ; 4. idea of change in number of <i>myosin</i> binding sites exposed ; 5. comment on <i>myosin</i> binding to <i>actin</i> ; 6. (loss of Ca^{2+} from cell / cytoplasm) therefore force exerted by muscle is lower than expected OR (more Ca^{2+} in cytoplasm) results in less ATP so less muscle contraction ;	(4)

Question Number	Answer	Mark						
(g)	<table><tr><th>Process</th><th>Two nucleic acids involved in the process</th></tr><tr><td>Transcription of the ACE gene</td><td>DNA & mRNA ;</td></tr><tr><td>Production of ACE at a ribosome</td><td>Any two from: mRNA, tRNA, rRNA ;</td></tr></table>	Process	Two nucleic acids involved in the process	Transcription of the ACE gene	DNA & mRNA ;	Production of ACE at a ribosome	Any two from: mRNA, tRNA, rRNA ;	(2)
Process	Two nucleic acids involved in the process							
Transcription of the ACE gene	DNA & mRNA ;							
Production of ACE at a ribosome	Any two from: mRNA, tRNA, rRNA ;							

Question Number	Answer	Mark
(h)	1. obtain a sample of cells / extract DNA (from cells) ; 2. reference to named enzyme ; 3. idea of how to increase amount of DNA ; 4. reference to electrophoresis ; 5. details of electrophoresis ; 6. use a {DNA / gene} probe ; 7. with a base sequence complementary to that on the {variant / eq} ; 8. idea of matching with known variant profile ;	(4)

Question Number	Answer	Mark
(i)	B ;	(1)

Question Number	Answer	Mark
(j)	1. (higher metabolic rate) means more chemical reactions / eq ; 2. more {energy released / ATP used} / eq ; 3. (which) releases heat / eq ; 4. keeps divers warmer / warm for longer / able to swim without a wetsuit / eq ;	(3)

Question Number	Answer	Mark
(k)	1. carbon dioxide due to {deforestation / land cleaning / burning fossil fuels / correct ref to respiration / eq} ; 2. methane from {rice fields / anaerobic bacterial action / ruminant fermentation / named ruminant} ;	(2)

Question Number	Answer	Mark
(l)	1. $1.4 \div 37 =$; 2. 3.8 (%) ; Correct answer gains both 2 marks	(2)

Q3.

	Answer					Mark
(i)						
	Investigation	Type of respiration	Potassium hydroxide solution absent or present	Coloured liquid moved to the left	Coloured liquid moved to the right	Coloured liquid did not move
	1	Anaerobic	Absent	☐	☐	☒
	2	Aerobic	Absent	☐	☐	☒ ;
	3	Aerobic	Present	☒ ;	☐	☐
						(2)

Question Number	Answer	Additional Guidance	Mark
(ii)	1. (as anaerobic) no O ₂ absorbed / eq ; 2. no CO ₂ produced / eq ; 3. so no change in {volume/pressure} (so liquid does not move) ; 4. since for each 6C glucose respired, 2x3C lactate formed / eq ;	1. ACCEPT No oxygen used	(3)

Question Number	Answer	Additional Guidance	Mark
(iii)	1. (reduced NAD from glycolysis) enters mitochondria/ moves through outer mitochondrial membrane / eq ; 2. moves to inner membrane of mitochondrion / eq ; 3. becomes {oxidised /NAD / NAD^+} ; 4. as {electrons / eq} transferred to {electron transport chain / eq} / eq ; 5. fate of hydrogen ions described e.g. pumped into membrane space ; 6. (NAD) returns to {Krebs cycle/ matrix / eq} ;	2. ACCEPT crista for inner mitochondrial membrane 6. ACCEPT cytoplasm, glycolysis	(4)

Q4.

Question Number	Indicative content
*	Answers will be credited according to candidates' deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme. 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. Indicative content: • membranes both made of phospholipid bilayer with embedded proteins • lipid content is the phospholipid bilayer • phospholipids needed for {fluidity / compartmentalisation} • higher protein : lipid ratio in the inner membrane / more protein compared to lipid in the inner membrane • protein content equals lipid content in outer membrane • role of inner membrane is oxidative phosphorylation / chemiosmosis / synthesise ATP • inner membrane contains proteins involved in electron transport • inner membrane contains ATPase channels • movement of protons through ATPase channels results in ATP formation • proteins in outer membrane to allow pyruvate to pass through

Level 0	Marks	No awardable content
Level 1	1-2	An explanation may be attempted but with limited interpretation or analysis of the scientific information with a focus on mainly just one piece of scientific information. The explanation will contain description of membrane structure 1 mark = 2 points 2 marks = 3 points
Level 2	3-4	An explanation will be given with occasional evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows some linkages between the two membranes and their lipid and protein content 3 marks = explanation of ATPase or electron transport proteins or outer membrane 4 marks = explanation of two from ATPase, electron transport proteins, outer membrane
Level 3	5-6	An explanation is made which is supported throughout by sustained application of relevant evidence of analysis, interpretation and/or evaluation of both pieces of scientific information. The explanation shows a well-developed and sustained line of scientific reasoning which relates named protein molecules to the high protein content of the inner membrane 5 marks = explanation of ATPase, electron transport proteins and outer membrane 6 marks = clear, accurate account of oxidative phosphorylation

Q5.

