Question Number	Acceptable Answer	Additional Guidance	Mark
1(a)	• plant cells have cellulose walls, whereas animal cells do not		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
1(b)	hydrolysis		**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
1(c)	A description that makes reference to the following: • a ring of one oxygen and 5 carbon atoms, with a 6th carbon projecting from the ring (1) • OH groups on carbon atoms 1 and 4 projecting to opposite sides of the molecule (1)	Allow marks if in drawing	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
1(d)(i)	non-competitive (inhibition)		**(1)**

Question Number	Acceptable Answer		Additional Guidance	Mark
1(d)(ii)	An answer that makes reference to the following:			
	• appropriate assembly of reaction mixture: copper ions added to cellulose and cellulase	(1)		
	• use of control with cellulose, cellulase and no copper ions	(1)	<u>Allow other controls e.g.</u> With copper ions, cellulose and no cellulase /	
	• details of steps taken to control two relevant variables	(1)	With copper ions, cellulase and no cellulose	
	• use of colorimeter to obtain quantitative measure of the dependent variable	(1)	Allow filtering, drying and weighing the precipitate	
	• calculation of mean results from repeat data	(1)		**(5)**

Total for Question 1 = 10 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
2(a)	One mark from ethical reason and one mark from economic reason • <u>ethical reason</u> (1) - human activities are the cause of many threats to biodiversity therefore humans have a responsibility to protect - future generations should inherit the same biodiversity as the current generation enjoy - all species have a right to exist • <u>economic reason</u> (1) - biodiversity as a source of food - fuel - building material - medicine - flood protection		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(b)(i)	An explanation that makes reference to the following: • high value of horn incentivised hunters to break the law (1) • because trade ban led to black market and increase in price of horn (1) **OR** • demand for horn remained high (1) • because CITES did not help to educate consumers / increasing disposable income in consuming nations / used for traditional medicine in some cultures (1) **OR** • ineffective enforcement (1) • because large areas of habitat are difficult to police / lack of resources available for enforcement / high value of horn funding bribery or corruption (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(b)(ii)	An explanation that makes reference to the following: • fewer alleles in the gene pool due to smaller number of individuals (1) • greater frequency of homozygous genotypes due to mating of related individuals (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(c)(i)	An experimental method that makes reference to five of the following steps: • use of experts to identify and collect many samples of rhinoceros dung from all areas of the park (1) • DNA extracted from rhinoceros cells and amplified using PCR (1) • use of { restriction endonucleases / appropriate primers } to obtain short tandem repeat sequences from DNA (1) • use of gel electrophoresis to separate DNA fragments (1) • description of method used to visualise fragments (1) • each different pattern of bands represents one individual rhinoceros (1)	e.g. radioactive probe / fluorescent probe / Southern blotting / UV light / autoradiography / X- rays	**(5)**

Question Number	Acceptable Answer	Additional Guidance	Mark
2(c)(ii)	An explanation that makes reference to the following: • no dung found from some rhinoceros, so they were not counted (1) • closely related individuals have similar DNA profiles, so they may not be distinguished as separate individuals (1)		**(2)**

Total for Question 2 = 13 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
3(a)(i)	An answer that makes reference to the following: • one group treated with { placebo / inert substance / saline } (1) • one group with no intervention (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(a)(ii)	An answer that makes reference to the following: • the vaccine is very effective against PV2 and PV3, supporting widespread use (1) • there is no alternative vaccine or treatment, so the 60-70% protection against PV1 is still useful (1) • allergic reaction is (very) rare given the size of the study (1) • the effects of polio are serious and there is no cure, therefore benefits of vaccination are greater than { risks / costs } (1)		**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(b)	• calculation of percentage decrease (1)	Example of Calculation: ($\frac{(400{,}000-291)}{400{,}000} \times 100 =$) 99.9%	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(c)	• calculation of 85% of 196 million but only 95% of this population is actually immune (1) • correct answer to the nearest million (1)	(196 000 000 x 0.85) / 0.95 OR (196 000 000 / 0.95) x 0.85 = 175 million Allow full marks for correct answer with no working	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
3(d)	An explanation that makes reference to the following: • inactivated poliovirus has antigens on surface that bind to complementary B cell receptor (1) • therefore B cells become { antigen-presenting cells / APCs } (1) • complementary T helper cells bind to { B cells / APCs } and produce cytokines (1) • therefore B cells differentiate into plasma cells that secrete antibodies (1)		**(4)**

