Mark scheme - Respiration

11		i	mitochondrion	1	**ALLOW** mitochondria.
		ii	*either* facilitated diffusion (1) conversion of ornithine into citrulline creates concentration gradients **or** (molecules are not lipid soluble so) require protein channels to cross membrane (1) ***or*** active transport (1) ornithine and citrulline need to be moved into and out of **D** more quickly than would be met by diffusion (1)	2	
		iii	deamination / removal of NH_2 group from amino acid (1)	1	
		iv	ATP (1)	1	
			Total	**5**	
12	a		*idea that* the oxygen will leak from the connectors so reduce the gas movement (1) **or** oxygen uptake may not be a good representation of respiration rate in germinating seedlings (1) **or** a small volume of gas is being measured in the capillary (1) **or** measurements only taken every 30 seconds (1) **or**	1	**ALLOW** seal not air tight so will not prevent gas escaping during the experiment **or** *the idea* that gas leakage is a problem and needs to be prevented. **ALLOW** the respiratory substrate stored in the seed will affect the oxygen needed **or** the idea that if photosynthesis has begun oxygen uptake will be disrupted. **ALLOW** need to record the maximum volume of gas taken up during the experiment. **ALLOW** alternative wording e.g. 'more frequent readings are needed'.

			difficult to read the meniscus (may be subjective) (1)		
	b		*Variable* the mass of the seeds is not given (1) *Improvement* take the mass of the seedlings at the start (1) *Variable* the volume / mass of soda lime is not specified (1) *Improvement* use a known mass of soda lime each time (1) *Variable* the size of the syringe is not given (1) *Improvement* use a 2 cm^3 syringe (1) *Variable* the capillary tube internal diameter is not given (1) *Improvement* use a capillary tube of length 20 cm and a 1 mm internal diameter (1) *Variable* temperature not controlled (1) *Improvement* allowing apparatus to, stabilise / equilibrate to temperature, before taking readings (1) *AVP* (1)	2	The control method must be suitable, and be directly linked to the variable. **ALLOW** suggested mass values. **ALLOW** suggested mass values. **ALLOW** alternative size if suitable for the activity. **ALLOW** *idea that* only a linear measurement is obtained not a volume. **ALLOW** alternative size if suitable for the activity. **ALLOW** use of a water bath and thermometer to stabilise the temperature. Must be explicit to provide valid data e.g. no scale on the capillary tube, no timing, no details of how to take the readings. Details must be workable and suitable to provide valid results e.g. scale on the capillary tube, use of timing devices, description of how to take readings from the scale etc.
	c		dipped into a small beaker and allowed to run	1	**ALLOW** suitable details of how the red fluid is added.
	d		*Explanation* it is more than 10% from the mean **or** it is different from the other data at 60 seconds	2	**ALLOW** 'it is out of line'

			or it does not follow trend for the times for replicate 3 (1) *Action* anomaly should be identified and excluded from processing **or** anomaly must be identified but could be included in calculations **or** repetition to obtain another reading (1)		**ALLOW** 'it is out of line'
	e		0.36 mm s^{-1} (1)	1	Rate and units required for the mark.
	f	i	the internal diameter of the capillary tube (1)	1	
		ii	the mass of the bean seeds (1)	1	
	g		* **Level 3 (5–6 marks)** Describes a clear and detailed experiment that has been effectively adapted for use with chosen invertebrate to allow for the comparison of the rate of respiration with that of mung beans. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** Describes an experiment to compare the rate of respiration of chosen invertebrate with mung beans but there is insufficient detail of the procedure to allow a valid comparison. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence.* **Level 1 (1–2 marks)** An attempt to describe an experiment to investigate the respiratory rate of an invertebrate but little comparison with mung beans. If results or conclusion suggested, likely to be muddled or inaccurate.	6	**Relevant points include:** **experiment** • mass of invertebrate and mass of beans the same • safe and ethical use of invertebrates e.g. add screen so that animal(s) cannot touch the muslin bag • bigger syringe needed (5–10 cm^3) • keep temperature constant / same for both assays • keep light constant / same for both assays • use same mass of soda lime in both assays • measuring distance moved by coloured, red liquid at regular time intervals • repeat experiments. **results and conclusions** • invertebrates rate of respiration is expected to be higher than the rate of respiration of the beans *because* • invertebrates are moving around • metabolic processes require energy / generate heat.

			The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear. **0 marks** No response or no response worthy of credit.		
			Total	**15**	
13	a	i	fossils in, known-age / Jurassic, strata / rocks	1	
		ii	DNA / cytochrome c	1	
	b	i	carbon dioxide diffuses down concentration gradient out of the respiring cell (1) carried through body from cell (to tracheoles) by blood passing out via tracheoles / trachea / spiracles (1) respiration generates heat (1) hot gases expand and are less dense so rise up by convection through the mound to vents at mound-top (1)	4	
		ii	*shape,* large or increased surface area to volume ratio (1) smallest area exposed to greatest heat (1)	2	Response **must** be linked to context of avoiding overheating / needing to get rid of heat.
			Total	**8**	
14		i	increased volume of water added (to seedlings), leads to lower survival (of seedlings) ✓ larger decrease in survival for added water, above / from, 30 (cm^3) ✓ volume of water has no effect on number (of seedlings) surviving up to the first 3 days / AW ✓ quote data points / calculation(s) used, to support any point ✓	3 max	**ALLOW** the more water the faster they die **ALLOW** ora e.g. less / little, decrease in survival for 30(cm^3) and below **DO NOT ALLOW** at 30cm^3 minimum one pair of readings quoted for two water volumes (no units needed)

					Examiner's Comments In **Q18(b)(i)** most candidates stated the correct trend or correlation and this was often supported with relevant comparisons of two or more data points. Few went on to expand their response and, consequently, a large percentage of candidates failed to achieve maximum marks here.
		ii	Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met. **The lower mark** should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing. **In summary:** • **The science content determines the level.**	**6**	**Indicative scientific points may include…** **Aerobic respiration (A)** *Statement* **(S)** *The scientific statement can be implied by giving good scientific detail* • (No oxygen so) no aerobic respiration occurs *Further detail* **(D)** • No, link reaction / Kreb's cycle / ETC / oxidative phosphorylation

