Mark scheme

Question			Answer/Indicative content	Marks	Guidance
1		i	(volume of) oxygen , consumed / inhaled / AW **AND** (volume of) carbon dioxide , produced / exhaled / AW ✓	1	**Both needed for the mark** **<u>Examiner's Comments</u>** Generally well-answered by most candidates.
		ii	RQ of carbohydrate is 1 / RQ of fat is (approx) 0.7 ✓ at rest fat is used ✓ as intensity increases (more) carbohydrate is used ✓ (even) at highest intensity some fat is used **OR** (even) at highest intensity <u>not just</u> carbohydrate is used ✓	max 3	**ALLOW** named carbohydrates e.g. sugars **ALLOW** fatty acids / named fats e.g. lipids **IGNORE** ref to protein at 0.8 (approx.) **ALLOW** 0% / low / 0-10% intensity for at rest **ALLOW** at 100% intensity **ALLOW** at high intensities mixed respiratory substrates / <u>mainly</u> carbohydrate being used **IGNORE** protein and fat / carbohydrate and fat **<u>Examiner's Comments</u>** Candidates that understood RQ values knew that lipids have an RQ of 0.7 and linked this to their use at low activity levels to gain two marks. Many candidates thought that use of proteins was the reason for the change of the RQ to 0.8 rather than the increasing use of carbohydrates. Only high achieving candidates noticed that the RQ value in Fig. 20.3 did not reach 1 even at 100% intensity and concluded that a mixture of respiratory substrates would be used.
			Total	**4**	
2			C	1	**<u>Examiner's Comments</u>**

					Candidates were required to use their knowledge of respiratory substrates and their energy values to determine which statement was **not** correct. Candidates that were able to recall relative energy values correctly identified option **C** as the **incorrect** answer, hence correct response.
			Total	**1**	
3		i	**X** = water / H_2O **Y** = carbon dioxide / CO_2 **Z** = oxygen / O_2 ✓✓	2	All **three** correct for **TWO** marks **One** or **two** correct for **ONE** mark **Examiner's Comments** Many candidates were able to correctly identify all three molecules in Fig.17.1. Some candidates found it difficult to interpret the diagram and so mixed up the three molecules on the answer lines or answered in terms of ATP, NAD, FAD, NADP, NADPH or electrons. **Misconception** It is a common misconception that candidates consider that ATP produced in respiration is used directly in photosynthesis.
		ii	**1** *idea that* light (energy) is the only requirement from outside the terrarium / AW ✓ **2** respiration provides carbon dioxide **and** water for photosynthesis **OR** photosynthesis provides glucose **and** oxygen for respiration ✓ **3** water used for photolysis **OR** oxygen used as final electron acceptor (in respiration) ✓ **4** carbon dioxide used for , light independent stage / Calvin cycle ✓ **5** ATP (still) produced / energy provided , for (named) cell activities ✓	max 3	**ALLOW** O_2 for oxygen, H_2O for water, CO_2 for carbon dioxide and $C_6H_{12}O_6$ for glucose throughout **MP1 ALLOW** e.g. as light (energy) can pass through glass for photosynthesis **MP1 ALLOW** e.g. plants in glass containers will have access to light **MP2 IGNORE** equations unqualified **MP5 ALLOW** e.g. active transport / protein synthesis / active uptake of mineral ions **IGNORE** produces energy **MP6 IGNORE** nutrients