Total for Question 3 = 13 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
4 (a)	An explanation that makes reference to the following points: • increase in number of cells by mitosis without growth (1) • therefore cells are progressively smaller (1) • cells form a thin layer surrounding a fluid-filled cavity (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4 (b)	• correct calculation (1)	Example of calculation ($\log_2 128 = 7$) Allow mark for correct answer with no working	**(1)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4 (c)(i)	An explanation that makes reference to the following points: • examine cells from different tissues in the mature sea urchin, under a microscope (1) • cells descended from the repositioned cell are fluorescent due to traces of the dye injected (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4 (c)(ii)	An explanation that makes reference to the following: • the cell was (still) pluripotent (1) • therefore cell signalling in the new position could determine the fate of the cell (1) • causing activation of transcription factors for transcription of genes relevant to the new position (1) • leading to synthesis of proteins for development into different tissue (1)	Allow totipotent	**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
4 (d)	An explanation that makes reference to the following: • great potential importance or medical implications of the research (1) • this outweighs concerns around the use of { invertebrates due to less developed nervous system / embryos have no nervous system } (1)		**(2)**

Total for Question 4 = 12 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
5(a)	A explanation that makes reference to three of the following: • both plates prepared with nutrient agar of the same composition, to provide both bacterial populations with the same resources for growth (1) • both plates seeded with the same volume of the same culture of *Campylobacter*, so all antibiotics are acting on the same bacterial population (1) • use of aseptic technique such as 'flaming' instruments or working in { updraught of flame / flow hood } , to reduce risk of contamination of either plate with extraneous bacteria (1) • both plates should be incubated at the same temperature for the same length of time, to give equal opportunity for bacterial growth (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(b)	A description that makes reference to the following: • inhibits formation of (new) crosslinks in peptidoglycan in cell wall (1) • causing lysis of cell due to osmotic pressure (1) • therefore penicillin is bactericidal (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
5(c)	An answer that makes reference to the following: <u>Evaluation</u> • judgment clearly stated and supported by an argument (1) AND at least one from each argument for 4 marks (1) <u>For</u> • antibiotic H is the most effective therefore spraying might help to reduce food poisoning (1) • which could prevent wider spread of infection or contamination of other products (1) <u>Against</u> • bacteria may be inside the chicken so unaffected by spraying (1) • possibility of promoting antibiotic resistance / effects on gut flora of consumers (1) • experimental results may not be {valid due to molecular size and diffusion / reliable due to lack of replicates} (1) • experiment used harmless strain of *Campylobacter* so results may not apply to { pathogenic strain / other bacteria that also cause food poisoning } (1)		**(5)**

Total for Question 5 = 11 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
6 (a)	A description that makes reference to the following: • description of appropriate method for varying light intensity (1) • quantification of light intensity (1) • description of appropriate method for measuring reading accuracy (1) • description of method for controlling two relevant variables (1)	E.g. use of filters, dimmer switch, different distances of lamp from experimental setup E.g. use of light meter E.g. number of errors, number of pauses, time taken, different text needed for each measurement E.g. subject at same distance from text, same time to adapt to each new light intensity, text same { size / font },	**(4)**

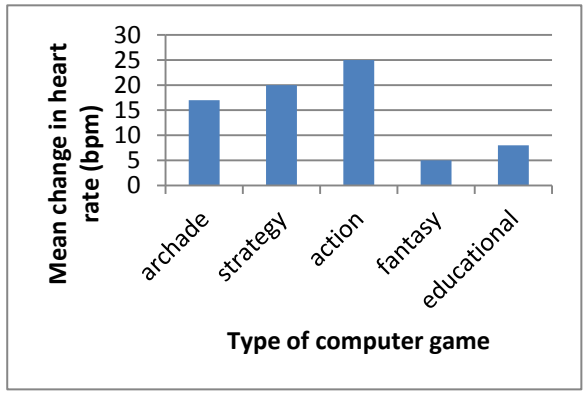
Question Number	Acceptable Answer	Additional Guidance	Mark
6 (b)	An explanation that makes reference to the following: • at a light intensity of 2 lux, monochrome vision is possible but colour vision is not (1) • because cones require higher light intensity to function (1) • at very low light intensities, vision is less accurate because insufficient rhodopsin broken down into retinal and opsin (1) • therefore action potential not generated in {bipolar / ganglion } cell (1)		**(4)**