			• **The communication statement determines the mark within a level.** **Level 3 (5–6 marks)** A detailed scientific statement about aerobic respiration **AND a** detailed scientific statement about anaerobic respiration **AND** more than one scientific consequence for the plant of overwatering *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** A detailed scientific statement about either aerobic or anaerobic respiration **AND** a scientific consequence for the plant of overwatering *There is a line of reasoning presented with some structure.* *The information presented in the most part relevant and supported by some evidence.* **Level 1 (1–2 marks)** A statement about either aerobic or anaerobic respiration **AND** a scientific consequence for the plant of overwatering *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant and correct.* **0 marks** No response or no response worthy of credit.		• No oxygen to act as the final, electron / hydrogen acceptor **Anaerobic respiration (An)** *Statement* **(S)** *The scientific statement can be implied by giving good scientific detail* • (Plant has to) switch to anaerobic respiration / only anaerobic respiration can occur *Further detail* **(D)** • Only glycolysis occurs • Alcoholic fermentation occurs • NAD regenerated (for glycolysis) • Pyruvate to ethanal to ethanol • Named enzyme e.g. pyruvate decarboxylase • (Only) 2 ATP **Scientific consequences for the plant(C)** • ethanol is toxic • (alcoholic fermentation) is irreversible • Less ATP produced / only 2 ATP from glycolysis • Less / no, active transport • (root hair cells) cannot take up mineral ions (by active transport) • so (plant) cannot make, proteins / amino acids / DNA / chlorophyll etc • cannot generate water potential gradient (into roots) / water potential (in root hair cells) is too high • water cannot be absorbed (so cells cannot remain turgid) • less / no, photosynthesis

					Examiner's Comments **Q18(b)(ii) Level of Response** Examiners reported that there were some excellent responses to this question. In such responses, candidates demonstrated the ability to discuss the consequences of lack of oxygen on both aerobic and anaerobic respiration. Details included a relevant discussion of the different 8 stages of aerobic respiration i.e. link reaction, Krebs cycle or oxidative phosphorylation, with some candidates starting their explanation with the statement *'there would be no oxygen to act as the final electron acceptor'*. Although stronger candidates also gave good detail about anaerobic respiration, generally this was not quite as well expressed. Candidates who referred to the lactate pathway were still able to gain the top level as some plants do use this mechanism. Candidates were often able to state that only glycolysis would be able to occur to produce small quantities of ATP and that NAD would be regenerated but detail about the pyruvate to ethanol pathway was seen less often. To obtain a Level 3 answer, candidates needed to talk about two consequences of the lack of oxygen to the plant and this proved problematic for candidates, as it required them to bring together a variety of different ideas from the A Level course. Many did know that ethanol is toxic, and that less ATP would be produced overall. The best answers included references to a reduction in active transport and the consequences of this on mineral uptake. Candidates who achieved Level 2 were often able to give a great deal of detail about aerobic respiration but were not able to provide the same level of detail about anaerobic respiration and were only able to give one consequence to the plant. Level 1 candidates gave a simple statement such as, *'with no oxygen the plant cannot carry out aerobic respiration'*. Candidates who did not also give a consequence did not pick up any marks. In general, candidates presented good lines of reasoning with structure, so many were able to achieve the higher mark within each level.
			Total	**9**	

15		i	length / size , similar to that of a bacterium ✓ contain (circular) DNA ✓ contain (70S / small / 20nm) ribosomes ✓ (may) have plasmids ✓ have double membrane ✓	max 2 (AO3.2) (AO2.1)	**If more than two responses given:** mark **first** response on each prompt line. If responses on first prompt line and nothing on second line then mark first **two** on first prompt line
		ii	*cells with mitochondria / early eukaryotes* **1** would be able to respire aerobically ✓ **2** (this) produces more ATP ✓ **3** ATP needed for , active transport / cell division / protein synthesis / DNA replication ✓ **4** more ATP allows faster metabolic , processes / reactions ✓	3 (AO2.1)	**Assume for cells with mitochondria** **Only need to mention ATP once** **ALLOW ORA** for cells without mitochondria for **MPs 1, 2, 4** **ALLOW** releases more energy **DO NOT ALLOW** 'produces' energy **IGNORE** growth **ALLOW** more ATP so can meet higher metabolic demand
			Total	**5**	
16		i	adenine ✓	1 (AO2.1)	**DO NOT ALLOW** adenosine **IGNORE** nitrogenous base / purine
		ii	hydrolysis ✓	1 (AO2.1)	**IGNORE** dephosphorylation
		iii	because ATP is , broken down / hydrolysed (to ADP) ✓ ATP is constantly recycled ✓ ATP used to provide energy for , (named) metabolic reactions / processes ✓ ATP is , not stored long term / used immediately ✓	max 2 (AO2.1)	**ALLOW** ATP is unstable **ALLOW** constant interconversion of ATP and ADP (+Pi) **ALLOW** ATP produced is coupled to metabolic reactions **IGNORE** used for respiration unqualified **ALLOW** ATP is used as fast as it is produced
			Total	**4**	
17	a		contain / location of , (named) electron carriers / ETC / ATP synth(et)ase / proton pumps ✓ (provide , site / location / surface) for , chemiosmosis / ATP synthesis / oxidative phosphorylation ✓ allow , formation / maintenance , of , H+ / proton / hydrogen ion , gradient ✓	max 2 (AO1.1)	**Mark as continuous prose**

			outer membrane is highly permeable to allow movement of (named) molecules ✓		
	b	i	transmission electron (microscope) ✓	1 (AO2.1)	**ALLOW** TEM, 'microscopy' for 'microscope'
		ii	**M** = matrix ✓ **N** = crista(e) ✓	2 (AO1.1)	**ALLOW** inner membrane for **N**
			Total	**5**	
18			mitochondria / mitochondrion	1 (AO2.5)	
			Total	**1**	
19		i	**U** matrix ✓ **W** crista(e) / <u>inner</u> (mitochondrial) membrane ✓ **Z** <u>inter</u>-membrane space ✓	**3**	**IGNORE** ETC / ATP synthase / cytochromes **ALLOW** <u>inter</u>-membranal space **Examiner's Comments** **Q19(c)(i)** was generally well-answered although some candidates failed to interpret the diagram correctly and gave totally irrelevant structures as their answers. The most common mistake was failing to identify the inter-membrane space or referring to it as the inner-membrane space.
		ii	cyanide, prevents / AW, aerobic respiration **AND** fluoride, prevents / AW, anaerobic respiration (which also prevents aerobic respiration) ✓	**1**	*BOTH statements required for one mark* **IGNORE** 'affects' throughout **ALLOW** link reaction / Krebs cycle / ETC / oxidative phosphorylation instead of aerobic respiration **ALLOW** cyanide allows, glycolysis / anaerobic respiration **ALLOW** prevents, all respiration / both stages of respiration **IGNORE** lactate fermentation **Examiner's CommentsQ19(c)(ii)** saw some strong responses with candidates using data to support their answer even though it was not required. Weaker candidates gave vague answers about how fluoride and cyanide 'affected' respiration or repeated the