			6 decomposing plant material provides (named) mineral ions ✓		**Examiner's Comments** Good responses showed good application of knowledge and understanding of photosynthesis and respiration and their interaction in plants. Higher attaining candidates set out their answers in a logical sequence and gave detailed accounts of the production and use of reactants for both processes.
			Total	**5**	
4	a		(produces) ATP to provide (chemical) energy / AW ✓ (DNA replication) requires ATP /AW ✓	1	**DO NOT ALLOW** 'produces energy' **ALLOW** requires ATP as it is an active process **ALLOW** 'because ATP is needed' e.g. need for ATP (in, DNA replication / to break bonds between bases / form phosphodiester bonds) **Examiner's Comments** This was well answered by most candidates. Even if they did not give a clear answer as to what the ATP was used for, they could gain the available mark for saying that ATP provides energy or DNA replication requires ATP. Some candidates did not score the mark for this question as they mentioned the use of ATP in protein synthesis, transcription or translation.
	b	i	*(pH, would increase / become less acidic / more alkaline)* because protons move into, chloroplasts / AW ✓ by, diffusion / down a concentration gradient / AW ✓ (for) protons (to be pumped / moved) into thylakoid, lumen / space / AW✓	2 max	**If pH decreases / becomes more acidic / less alkaline = 0 marks** **ALLOW** H+ / hydrogen ions for protons throughout **DO NOT ALLOW** H / hydrogen for protons throughout (but penalise only once) e.g. 'protons diffuse from high to low concentration into the chloroplasts' = 2 marks **IGNORE** 'along a concentration gradient'

					IGNORE active transport (*as energy provided by ETC*) **IGNORE** 'intermembrane' *(as confusing chloroplasts with mitochondria)* **Examiner's Comments** This was a challenging question, but a reasonable number of candidates managed to interpret the information provided and explain why the pH of the solution would increase. Some candidates that understood the principles of the process did not gain both marks because they described how the H+ ions would be used inside the chloroplasts without initially explaining that these ions would need to move into the chloroplasts and then into the thylakoid spaces. Other candidates explained that the protons would move from the solution into the chloroplasts, which was credited, but their answer did not state that the protons would move down a concentration gradient by diffusion.
		ii	*(ATP produced in 3 / pH 8 solution, but not 2 / pH 4 solution, because)* proton gradient between thylakoid (lumen / space) and solution 3 ✓ protons diffuse through ATP synthase (into solution 3) ✓	2	**If ATP produced in 2 but not 3 or ATP production is, higher / highest, in 3 or more ATP produced in 3 than 2 = 0 marks** **ALLOW** H+ / hydrogen ions for protons throughout **DO NOT ALLOW** H / hydrogen for protons throughout (but penalise only once) **ALLOW** electrochemical gradient for proton gradient **ALLOW** higher concentration of protons in thylakoid (lumen / space) than in solution 3 **ALLOW** no proton gradient / equal proton concentration, between thylakoid (lumen) and solution 2 **ALLOW** no protons diffuse through ATP synthase into solution 2 **DO NOT ALLOW** 'pumped through by diffusion'

					ALLOW 'pass' / move / travel' for 'diffuse' **Examiner's Comments** This was the most challenging question in the examination. Candidates were required interpret the information and make several logical steps to realise that ATP production would occur in solution 3. The majority of candidates suggested that ATP production would be higher in solution 2; the logic of these answers was often that the lower pH and therefore higher H+ ion concentration in that solution had the potential to provide more protons for chemiosmosis. Only the higher performing candidates realised that the initial placement of the thylakoids, in the dark, in a solution of pH 4 would have resulted in a pH of 4 inside the thylakoids. As a consequence, no concentration gradient would have existed across the thylakoid membranes in solution 2 (and no light was present to activate the ETC to allow protons to be pumped into the thylakoids). A concentration gradient would have existed in solution 3, allowing the diffusion of protons through ATP synthase even without the ETC functioning.
			Total	**5**	
5	a	i	CO_2 is produced earlier with maltose /AW ✓ CO_2 production is higher with maltose / AW ✓ difference between maltose and glucose increases (over time) / AW ✓ both show slow increase at start	2 max (AO2.8)	**ora** for glucose **ALLOW** quoted data for mp1 e.g. 'starts rising after 0 minutes for maltose but after 20 minutes for glucose' **IGNORE** 'quicker / faster' as implies rate **ALLOW** quoted data for mp 2 e.g. 'a total of, 84 / 85 , cm^3 of CO_2 is produced by glucose compared to 100 cm^3 by maltose' **Examiner's Comments** Many candidates were given credit for