Question Number	Acceptable Answer	Additional guidance	Mark
(a)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(b)	B		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(c)	C		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(d)	A description that makes reference to the following: - it is transported into the (matrix) mitochondria (1) - link reaction oxidises pyruvate to form NADH + H⁺ (1) - carbon dioxide is removed (1) - molecule combines with acetyl CoA to form coenzyme A (1)		(4)

Q6.

Question Number	Acceptable Answer	Additional guidance	Mark
(i)	B (Krebs cycle)		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(ii)	B (5%)		(1)

Question Number	Acceptable Answer	Additional guidance	Mark
(iii)	A description that makes reference to the following: - glucose is phosphorylated using ATP (1) - this product is converted into glycerate 3-phosphate (GP) (1) - GP converted to pyruvate producing reduced NAD (NADH) and ATP (1)		(3)

Q7.

Question Number	Answer	Mark
(i)	The only correct answer is B <i>A is not correct because no bonds are being broken</i> <i>C is not correct because no phosphate group is being added</i> <i>D is not correct because if FAD is reduced to FADH₂ the succinate is being oxidised</i>	(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 FADH₂ / FADH / reduced {NAD / NADH} / reduced {FAD / FADH / FADH₂}	(4)

Q8.

Question Number	Answer	Additional Comments	Mark
(a)	- only (alpha) 1-4 glycosidic bonds in amylose / (alpha) 1-6 only found in amylopectin ; - only amylopectin has side branches / only amylose is {coiled / eq} ; - Amylopectin is a {larger / eq} molecule than amylose ;	1. ACCEPT 1-6 and 1-4 in amylopectin	(2)

Question Number	Answer	Additional Comments	Mark
(b)	- Different individuals in the {colony / eq} take on specific {roles / jobs / eq} ; - Example given e.g. queen produces offspring ;	1. Accept division of labour 2. Accept dominance by queen, {few of the males / kings} involved in breeding	(2)

Question Number	Answer	Additional Comments	Mark
(c) (i)	Idea that body temperature of animal mimics the ambient temperature ;	Accept body temp follows environmental temperature	(1)

Question Number	Answer	Additional Comments	Mark
(f)	1. idea of heart working less efficiently ; 2. idea of less oxygen absorbed at lungs / eq ; 3. less blood pumped to brain ; 4. concentration gradient (for oxygen) at brain reduced / eq ; 5. less oxygen in blood (in brain) diffuses into brain tissue / eq ; 6. idea of less oxygen in brain tissue due to continual (aerobic) respiration ;		(3)

Question Number	Answer	Additional Comments	Mark
(g)	gonadotrophin-releasing (hormone) stimulates gonadotrophin release / gonadotrophin stimulates ovulation / testosterone stimulates {sperm production / (male) secondary sexual characteristics / other named example} ;		(1)

Question Number	Answer	Additional Comments	Mark
(h)	1. Idea of effect on mitochondria ; 2. (therefore) reduced {energy / ATP / eq} for flagellum movement ;	1. Accept less efficient / fewer / none 2. Accept tail for flagellum	(2)

Question Number	Answer	Additional Comments	Mark
(i)	1. idea that fat is an energy store ; 2. reduces dependence on external food source / eq ; 3. enables disperser to travel / eq ; 4. (metabolic) water is released (on oxidation) / eq ; 5. acts as a thermal insulator / eq ;	Accept energy-rich	(3)

Question Number	Answer	Additional Comments	Mark
(j)	1. idea that unfamiliar males are likely to be genetically different ; 2. idea that this is outbreeding ; 3. idea that this increases genetic diversity ;	3. Accept producing offspring that are genetically different	(2)

Question Number	Answer	Additional Comments	Mark
(k)	the order of the {bases / genes and non-coding sequences / eq} in the DNA (of the naked mole rats) is found / eq ;	Accept exons and introns Ignore genes unqualified	(1)