					information in the table without attempting a conclusion.
			Total	**4**	
20			2 (ATP molecules per glucose) from, glycolysis / (breakdown of) triose (bis)phosphate ✓ (when) triose (bis)phosphate / TP, converted / broken down, to pyruvate ✓ *ref to* net yield of 2 (ATP) / 4 (ATP) made but 2 used up (in glycolysis) ✓ 1 ATP (produced) per, (turn of the) Krebs cycle / acetyl (coA) ✓ when 5-carbon compound is converted to, 4-carbon compound / oxaloacetate ✓	**4 max**	**ALLOW** '4 ATP made from 2 TP's' 'net yield of 2 ATP's in glycolysis' = mp1 and 3 for 2 marks **ALLOW** 2ATP, per glucose in Krebs cycle / from every 2 acetyl (coA) **ALLOW** 'when citrate converted to oxaloacetate' **ALLOW** 'when succinyl CoA converted into succinate' **ALLOW** 'between (intermediate) 4C compounds' **<u>Examiner's Comments</u>** The production of ATP by substrate level phosphorylation was well understood by many. Candidates began their answer by stating that there would be a net production of 2ATP in glycolysis, or that 4 ATP would be produced but 2 were used up at the start. While many referred to triose phosphate being the source of phosphate, few then added that TP would be converted to pyruvate. Many candidates were unclear as to how many ATP would be generated in Krebs' cycle although higher ability ones commented that one ATP would be made per turn of the cycle, or two per molecule of glucose. Some correctly described where in the cycle ATP would be made while others thought it would be between citrate and the 5C compound, or at multiple points in the cycle. Some candidates believed that ATP would be produced in the link reaction and many

<table>
<tr><td></td><td></td><td></td><td></td><td></td><td>went on to describe oxidative phosphorylation , which gained no credit.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>4</td><td></td></tr>
<tr><td>21</td><td></td><td>i</td><td>glycolysis / anaerobic respiration, can continue / AW✓

because, conversion of glucose to TP is not needed / lactate inhibition is irrelevant / AW ✓

ATP is produced when TP is converted to pyruvate ✓</td><td>2 max (AO2.6)</td><td>IGNORE lactate pathway
ALLOW description of glycolysis

e.g. 'enzymes needed to convert fructose to triose phosphate are not inhibited by lactate'

<u>Examiner's Comments</u>

Candidates often referred to glycolysis being able to continue, though only a few explained that the alternative pathway would be inhibited by lactate, or that the conversion of TP to pyruvate would yield ATP.</td></tr>
<tr><td></td><td></td><td>ii</td><td>low body temperature / slow metabolic rate ✓

less energy is spent on thermoregulation ✓</td><td>1 max (AO2.1)</td><td>ALLOW low metabolic rate / fewer metabolic reactions

ALLOW other plausible physiological adaptations e.g. more <u>creatine</u> phosphate stores / more able to buffer H^+ ions / more myoglobin / Hb has higher affinity for oxygen / dissociation curve shifted to left / bradycardia / more erythrocytes

<u>Examiner's Comments</u>

This question was not well answered by the majority of candidates with many relating this to SA:V ratios or the idea of size. Most correct responses identified the slow metabolic rate of the mole rat, with few using the information gained at the start of the question to state that mole rats spend less energy on thermoregulation.</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>3</td><td></td></tr>
<tr><td>22</td><td></td><td>i</td><td><table><tr><td>Description of amino acid amino acid</td><td>Name of Justification</td><td></td></tr><tr><td>Converted to pyruvate with the</td><td>Alanine</td><td>(Both have) 3 carbon</td></tr></table></td><td>4 (AO3.1)</td><td>ALLOW (both have) 3C atoms
DO NOT ALLOW 'same number of C and, H / O, atoms'</td></tr>
</table>

<table>
<tr><td></td><td></td><td></td><td>
<table>
<tr><td>fewest changes</td><td></td><td>atoms / Same number of carbon atoms</td></tr>
<tr><td>Converted to alpha-ketoglutarate with the fewest changes</td><td>Glutamic acid</td><td>(Both have) 5 carbon atoms / Same number of carbon atoms</td></tr>
<tr><td>The amino acid with the highest respiratory quotient (RQ)</td><td>Aspartic acid</td><td>Highest proportion of oxygen atoms (in its structure) / lowest proportion of C-H bonds (relative to other bonds)</td></tr>
</table>
First row correct ✓
Second row correct ✓
Aspartic acid ✓
Aspartic acid explanation ✓</td><td></td><td>IGNORE ‘both have 2 carboxyl groups’

ALLOW (both have) 5C atoms
DO NOT ALLOW ‘same number of C and, H / O, atoms’</td></tr>
<tr><td></td><td></td><td>ii</td><td>decarboxylation / carbon dioxide produced ✓
dehydrogenation / hydrogen removal / reduced NAD produced / reduced FAD produced✓
ATP produced ✓
succinyl co-A / succinate / fumarate / malate / 4 C intermediate, produced ✓</td><td>2 max
(AO1.2)
(AO2.5)</td><td>ALLOW mp’s from correct equations</td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>6</td><td></td></tr>
<tr><td>23</td><td></td><td></td><td>B</td><td>1
(AO1.1)</td><td></td></tr>
<tr><td></td><td></td><td></td><td>Total</td><td>1</td><td></td></tr>
</table>

24			matrix of mitochondrion	1	**ALLOW** mitochondria
			Total	**1**	
25		i	12.5 /13 (%) ✓	**1**	• 16 carbon atoms in the fatty acid • 2 carbon atoms in acetyl CoA (which enters the Krebs cycle) • 2/16 x 100 = 12.5% **Examiner's Comments** The percentage of carbon atoms of palmitoyl CoA entering the Krebs cycle was frequently incorrectly calculated, with many candidates failing to read the question and thus stating 100% for complete oxidation. Few appreciated that in Figure 2, only two of the 16 carbon atoms would enter the Krebs cycle, giving a percentage of 12.5. Many divided a seemly arbitrary number by 16.
		ii	67(%) **AND** (the link reaction is) more efficient✓ **Examiner's Comments** The calculation of the efficiency of the link reaction was also often incorrect, with candidates giving an array of different answers. Higher ability candidates provided the correct answer of 67% and then stated that the link reaction would be more efficient than beta oxidation.	**1**	**ALLOW** 66.6· / 66.667 / 66.67 / 66.7 (%) **DO NOT ALLOW** 66.6 (incorrect rounding) • acetyl CoA (2 carbon atoms) is produced from pyruvate (3 carbon atoms) in the link reaction • 2/3 x 100 = 67 % **ALLOW** ECF if the answer to (i) is greater than 66.7% and 'less efficient' has been written ***OR*** if the answer to (i) is 66.7% and 'equally efficient' has been written if NR or no answer given in (i) then 1 mark for correct efficiency calculation and **IGNORE** efficiency statement **Examiner's Comments** The role of co-enzymes in beta oxidation was well understood by many candidates, with comments such as NAD/FAD would act as hydrogen acceptors or transfer hydrogen atoms. Some also stated that the carriers