			followed by a steeper increase later on / AW ✓		a direct statement comparing CO_2 production, or a correct data quote for CO_2 production being higher with maltose. A minority were also credited for recognising the earlier production with maltose. Some candidates who recognised that carbon dioxide was produced earlier, did not get the mark because they either stated the wrong time or stated the time interval in seconds rather than minutes. Others made a comparison of the curves but most of these were too vague to gain credit, e.g. "curves are a similar shape", without describing how they are similar. A common mistake was referring to rate of reaction and using terminology such as "faster" or "quicker".
		ii	*agree* (final) volumes of CO_2 produced are low / AW ✓ volumes of CO_2 produced is same , up to 20 minutes / at 90 minutes ✓ the data have the same order of magnitude ✓ *disagree* sucrose , increases earlier / plateaus / stops producing CO_2 ✓ final sucrose volume is (approximately) half that of fructose / AW ✓	2 max (AO3.2)	e.g. 'neither rise above 18 - 20 cm^3' **ora** fructose , increases later / continues to rise **ora** final fructose volume is (approximately) double that of sucrose **ALLOW** quoted data from graph e.g. 'sucrose produces 8-10 cm^3 of CO_2 whilst fructose produced 18-19 cm^3 (after, 140 /150, minutes)' e.g. 'fructose produces 15-17 cm^3 of CO_2 whilst sucrose produced 8-10 cm^3 (after 125 minutes)' **Examiner's Comments** Most candidates disagreed with the student's conclusion and were credited for stating that the carbon dioxide concentration plateaus with sucrose - this was the most common response. Many candidates also quoted data from graph for the final volumes of carbon dioxide production, for sucrose and fructose and gained credit for the *idea* that the final volume for fructose was double that of

					sucrose. Only a few candidates agreed with the conclusion and identified that at two times on the graph, sucrose and fructose, had the exact same volume. They usually mentioned that at 90 minutes the volumes of carbon dioxide produced for sucrose and fructose were the same.
	b	i	use (named) equipment with high(er) resolution / AW ✓ use volumetric flask, instead of measuring cylinder / to measure the water ✓ use graduated pipette, instead of dropping pipette / to measure the glucose solution ✓ use one dilution instead of two ✓ produce one 0.01 mol dm^{-3} solution for all the populations instead of separate solutions ✓	2 max (AO3.4)	**MARK AS PROSE** e.g. 'use, measuring cylinder / pipette, with high(er) resolution' e.g. 'use equipment with, smaller gaps between divisions / smaller intervals' **IGNORE** 'more, intervals / divisions' **IGNORE** precise / accurate **ALLOW** use, burette / syringe, instead of measuring cylinder / to measure the water **ALLOW** use, micropipette / volumetric pipette / pipette filler / syringe, instead of dropping pipette / to measure the glucose solution 'instead of a pipette, use a syringe which has a higher resolution' = mp1 and 3 **ALLOW** 'use fewer dilutions' **Examiner's Comments** Candidates found this experimental design question very challenging and found naming apparatus with a higher resolution very difficult. Many candidates didn't link their suggestions to the reduction of percentage error, as per the question. This led to references such as: repeating the experiment and identifying anomalies, calculating means, and controlling variables such as temperature. A substantial number of candidates referred to rinsing/drying equipment (i.e., glucose being left in the pipette), or using a clean/new pipette every time. Some candidates used the terms 'accuracy' and 'precision' rather than 'resolution'