Question Number	Answer	Additional Comments	Mark
(I)	Paired responses: 1. reduced sensitivity to chemical pain / disconnection of 'pain nerves' ; 2. Idea of pain relief e.g. dealing with post traumatic pain, post surgical pain, joint pain after a knee operation ; 3. haemoglobin has higher affinity for oxygen ; 4. Idea of dealing with reduced oxygen situations such as due to a heart attack or stroke ; 5. Naked mole rat {incisors / eq } grow through skin (of lip) without damage ; 6. Idea of better prosthesis e.g. new {coatings / permanent seal} at {skin / bone / metal} interface, soft tissue not damaged, avoid infection ; 7. High protein stability / does not (easily) lose 3D shape ; 8. (so) reduced effect of oxidative {damage / stress} / reduced effect of oxygen-containing free radicals / live healthily into old age ; 9. Cell overcrowding early warning gene / ref. to two tiered contact inhibition / presence of gene p16 ; 10. Idea of cancer prevention e.g. cancer resistance, future cancer therapy ; 11. Naked mole rat neurones display immature {characteristics / physiological properties} / brain cells that cope with {low oxygen / hypoxia} ; 12. To treat people with temporary loss of oxygen to brain e.g. heart attack, stroke, drowning / to prevent permanent brain damage ; 13. High levels of oxytocin receptors in {brain / nucleus <u>accumbens</u>} ; 14. Idea of links to autism ; 15. Naked mole rats do not experience menopause ; 16. Ref to osteoporosis {treatment / prevention} (without side effects) ; 17. circadian rhythms / sleep patterns of naked mole rats ; 18. Idea that may help with sleep disorders ;	9. Accept anticancer mechanism	

Q9.

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)

Q10.

Question Number	Answer	Additional guidance	Mark
(a)	- Idea an enzyme converts a named substrate into named product e.g. enzyme 1 converts P to Q ; - idea that this product becomes the substrate of next step ; - Idea of specificity ; {controls / eq} the conversion / eq ; - speeds up the conversion / eq ; - by reducing activation energy / eq ; - credit reference to control of whole process ;	ACCEPT answers in context of respiration ACCEPT 1 - ref to an enzyme converting one named intermediate to the next e.g. {enzyme/ named enzyme} used to convert hexose to phosphorylated hexose ACCEPT 3 - description of specificity e.g. active site of enzyme 1 only accepts substance P or in context of named respiratory intermediate ACCEPT 4 - regulates ACCEPT 5 - catalysis / enzyme acts as a catalyst ACCEPT 7 - end product inhibition or description	(4)

Question Number	Answer	Additional guidance	Mark
(b)(i)	- W = {NAD / NAD⁺ / NAD_{ox} / eq} ; Any two of the following: (due to) reduced NAD {releasing/eq} {electrons / eq} ; - Idea of electrons go to {carrier A / ETC / eq} ; - Idea of H⁺ moved into inter-membranal space ;	ACCEPT 2 – being oxidized Releasing hydrogen (atoms), H⁺/protons⁺ ACCEPT 3 – 1st electron carrier/correctly named carrier	(3)

Question Number	Answer	Additional guidance	Mark
(b)(ii)	- substance X is ATP ; Any two of the following : - due to H⁺ pass through {stalked particle / ATP synthase} ; (H⁺ passes) down an electrochemical gradient ; (sufficient) energy is {released / eq} ; - to join ADP and {Pi / eq} ; - reference to chemiosmosis ;	ACCEPT 2 –ATPase ACCEPT 3 - description of electrochemical gradient ACCEPT 5 – phosphorylation of ADP	(3)

Question Number	Answer	Additional guidance	Mark																			
(c)	<table border="1"> <tr> <th rowspan="2">Situation</th><th colspan="3">Movement of coloured liquid</th></tr> <tr> <th>towards A</th><th>towards B</th><th>does not move</th></tr> <tr> <td>Screw clip is open</td><td></td><td></td><td>☒</td></tr> <tr> <td>Screw clip is closed</td><td>☒</td><td></td><td></td></tr> <tr> <td>Potassium hydroxide is replaced with water and screw clip is closed</td><td></td><td></td><td>☒</td></tr> </table>	Situation	Movement of coloured liquid			towards A	towards B	does not move	Screw clip is open			☒	Screw clip is closed	☒			Potassium hydroxide is replaced with water and screw clip is closed			☒		(3)
Situation	Movement of coloured liquid																					
	towards A	towards B	does not move																			
Screw clip is open			☒																			
Screw clip is closed	☒																					
Potassium hydroxide is replaced with water and screw clip is closed			☒																			

Q11.

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 / FADH₂	(3)

Q12.

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)	<u>Example of calculation:</u> oxygen volume = $4.5 \times 21 + 3.75$ = 98.25 carbon dioxide volume = $3 \times 21 + 6$ = 69 $69 \div 98.25 = 0.70 / 0.7 / 0.702$ ACCEPT ecf	(2)