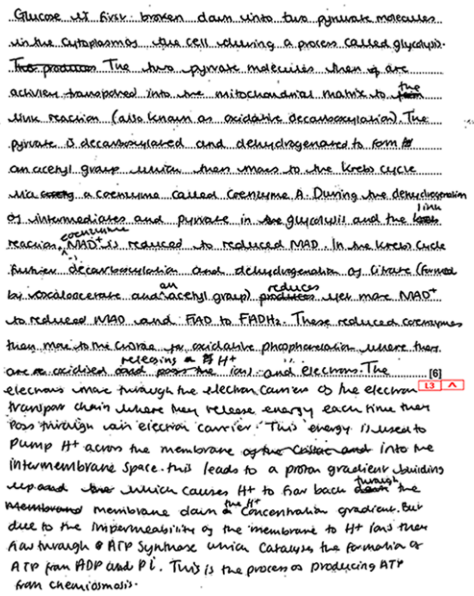
					would become reduced. Common errors included the co-enzymes simply removing hydrogen atoms, rather than accepting or transporting them, or an incorrect reference to hydrogen ions or molecules.
		iii	(FAD/NAD) accepts / is reduced by/ transfers / AW, hydrogen (atoms) ✓	**1**	**DO NOT ALLOW** hydrogen, ions / molecules **ALLOW** 'carries / transports / picks up, hydrogens' **IGNORE** 'removes, hydrogens'
			Total	**3**	
26		i	**K** acetyl group (of CoA) (1) **L** citrate (1) **M** carbon dioxide / CO_2 (1) **N** oxaloacetate (1)	4	**ALLOW** acetate
		ii	**Q** substrate level phosphorylation (1)	1	
			Total	**5**	
27			* Read through the whole answer from start to finish, concentrating on features that make it a stronger or weaker answer using the indicative scientific content as guidance. The indicative scientific content indicates the expected parameters for candidates' answers, but be prepared to recognise and credit unexpected approaches where they show relevance. Using a 'best-fit' approach based on the science content of the answer, first decide which set of level descriptors, Level 1, Level 2 or Level 3, best describes the overall quality of the answer using the guidelines described in the level descriptors in the mark scheme. Once the level is located, award the higher or lower mark. **The higher mark** should be awarded where the level descriptor has been evidenced and all aspects of the communication statement (in italics) have been met.	6	**Indicative scientific points may include…** • Coenzyme A: ○ transfers acetyl / acetate / 2C from link reaction to Krebs cycle • ADP/ATP: ○ phosphorylation of / addition of phosphate group to, glucose to form hexose-1, 6-bisphosphate in glycolysis ○ dephosphorylation of / removal of phosphate group from, TP in glycolysis ○ dephosphorylation of / removal of phosphate group from, intermediate in Krebs cycle ○ formation from substrate level phosphorylation ○ formation from oxidative phosphorylation, harnessing chemical energy from chemiosmosis / proton motive force

			The lower mark should be awarded where the level descriptor has been evidenced but aspects of the communication statement (in italics) are missing.
			
			In summary:
			
			• **The science content determines the level.**
			• **The communication statement determines the mark within a level.**
			
			Level 3 (5–6 marks)
			A full and detailed summary of the role of the different coenzymes in respiration, including their importance in processes that link together the component stages.
			
			There is a well-developed line of reasoning which is clear and logically structured. The processes are detailed and clearly explained.
			
			Level 2 (3–4 marks)
			A clear summary of the role of coenzymes in respiration is present, including some discussion of their involvement with various processes in the component stages.
			
			There is a line of reasoning presented with some structure. The processes have some detail and are explained generally well.
			
			Level 1 (1–2 marks)
			A limited summary of the role of some of the coenzymes in respiration is present, including some discussion of their involvement with process(es) in the component stages.
			
			There is a logical structure to the answer. The explanation, though basic, is clear.
			
			0 marks
					• NAD:
					  ○ oxidation of / removal of H / removal of electrons from, triose (bis)phosphate in glycolysis
					  ○ oxidation of / removal of H / removal of electrons from, pyruvate in link reaction
					  ○ oxidation of / removal of H / removal of electrons from, intermediates in Krebs cycle
					  ○ reduction of / addition of electrons to, electron transport chain / cytochrome in oxidative phosphorylation
					  ○ reduction of / addition of electrons to, pyruvate in lactate fermentation
					  ○ reduction of / addition of electrons to, ethanal in alcoholic fermentation
					• FAD:
					  ○ oxidation of / removal of H / removal of electrons from, intermediates in Krebs cycle

			No response or no response worthy of credit.		
			Total	**6**	
28	a		***Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit ' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1****,* ***Level 2*** *or* ***Level 3****, best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* • *award the higher mark where the Communication Statement has been met.* • *award the lower mark where aspects of the Communication Statement have been missed.* ***In summary:*** • ***The science content determines the level.*** • ***The Communication Statement determines the mark within a level.***	•	
			Level 3 (5–6 marks) Full and detailed explanation of how increased proton channels in inner mitochondrial membranes results in less likelihood of fat deposition in the body. Learner demonstrates a detailed understanding of the different processes involved and explains their implications. *There is a well-developed line of*	6	**Indicative scientific points may include…** • larger number of protons pores results in protons leaking back into matrix • reduces yield of ATP from chemiosmotic gradients • less ATP is made from oxidative phosphorylation • more energy wasted as heat

			reasoning supported by clear scientific detail. The information presented is relevant and clearly explained. **Level 2 (3–4 marks)** Generally clear explanation of how increased proton channels in inner mitochondrial membranes results in less likelihood of fat deposition in the body. Learner demonstrates a reasonable understanding of the different processes involved and explains their implications. *There is an attempt at a line of reasoning supported by some scientific detail. The information presented is largely relevant and clearly explained.* **Level 1 (1–2 marks)** Limited explanation of how increased proton channels in inner mitochondrial membranes results in less likelihood of fat deposition in the body. Learner demonstrates a limited understanding of the different processes involved and explains their implications. *There is little attempt at a line of reasoning supported by basic scientific detail. The information presented may be unclear and lack organisation.* **0 marks** No response or no response worthy of credit.		• energy from chemiosmosis decoupled from ATP synthesis • energy yield from aerobic respiration reduced per molecule of glucose • food not converted to ATP as efficiently • less excess energy intake in diet • less deposition of fat • fat stores may be respired for energy
	b	i	**U** ATP synthase ✓ **Q** electron carrier ✓	2	**ALLOW** ATP synthetase / F1 complex **ALLOW** cytochrome / proton pump
		ii	**P** inter-membrane space ✓ **S** matrix ✓	2	
		iii	**R** Krebs cycle ✓ **T** ATP synthesis ✓	2	**ALLOW** citric acid / tricarboxylic acid / TCA
	c	i	(mostly) impermeable to H^+ ions / protons ✓ large surface area ✓	2 max	**DO NOT ALLOW** H / hydrogen