					when referring to the measuring equipment. 'Accuracy' and 'precision' are terms used to describe data and experimental results rather than equipment. Some candidates also described changes to volumes as a way to reduce percentage error. This is relevant in many cases, but volumes were not stated in the question stem, therefore an increase in the volume measured would not represent an improvement based on the information provided. A common mistake was the reference to **more** intervals/divisions rather than **smaller** intervals/divisions when talking about measuring equipment. Candidates who read and understood the instructions in the question often gained 2 marks for naming a piece of equipment, and explained they had higher resolution. **OCR support** Advice on language of measurement can be found in this OCR resource
		ii	sterilised / boiled / distilled ✓ sealed / vacuum / airtight / closed / described ✓ standard deviation(s) ✓	3 (AO3.3)	e.g. 'put bung in (flask)' **Examiner's Comments** Most candidates found this word-fill straightforward. Some candidates lost a mark for the first blank by stating deionised water, however the majority got this mark for stating distilled water. The most common mistake for the second blank was simply stating "conical" and not referring to the need for the flask to be sealed/airtight, etc. The incorrect answers for the third blank included means, medians, modes, averages, hypotheses, anomalies, and ranges.
			Total	**9**	
6		i	label E anywhere in the mitochondrial matrix ✓	2 (AO1.1) (AO2.1)	**CON** a second label E in the cytoplasm **ALLOW** a line to the inner membrane

<table>
<tr>
<td></td><td></td><td></td>
<td>label F on inner mitochondrial membrane ✓</td>
<td></td>
<td>or any part of the letter F touching the membrane

<u>Examiner's Comments</u>

Few candidates did not score any marks on this question. The labelling of letter E was more commonly scored than F, but many candidates scored both marks. The most common misconception was that FAD released H atoms (letter F) in the inter-membranal space, rather than on the inner mitochondrial membrane.</td>
</tr>
<tr>
<td></td><td></td><td>ii</td>
<td>
<table>
<tr><th>Feature</th><th>FAD</th><th>NAD</th></tr>
<tr><td>Is a prosthetic group</td><td>✓</td><td>x</td></tr>
<tr><td>Is reduced in the link reaction</td><td>x</td><td>✓</td></tr>
<tr><td>Oxidises molecules in the electron transport chain</td><td>x</td><td>x</td></tr>
</table>
✓ ✓
</td>
<td>2
(AO1.1)</td>
<td>2 rows correct = 1 mark
3 rows correct = 2 marks

DO NOT ALLOW hybrid ticks
ALLOW 'yes' or 'no' in place of '✓' or 'x'
ALLOW if only '✓' or 'x' used in table

ALLOW 'x' for FAD is a prosthetic group

<u>Examiner's Comments</u>

FAD and NAD are often described as coenzymes, but FAD can be considered a prosthetic group. The categorisation of coenzymes and prosthetic groups differs between textbooks and other sources. For this reason both '✓' and 'x' were accepted as correct for the 'FAD is a prosthetic group'. Most candidates knew that NAD is not considered a prosthetic group. Few candidates realised that neither FAD nor NAD oxidise molecules in the ETC (reduced FAD and reduced NAD reduce molecules in the ETC).</td>
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<tr>
<td></td><td></td><td>iii</td>
<td>active, transport / uptake (of pyruvate or another named molecule) ✓

synthesis of (named) enzymes (involved in respiration) ✓</td>
<td>1 max
(AO2.5)</td>
<td>ALLOW pumping / acts as a pump
IGNORE ref. to role of ATP in glycolysis
DO NOT ALLOW ref to active transport of H^+ ions

<u>Examiner's Comments</u></td>
</tr>
</table>

					This question proved challenging to many candidates. Many candidates named the phosphorylation of glucose in glycolysis and did not realise this example is already described in the question. A common misconception was that protons are moved into the inter-membrane space using energy from ATP. Candidates did not realise that the energy for this process came from the electrons. Several answers correctly named the movement of pyruvate into the mitochondria but did not make reference to active transport. Very few candidates mentioned using ATP to synthesise respiratory enzymes such as ATP synthase.
			Total	**5**	
7			**D**	1 (AO2.1)	
			Total	**1**	
8			***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.***	6 (AO1.2) (AO2.5)	**Indicative points include** *Sources of ATP* • Free ATP in muscle cells / sarcoplasm • ATP formed from creatine phosphate or phosphocreatine • runs out in a few seconds / quickly *Aerobic respiration stated* • occurs if oxygen available • oxidative phosphorylation • greater yield of ATP • delivery of O_2 to tissues does not meet demand • O_2 is limited during strenuous exercise *Anaerobic respiration stated* • needed during strenuous exercise • anaerobic only involves glycolysis