			presence of, ATP synthase / stalked particles ✓		**IGNORE** ETC / cytochromes
		ii	pH decreases **AND** becomes more positive(ly charged) ✓	1	
			Total	**15**	
29			***In summary:*** *Read through the whole answer. (Be prepared to recognise and credit unexpected approaches where they show relevance.)* *Using a 'best-fit' approach based on the science content of the answer, first decide which of the level descriptors,* ***Level 1***, ***Level 2*** *or* ***Level 3***, *best describes the overall quality of the answer.* *Then, award the higher or lower mark within the level, according to the* ***Communication Statement*** *(shown in italics):* ◦ award the higher mark where the Communication Statement has been met. ◦ award the lower mark where aspects of the Communication Statement have been missed. • **The science content determines the level.** • **The Communication Statement determines the mark within a level.** **Level 3 (5–6 marks)** Full and detailed description of the processes involved in chemiosmosis. Learner demonstrates a detailed understanding of where it occurs, the stages, reactants and products, describing a range of the processes involved. *There is a well-developed line of reasoning with accurate descriptions of the processes. The information presented is relevant and clearly outlined.*	6	**Indicative scientific points may include…** These are not mark points **See appendix** • occurs in mitochondria / on membrane • involves inner membrane and matrix • involves movement of hydrogen across membrane • use of enzyme / channel protein / ATP synthase • Hydrogen ions / H^+ ions pumped out of matrix across membrane into intermembrane space • Proton / H^+ gradient created • proton-motive force • H^+ ions pass through hydrophilic transmembrane protein • cristae / stalked particles involved • ATP synthase produces ATP from ADP + Pi • H^+ ions move from area of high concentration to low concentration • Some H^+ ions leak back into matrix / process is not completely efficient **<u>Examiner's Comments</u>** This Level of Response question assessed AO1 in the context of chemiosmosis. There were some excellent responses with candidates across the ability range demonstrating their ability to recall the process of chemiosmosis, the molecules involved and where in the cell it takes place. Many candidates followed the prompt in the question stem and referred only to

			Level 2 (3–4 marks) Detailed description of the processes involved in chemiosmosis. Learner demonstrates understanding of the where it occurs, stages, reactants and products, describing some of the processes involved. *There is a line of reasoning with accurate descriptions of the processes. The information presented is in the most-part relevant and supported by some detail.* **Level 1 (1–2 marks)** A description of the processes involved in chemiosmosis is attempted, with some understanding of the different stages, reactants and products. *The information is basic and communicated in an unstructured way. The information is supported by limited detail which may be unclear.* **0 marks** No response or no response worthy of credit. **NR** No response		chemiosmosis. Some candidates wrote extended responses including all stages of aerobic respiration which was not required and so were credited the lower mark within the level for their communication statement. There were some common errors seen in lower attaining responses which included mixing up the structures of mitochondria and chloroplasts and confusion about whether it was electrons or protons moving through the electron transport chain or ATP synthase. **Exemplar 4**  Glucose is first broken down into two pyruvate molecules in the cytoplasm of the cell during a process called glycolysis. The two pyruvate molecules then are actively transported into the mitochondrial matrix to the link reaction (also known as oxidative decarboxylation). The pyruvate is decarboxylated and dehydrogenated to form an acetyl group which then moves to the Krebs cycle via a coenzyme called Coenzyme A. During the dehydrogenation of intermediates and pyruvate in the glycolysis and the link reaction, coenzyme NAD⁺ is reduced to reduced NAD. In the Krebs cycle further decarboxylation and dehydrogenation of citrate (formed by oxaloacetate and an acetyl group) reduces yet more NAD⁺ to reduced NAD and FAD to FADH2. These reduced coenzymes then move to the cristae for oxidative phosphorylation where they are oxidised releasing H+ ions and electrons. The [6] electrons move through the electron carriers of the electron transport chain where they release energy each time they pass through an electron carrier. This energy is used to pump H+ across the membrane into the intermembrane space. This leads to a proton gradient building up which causes H+ to flow back through the membrane down the H+ concentration gradient. But due to the impermeability of the membrane to H+ ions they flow through ATP synthase which catalyses the formation of ATP from ADP and Pi. This is the process of producing ATP from chemiosmosis. This exemplar shows an excellent Level 3 response for science content. The candidate has been credited with the lower mark within the level as over half of the response contains irrelevant detail about other stages in aerobic respiration which was not required.
			Total	**6**	
30			*idea of* establishment of H+ ion gradient ✓ H^+ ions, flow down a concentration gradient / AW ✓ from intermembrane space to matrix ✓ through ATP synthase ✓	3 max (AO1.1)	e.g. ‘ pumping protons into intermembranal space’ **DO NOT ALLOW** ‘H^+ ions pumped (from intermembrane space / through ATP synthase) **DO NOT ALLOW** ‘energy produced to join ADP and Pi’

			energy, provided / AW, to join ADP and Pi (to form ATP) ✓		
			Total	**3**	
31	a		5 ✓✓✓	**3**	*If no definitive answer given in Table 20, look in space above for working and / or answer.* **ALLOW** 3, 4, 5 **OR** 6 to correct SF for **3 marks** **ALLOW 3**, 4, 5 **OR** 6 to incorrect SF for **2 marks** **ALLOW** 2 **OR** 7 to correct SF for **2 marks** **ALLOW** 2 **OR** 7 to incorrect SF for **1 mark** **ALLOW** any other figure to correct SF for **1 mark** any other figure to incorrect SF = **0 marks** If no marks awarded from above, look for the following evidence of working for **1 mark** mean / $\bar{x}$ = 30 **OR** Σ = 228 **OR** $s = \sqrt{\frac{\sum(x - \bar{x})^2}{n - 1}}$ **OR** $\sqrt{\frac{\sum(X - \bar{X})^2}{N}}$ **Examiner's Comments** In **Q20(a)** it was pleasing to see some candidates remembering the formula for standard deviation (SD), despite this not being a requirement of the specification, and completing the calculation correctly. A few candidates appear to have estimated the SD by looking at the SD calculated for the other sets of data, or using the SD function on their calculators to elicit an answer. Overall many candidates were awarded maximum marks by either calculating the correct answer **5**, or estimating it would be somewhere between **3** and **6**. Bearing in mind that candidates were told to give their response to one significant figure, Examiners noted that some candidates gave responses

					to two or more significant figures. A proportion of candidates who had not given a final answer were credited with one mark for calculating the mean. However, there were quite a few candidates who understandably did not attempt the question in the absence of the formula, which should have been included.
	b		SD bars plotted correctly for the first four yeast species above and below the mean. ✓✓	**2**	*A correctly plotted SD bar is an accurately drawn vertical line. If the top and bottom of the line are capped, accept only the following symbols* —, X, ⊙ **IGNORE** *A. pullulans* (both columns) **ALLOW** one complete SD bar incorrect **For one mark** Four, five or six complete correct SD bars **Examiner's Comments** Candidates did not require an answer to Q20(a) in order to achieve full marks for **Q20(b)**, however those that did were in the minority. When the bars were plotted they were usually correct, though some candidates plotted the bars thinking the standard deviation was the total length of the bar rather than the length each side of the mean, resulting in the bars being half the required length. Some candidates appeared to have little knowledge of what an error bar should look like and plotted the SD as a number and even sometimes drew a line between points at the base of the graph or drew them as an extra bar. It is worth noting that a number of candidates who drew more conventional error bars would have lost marks had there been a requirement to use a ruler as there were some very poor freehand lines. Some candidates were unsure how to cap the line but the crosses and circles added rarely interfered with the accuracy of the plot.
	c		61.54 (%)	**3**	**IGNORE** + or - signs **ALLOW for two marks** *correctly calculated answer not to 4 SF* e.g. 61.538 / 61.5

			OR 70.20 (%) *(calculated from Table 20)* ✓✓✓		e.g. 70.198 / 70.2 **ALLOW for one mark** *evidence of a correct calculation* e.g. $\frac{21-13}{13} \times 100$ **OR** $\frac{21.417-12.583}{12.583} \times 100$ **Examiner's Comments** As the question stem for **Q20(c)** did not guide candidates to use Fig. 20 to access the means some picked a different route and used the figures from Table 20 in their calculations. Both routes could access three marks with 61.54% the most commonly seen correct response. Some candidates lost marks for errors of arithmetic or rounding whilst others that gave the correct number of significant figures in other questions occasionally failed to do so here. Percentage change for the wrong yeast species was seen and, unfortunately, many candidates incorrectly calculated from aerobic to anaerobic giving the incorrect response of 38.10%. A number of candidates also made the mistake of dividing the actual value of the anaerobic CO_2 production rather than the difference between the two values.
	d	i	**1** *incorrect because* *A. pullulans* / one yeast (species), produced more CO_2 in anaerobic conditions ✓ **2** *incorrect because* error bars / standard deviations, overlap ✓	**2**	**ALLOW** no *t*-test carried out **DO NOT ALLOW** range bars **Examiner's Comments** In **20(d)(i)** the majority of candidates identified the first statement as incorrect and went on to give the correct reason that *A. pullulans* produced more CO_2 in anaerobic conditions. Most candidates did identify the second statement as incorrect but only stronger candidates stated that it was incorrect because of the standard deviation overlap or that a statistical test was not carried out. Only stronger candidates grasped the fact that for error to be random the SDs must be wide-ranging thereby gaining credit in

					Q20(d)(ii). Most candidates cited some aspect of the methodology as being inaccurate as evidence for their answer or limitations of equipment rather than reflecting on the results.
		ii	random error (because) some (experiments / yeast species / columns on chart with) large SDs / error bars ✓	**1**	**DO NOT ALLOW** standard error **DO NOT ALLOW** range bars **Examiner's Comments** In **20(d)(i)** the majority of candidates identified the first statement as incorrect and went on to give the correct reason that *A. pullulans* produced more CO_2 in anaerobic conditions. Most candidates did identify the second statement as incorrect but only stronger candidates stated that it was incorrect because of the standard deviation overlap or that a statistical test was not carried out. Only stronger candidates grasped the fact that for error to be random the SDs must be wide-ranging thereby gaining credit in **Q20(d)(ii)**. Most candidates cited some aspect of the methodology as being inaccurate as evidence for their answer or limitations of equipment rather than reflecting on the results.
	e		ribosome(s) ✓	**1**	**ALLOW** rough endoplasmic reticulum / RER **Examiner's Comments** **Q20(e)** was generally well-answered with only a few incorrect responses seen, the most common being Golgi apparatus or nucleus.
			Total	**12**	
32		i	1. (at start) respiration is anaerobic / glucose converted into ethanol✓ 2. respiration, decreases rapidly / stops , once glucose used up ✓ 3. ethanol used (as a carbon source) once glucose has been consumed ✓ 4. aerobic respiration (of ethanol) ✓	**3 max**	**ACCEPT** oxygen is needed for the

			5. (because) acetyl Co A used in Krebs cycle ✓ 6. respiration stops when, ethanol / respiratory substrate, has been used up ✓		metabolism of ethanol **Examiner's Comments** This question proved to be a good discriminator. This was a difficult graph to interpret and some candidates were confused in their answers. There were numerous responses based entirely on recall of aerobic respiration followed by anaerobic respiration when yeast is used to produce ethanol. Candidates seemed quite happy to ignore or misrepresent the evidence of the graph to fit with their preconceptions. Good candidates just looked at the evidence and drew the correct if unfamiliar conclusion, which was that anaerobic respiration was followed by aerobic respiration. Weaker candidates did not get to grips with the idea that glucose was used as a respiratory substrate at first, and then ethanol. Neither did they link that with the type of respiration. Weaker candidates often gave a detailed description of the graph, quoting data in great detail, but did not mention the type of respiration occurring rather taking the approach of manipulating data, which gained no credit.
		ii	(use) aseptic techniques / avoid contamination ✓ provide (sources of) nutrients / respiratory substrates ✓ (incubate at) suitable temperature ✓ use (pH) buffer ✓ agitation / stirring / shaking ✓	**2 max**	**Mark first two suggestions given** **ACCEPT** a description of an aseptic technique **ACCEPT** sterile techniques **ACCEPT** a specific example of a nutrient **ACCEPT** optimum temperature / right temperature /a specific, appropriate temperature (15 – 35°C) **IGNORE** keep temperature constant / low temperature/ monitor temperature / control temperature **ACCEPT** maintain optimum pH / right pH /a specific, appropriate pH (4–7) **IGNORE** keep pH constant / monitor pH / control pH **ACCEPT** mixing

					IGNORE ref to aeration / oxygen supply / sparging **Examiner's Comments** This was well answered on the whole, and many candidates scored two marks. The majority of candidates got two marks for mentioning the use of aseptic techniques and mark point 3 or 4 for the use of optimum temperature or optimum pH. Some candidates stated control temperature and pH rather than the idea that these factors needed to be suitable for the yeast, and it was disappointing to see that some candidates suggested that the 'culture' should be sterilised, which gained no credit.
		iii	3.75 ✓ x 10^5 ✓	**2**	**One mark** awarded for a correct calculation with the wrong number of significant figures or not in standard form (e.g. 375000 , 375 x 10^3 ,3.8 x10^5) **Examiner's Comments** Many candidates had trouble with this calculation. It was clear which candidates had been taught how to calculate population numbers in relation to dilutions. However, a large proportion of the candidates then failed to give their answer in standard form or to three significant figures, and so only gained one mark. It is important that centres make sure that candidates know how to calculate serial dilutions and are able to put their answer into standard form and the correct number of significant figures. Some candidates were able to work out that there were 150 bacteria in 1 ml of 10^{-2} dilution, but then got confused and were unable to convert this to 15000 in 1 ml of original culture and hence then calculate 15000 x 25 = 375000 (3.75 x 10^5) in 25 cm^3 of the original culture.
		iv	*Yes because…* a suitable, range / intervals, of temperatures have been chosen ✓	**3 max**	**Max 2 for statements supporting only one view** **IGNORE** large / wide, range of temperatures