			• ***The Communication Statement determines the mark within a level.*** **Level 3 (5–6 marks)** A description of source of ATP during strenuous exercise **AND** detail of both aerobic **AND** anaerobic respiration *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 description of source of ATP during strenuous exercise **AND either** detail of aerobic **OR** anaerobic respiration. **OR** A description that includes detail of aerobic **AND** anaerobic respiration *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** A description of a source of ATP for muscle contraction **OR** detail of aerobic **OR** anaerobic respiration. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*		• ATP formed by substrate level phosphorylation • net yield of 2 ATP / smaller yield of ATP • NAD regenerated so glycolysis can continue • cannot continue indefinitely due to lactic acid build-up **Examiner's Comments** Many candidates gave good descriptions of aerobic, anaerobic respiration and the formation of ATP using creatine phosphate, briefly describing and comparing the main points of each ATP source as required by this LoR style question. However, several candidates frequently included a lot of unnecessary detail about aerobic respiration and wrote at length describing the biochemical details, which would been time-consuming. As with Question 17*, many candidates used extra pages to provide their response. Some candidates left out reference to aerobic respiration completely, possibly due to the reference to strenuous exercise in the question and went straight to discussing the role of anaerobic respiration and sometimes creatine phosphate.
			Total	**6**	
9	a	i	**any two from**: thermostat (to control temperature whilst taking measurements) ✓	2 (AO3.3)	**Mark as continuous prose** **ALLOW** e.g. use heater **or** iced water to get water to (required) temperature **or** use thermostatically controlled

			thermometer (to monitor temperature in the respirometer chamber) ✓ oxygen probe, in water entering / before respirometer ✓		water bath **ALLOW** temperature probe **Examiner's Comments** Most responses suggested a thermometer. Examiner's reports have stressed that use of a water bath is not considered sufficient. Some suggested use of a heater but didn't say that this was to achieve the required temperature. Some referred to use of a stop clock to measure rate, but this is not a modification to this apparatus. Some candidates suggested adding a carbon dioxide probe or referred to controlling other variables such as pH.
		ii	**any one from**: allows continual data collection ✓ less risk of error / remove human error ✓ allows for, easier / direct / immediate, data analysis ✓	1 (AO3.3)	**IGNORE** refs to accuracy / precision **ALLOW** person does not need to be present **ALLOW** e.g. description of experimental or operator error **ALLOW** reduces bias or results not subjective **Examiner's Comments** This question was well answered with reference to human error the most common answer. Several candidates gave accuracy or precision as their response. Only a few candidates referred to the idea of continual data collection or easier data analysis. Some candidates mistakenly thought that an advantage of a computer was that quantitative results could be obtained.
		iii	**any two from**: **1** to maintain (adequate) supply of oxygen / AW ✓ **2** so that fish can respire (aerobically) ✓ **OR**	2 (AO3.3)	**Mark in pairs e.g**. either MP1 and MP2 **OR** MP3 and MP4 **MP1 ALLOW e.g**. maintains gaseous exchange **or** allows counter current flow across the gills **MP2 ALLOW** so fish doesn't respire anaerobically

			3 to remove (named metabolic) waste products / AW ✓ **4** that could, damage / kill / be toxic to, fish ✓		**Examiner's Comments** There were some excellent answers to this part question, including reference to the need for a supply of oxygen to allow gas exchange across the counter current flow system of the gills linked to respiration. Fewer candidates opted for the alternative of removing waste products such as carbon dioxide.
		iv	**P1** allow temperature to reach the required point before taking measurements ✓ **E1** allow fish to acclimatise to the temperature of the tank / AW ✓ **OR** **P2** use, appropriate / suitable, temperature range ✓ **E2** to avoid stress to the fish / oxygen solubility varies with temperature ✓ **OR** **P3** idea of waiting for fish to calm down / adjust to the tank or new surroundings ✓ **E3** because, stress / AW, can affect oxygen consumption ✓ **OR** **P4** ensure correct, salt concentration / AW, of the water ✓ **E4** because it is a saltwater fish / maintain osmotic balance ✓ **OR** **P5** maintain, optimum / correct, pH ✓ **E5** changes in pH can, damage the fish / affect metabolism ✓ **OR** **P6** *idea of* removing other (micro)organisms from the, tank / water ✓	Max 2 (AO3.4)	**ALLOW** e.g. any one precaution **(P)** or any one explanation **(E)** mark point but to get 2 marks **(P) and (E)** must match **P2 ALLOW** don't use too high **or** too low temperatures **P2 ALLOW** stated temperature range between 5 and 35°C **Examiner's Comments** This question was not very well answered, and most candidates did not gain any marks for their responses. Many did not seem to understand what 'precautions' meant and talked about use of controls, the number of fish or repeating and taking a mean. Common answers that did not gain marks were those referring to sealing leaks, so the oxygen content of the water was not affected, placing soda lime in the water to absorb carbon dioxide or references to size, number and health of fish. Testing the probes was also sometimes given as an answer.

			E6 (micro) organisms remove oxygen from the water / may cause disease ✓		
	b	i	**FIRST CHECK THE ANSWER ON ANSWER LINE** **If answer is 2.22 / 2.20 award 2 marks** $Q_{10} = \frac{R_2}{R_1}$ 200 / 90 = 2.22222 correct values for O2 consumption at 23 °C **AND** 13 °C ✓ correct calculation of Q_{10} based on values from graph ✓	2 (AO3.1) (AO3.2)	**If answer incorrect then**: **ALLOW** 1 mark if answer not given to 3 sig. fig. e.g. 2.22222 **OR** **ALLOW** 1 mark if you see 200 and 90 or 91 as the two correct readings from Fig. 20.2 **DO NOT ALLOW** if 170 is also given as this is the incorrect reading for 18°C **Examiner's Comments** It was encouraging to see candidates calculating Q10 correctly. The rate of reaction doubles for a 10°C rise in temperature for enzyme-controlled reactions. Q10 = 2. Candidates were given 1 mark for reading the correct values of 200 and 90 from the graph then 200/90 = 2.22 was a straightforward calculation.
		ii	*Conclusion supported because…* **1** larger increase in O_2 consumption between 13 °C and 18 °C ✓ **2** *idea that* higher temperature / 23°C, may not be economic / ORA ✓ ***Max 3 marks from MPs 3 to 7**: Conclusion not supported because…* **3** greater O_2 consumption may indicate high metabolic rate (rather than growth rate) ✓ **4** greater O_2 consumption may result in, more food consumption / higher feeding costs ✓ **5** temperatures below 13 °C and above 23 °C not used / only three temperatures used ✓ **6** no indication of sample size used ✓ **7** *idea that* there is no evidence of, statistical tests / replicates / repeats / mean values obtained ✓	max 4 (AO3.1) (AO3.2)	**MP1 ALLOW** smaller increase between 18 °C and 23 °C **MP2 ALLOW** reference to e.g. extra heating costs **Examiner's Comments** Candidates should be encouraged to read the detail of the experiment and the results provided and be more critical of experimental methods that are presented to them. Some candidates were able to spot that only three temperatures had been used, and others that no statistical tests had been carried out. Some were able to suggest that warming to the highest temperature may not be economically sound; a question that is often asked in the context of photosynthesis and greenhouse temperatures. Candidates should be encouraged to give responses and critiques that both support and do not support the stated conclusion.
			Total	**13**	

10			**B**	1 (AO2.1)	
			Total	**1**	
11			**B**	1 (AO2.6)	**Examiner's Comments** Knowledge of the respiratory quotient (RQ) as being the ratio between the carbon dioxide used and the oxygen consumed during the oxidation of a substrate was required to produce a response for this question. Many candidates were able to recall RQ and calculate 18/25 = 0.72 giving option B as the correct response. It was a common error to calculate 25/18 =1.39 giving option D as an incorrect response
			Total	**1**	