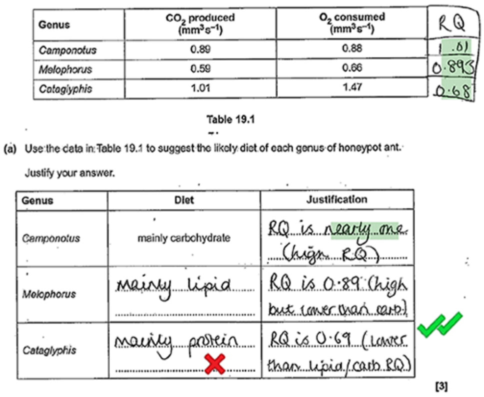
			volume controlled ✓ temperature , controlled / maintained ✓ repeats, to identify anomalies / outliers ✓ same yeast suspension used ✓ *No because…* availability of, oxygen/ nutrients / yeast concentration, not controlled ✓ pH is not be controlled at start of experiment ✓ *idea of* pH change would not be an accurate measure of respiration rate ✓ no time reference (to calculate rate) ✓ no control (sample) ✓		**IGNORE** repeats exclude anomalies **ACCEPT** 'better to collect (volume of) carbon dioxide produced' / 'It is better to use a respirometer' (implies pH change not accurate) 'because some CO_2 would diffuse into the air' **Examiner's Comments** Many candidates scored well on this question and it was good to see how many realised that using a pH probe is not an accurate way to measure respiration rate. However, some candidates used very vague language, such as 'a range of temperatures' without qualification, and a sizeable proportion gave only 'yes, because…' or 'no, because…' answers, obviously not understanding the significance of term 'evaluate'. Candidates need to be taught that when asked to evaluate they need to put arguments for and against. Weaker candidates suggested that pH needed controlling which showed a lack of understanding of the question. A number also did not get mp 4 under the Yes section because they did not mention that by doing repeats one can help to identify the anomaly. Instead they went one step further and were mentioning removing the anomaly or discarding it in order to calculate the mean.
		v	difference (between the means), is not significant / can be explained by chance (at p = 0.05) ✓	**1**	**ACCEPT** null hypothesis / H_o, can be accepted **DO NOT ACCEPT** null hypothesis / H_o can be rejected **ACCEPT** the results are not significantly different (p = 0.05) **Examiner's Comments** This was well answered, showing that many

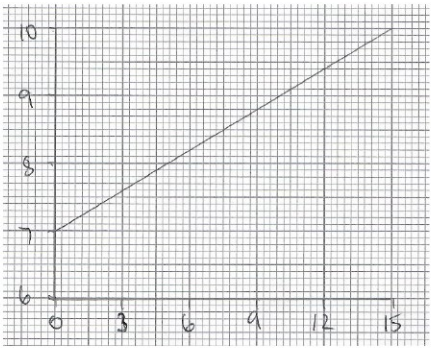
					candidates seem to understand how to interpret statistical calculated values. It was clear that many candidates had been taught this basic statistical test and what it showed. However a significant number of students still gave confusing answers and failed to understand that if the t value is less than the critical value at p = 0.05, the null hypothesis should be accepted and there is no significant difference. They often confused results not being significantly different with the null hypothesis being rejected so they ended up getting no marks. Very weak candidates just stated that the results were not different. The words significant or different were missing from the responses.
			Total	**11**	
33		i	it (only) respires in the absence of oxygen	1	Must imply that the absence of oxygen is the preferred / essential condition. e.g. 'can respire in the absence of oxygen' does not really imply this, as this statement also applies to aerobic organisms.
		ii	it hydrolyses a peptide bond between two amino acids (residues) which are joined by a disulfide bond	1	
			Total	**2**	
34	a		*two from* cells are able to tolerate, high levels of lactate / acidity / low pH (1) have high phosphocreatine stores (1) use of stored ATP (1)	2	
	b	i	**D** pyruvate (1) **E** lactate (1)	2	
		ii	is a hydrogen acceptor / removed hydrogen from reduced NAD	1	
		iii	*two from* for glycolysis to take place, NAD / **G**, is needed (1) there is a limited amount of NAD in the cell (1) formation of, NAD / **G**, allows, glycolysis to continue / some ATP to be formed (1)	2	
		iv	liver **and** in the blood	1	Both required for 1 mark.

			Total	8	
35	a		pyruvate ✓ Krebs ✓ liver ✓ link ✓ ATP ✓	5	**ALLOW** citric acid / tricarboxylic acid / TCA
	b	i	1122.06 ✓✓	2	**1 mark max** if answer is not to 6 s.f. **1 mark max** for rounding error If incorrect, **ALLOW** 1 mark for evidence of: $\frac{831 - 68}{68} \times 100$ **ALLOW** 1 mark for 91.8171
		ii	1.38×10^{25} ✓✓✓	3	**2 marks max** if answer is not to 3 s.f. If incorrect, **ALLOW** 1 mark for evidence of any of the following, up to a maximum of 2: ○ conversion of 100g to 35g, e.g. $478 \times \frac{35}{100} = 167.3$ kCal ○ conversion of kcal to kJ, e.g. 167.3 × 4.18 = 699.31 kJ • conversion of moles to molecules × 6.02×10^{23}
		iii	(cheese is high in) fat which has, the highest / 831, kcal per 100g ✓ fatty acids have many H atoms ✓	2 max	

			can be oxidised many times in Krebs cycle ✓ (so) reduce many NAD / produce many NADH (in Krebs cycle) ✓		**ALLOW** many turns of Krebs cycle
			Total	**12**	
36	a		cookie <u>2</u> is protein cookie ✓ RQ of cookie 2 is 0.94 **AND** RQ of cookie 1 is 0.98 ✓ lower RQ means (cookie 2) must have more protein ✓ RQ closer to 1.0 means more carbohydrate ✓	3 max	**ALLOW** ORA
	b		maggots will not produce CO_2, during lactate fermentation ✓ yeast will produce CO_2, during alcoholic fermentation ✓ measuring RQ requires CO_2 production / RQ value (for maggots) will be lower than normal ✓ **OR** 2 minutes not long enough for, yeast / maggots, to, break down / respire, cookie ✓ CO_2 produced (by yeast) is not from respiration of cookie ✓ RQ (comparison) will be invalid ✓	3	**IGNORE** "maggots will die" because experiment is only for 2 minutes
			Total	**6**	
37			<table><tr><th>Genus</th><th>Diet</th><th>Justification</th></tr><tr><td>*Camponotus*</td><td>mainly carbohydrate</td><td>(RQ is) 1.0</td></tr><tr><td>*Melophorus*</td><td>protein **OR** lipid <u>**and**</u> carbohydrate</td><td>(RQ is) 0.9</td></tr></table>	3	**DO NOT ALLOW** all three substrates for *Melophorus* **ALLOW** amino acids for protein for *Melophorus* **ALLOW** fat / oil / triglyceride / fatty acid for lipid for *Cataglyphis*

			Cataglyphis | lipid | (RQ is) 0.7 ✓✓✓		**ALLOW THREE** marks for correctly completed table **ALLOW RQs** to greater number of sig.figs. e.g. 1.01 / 0.89 / 0.687 If **Rf** or **RV** is stated instead of RQ allow **max 1** for **justification** column **ALLOW TWO** marks for all correctly calculated RQ values in **justification** column / on Fig.19.1 **OR** **ALLOW TWO** marks for: correct two responses in **diet** column **AND** for correct three **justifications** written in words i.e. *Camponotus* – CO_2 produced is , similar / equal to O_2 consumed *Melophorus* - CO_2 produced is 0.07 less than O_2 consumed *Cataglyphis* - CO_2 produced is 0.46 less than O_2 consumed **If RQ values have not been calculated or are incorrect** **ALLOW ONE** mark for correct **diet** column **OR** correct **justification** column written in words **OR** two correct RQ values **Examiner's Comments** There were some excellent responses from candidates who were able to correctly calculate RQ values and then suggest the correct diet, although some candidates confused protein and lipids. Some candidates described the justifications in words but did not include numerical data or calculations and whilst not credited for this, they could still be credited for a correct diet column. **Exemplar 3**

					 Genus / CO_2 produced (mm^3s^{-1}) / O_2 consumed (mm^3s^{-1}) / RQ Camponotus / 0.89 / 0.88 / 1.01 Melophorus / 0.59 / 0.66 / 0.893 Cataglyphis / 1.01 / 1.47 / 0.68 Table 19.1 (a) Use the data in Table 19.1 to suggest the likely diet of each genus of honeypot ant. Justify your answer. Genus / Diet / Justification Camponotus / mainly carbohydrate / RQ is nearly one (high RQ) Melophorus / mainly lipid / RQ is 0.89 (high but lower than carb) Cataglyphis / mainly protein / RQ is 0.69 (lower than lipid/carb RQ) [3] This exemplar shows correct justification with clear calculations of the RQ values. Although they have confused the two respiratory substrates in the diet column.
			Total	**3**	
38			*0 watts*: (mainly) carbohydrates respired / AW ✓ *50 watts:* (more) fats / lipids / amino acids / proteins, respired / AW ✓ *250 watts:* (more) anaerobic respiration / AW ✓	3 (AO3.1)	**ALLOW** (mainly) glucose respired **DO NOT ALLOW** 'only, fats / amino acids / proteins, respired'
			Total	**3**	
39		i	**1** correct description of 1:10 dilution ✓ **2** need to make , a total of four 1:10 dilutions / hree further 1:10 dilutions ✓ **3** correct values of dilutions given between stages e.g.1:10 to 1:100 ✓ **4** (ensure) mixing of yeast (suspension) at each stage ✓	3 max (AO2.4) (AO3.3)	**e.g.** take 1 cm^3 of culture and make up to 10 cm^3 **ALLOW** diagram showing serial dilution steps **DO NOT ALLOW** 1cm^3 + 10cm^3 **DO NOT ALLOW** add 0.1 cm^3 into 9.9cm^3 for **MP1** (due to measuring cylinders provided) but then ECF for **MPs 2 and 3** **ALLOW** values in standard form e.g. 1: 102 **ALLOW** e.g. stir thoroughly and repeat
		ii	eyepiece graticule ✓ stage micrometer ✓	2 (AO2.3)	**IGNORE** haemocytometer
		iii	1.25×10^8 ✓✓	2 (AO2.4)	**FIRST CHECK ON THE ANSWER LINE if answer = 1.25×10^8, award 2 marks If answer incorrect:** **ALLOW** 1 mark for

					answer not in standard form **OR** incorrect standard form e.g. 125 x 10^6 **OR** use of equation with correct figures $number\ of\ cells = \frac{2.5 \times 10^{-3}}{2.0 \times 10^{-11}}$
		iv	straight line ✓ starting at 0,7 ✓ ending at 15,10 ✓	3 (AO2.4)	
			Total	**10**	
40			A	1 (AO2.7)	
			Total	**1**	
41	a	i	**1** rate of respiration is proportional to rate of gas production ✓ **2** use a tangent (on non linear part of curve) ✓ **3** measure / calculate , slope / gradient (of each line) ✓ **4** volume of gas (collected) divided by time ✓ **5** compare the same , time / period (between sugars) ✓	max 3 (AO2.3) (AO3.3)	**ALLOW MPs 2, 3 and 5** from annotation of graph **ALLOW** seen as units e.g. $cm^3\ min^{-1}$ **ALLOW** within prose / calculations
		ii	***Summary of instructions to markers:*** *See instruction 10 on page 5 of this mark scheme.* **Level 3 (5–6 marks)** An evaluation of **both** conclusions to include for **and** against statements *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated* **Level 2 (3–4 marks)** An evaluation of **one** conclusion to	6 (AO3.2)	**Indicative scientific points may include:** *Conclusion that rate of respiration of glucose, maltose and sucrose is similar* ***Supporting statements (correct because)*** • the slope of each curve is similar • values for overall / mean rates are similar • calculated values e.g. sucrose ~1.9$cm^3\ min^{-1}$, glucose ~2.1$cm^3 min^{-1}$, maltose ~2.4$cm^3 min^{-1}$ ***Against statements (incorrect because)***

			include for **and** against statements. **OR** for **or** against statements for **both** conclusions. *There is a line of reasoning presented with some structure. The information presented is in the most-part relevant and supported by some evidence* **Level 1 (1–2 marks)** Incomplete evaluation e.g. for **or** against statements for **one** conclusion. *The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.* **0 marks** *No response or no response worthy of credit.*		• glucose respiration begins sooner than maltose / sucrose • glucose has more rapid increase at beginning • lag before respiration of maltose / sucrose begins • sucrose / maltose rate continues to increase as glucose is slowing down • maltose / sucrose may need to be hydrolysed before used in respiration *Conclusion that yeast could not hydrolyse disaccharides* ***Supporting statements (correct because)*** • little / no lactose respiration • lactose is disaccharide • lactose was not hydrolysed • yeast do not have the enzyme to hydrolyse lactose ***Against statements (incorrect because)*** • maltose / sucrose are disaccharides • maltose / sucrose are respired • may be that lactose could be hydrolysed but cannot be absorbed ***Either conclusion (against)*** • need statistical analysis to determine significance • e.g. t-test / standard deviation • measuring volume of gas over time only estimate of rate of respiration
	b	i	rinse / change , flask / equipment ✓ stir yeast , (stock) solution / suspension ✓ (yeast stock solution made from) same type of yeast ✓ ensure connection to gas syringe is tight ✓	max 2 (AO3.3)	**ALLOW** e.g. use different stirrer each time **ALLOW** ensure no leaks in gas syringe

			check temperature of , water bath / yeast (stock) solution , is 35 ºC ✓		
		ii	boiled (and cooled) yeast / use buffer instead of yeast ✓	1 (AO3.3)	
			Total	**12**	