Total for Question 6 = 8 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
7(a)	• correct numerical calculation (1) • correct units (1)	Example of Calculation: 22 ÷ 120 =0.183 beats per minute per minute / beats minutes^{-2}	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7 (b)	An explanation that makes reference to the following: • { stress / fear } causes the adrenal glands to release adrenaline into the bloodstream (1) • because of impulses along sympathetic nerve (1) • from the { cardiac control centre / medulla (oblongata) } in the brain (1) • increase in heart rate caused by increased rate of depolarisation of SAN (1) • due to release of noradrenaline at SAN (1)		**(5)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(c)(i)	An explanation that makes reference to four of the following: • all games must be played for the same length of time to make a valid comparison (1) • a recovery period is needed for the heart rate to return to normal before each subsequent game (1) • repeats should be { at the same time of day / under the same conditions } to avoid effect of other variables (1) • games should be tested in a different sequence each time, to account for effects of fatigue (1) • more individuals should be tested, other than the student himself, to obtain valid results (1)		**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
7(c)(ii)	• bar chart (1) • x-axis: type of computer game and y-axis: mean change in heart rate (1)		**(2)**

Total for Question 7 = 13 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)(i)	• correct division of figures provided (1) • answer in correct standard form (1)	Example of calculation (250 ÷ 3.7 =) 67.568 / correct rounding of this figure 6.8×10^{-12} g Must be standard form to 2sf with units Allow full marks for correct answer with no working.	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(a)(ii)	An explanation that makes reference to the following: • a nerve cell carries out a lot of active transport (1) • so it may have a greater requirement for ATP than other cells (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(b)(i)	• correct calculation of body mass in grams divided by seconds in a day (1) • correct answer and units (1)	Example of calculation 62 000 ÷ (24 x 60 x 60) 0.72 g s^{-1} / 0.72 g per second ACCEPT 7.2×10^{-1} g s^{-1} / 7.2×10^{-4} kg s^{-1}	**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(b)(ii)	An explanation that makes reference to the following: • this level of mass is not gained because ATP is continually broken down to provide energy (1) • mass is fairly constant over 24 hours because { rate of breakdown is comparable to rate of synthesis / the same ADP and P_i molecules are reused many times } (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
8(c)	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) **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)	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 Max 3 marks if only 4 differences provided Max 2 marks if only 3 differences provided Max 1 marks if only 2 differences provided	**(5)**

Total for Question 8 = 13 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
9(a)	An explanation that makes reference to the following: • photosynthesis causes a decrease in concentration of CO_2 inside the cell, producing a concentration gradient (1) • therefore CO_2 diffuses from solution into cells (1)		**(2)**

Question Number	Acceptable Answer	Additional Guidance	Mark
9(b)(i)	An explanation that makes reference to the following: • (as) wavelength of light decreases, rate of photosynthesis increases (1) • because the data show a greater colour change at shorter wavelengths of light, indicating faster CO_2 uptake (by alga) (1)	ACCEPT converse throughout	**(2)**

<table>
<tr><th>Question Number</th><th colspan="2">Indicative content</th></tr>
<tr><td>*9(b)(ii)</td><td colspan="2">Answers will be credited according to candidate's deployment of knowledge and understanding of the material in relation to the qualities and skills outlined in the generic mark scheme.

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.

• the trend of the results is opposite in the two repeats: results are not reliable
• variables such as organism and indicator are controlled whereas variables such as temperature and light intensity are not controlled
• colour changes judged by eye are qualitative and not precise
• fastest rate is seen with the last filter used, therefore temperature may be responsible for change in rate
• experiment left for 30 minutes, other additional times would give extra information about the rate
• coloured indicator may affect the wavelengths of light reaching the algae
• the algae will be respiring and producing CO_2, which complicates measurement of the rate of photosynthesis
• rate of respiration is assumed to be constant, but this may not be the case
• changes in temperature or pH may alter the activity of the enzymes responsible for photosynthesis
• conclusion that the experiment is invalid / not measuring effect of wavelength on photosynthesis</td></tr>
<tr><td>Level</td><td>Marks</td><td>Descriptor</td></tr>
<tr><td>Level 0</td><td>0</td><td>No awardable content</td></tr>
<tr><td>Level 1</td><td>1-3</td><td>Limited scientific judgement made with a focus on mainly one aspect. A few strengths or weaknesses identified.

A conclusion may be attempted, demonstrating isolated elements of biological knowledge and understanding but supported with limited evidence.</td></tr>
<tr><td>Level 2</td><td>4-6</td><td>Scientific judgements are made through the application of relevant evidence, referring to both methods and trends in results. Both strengths and weaknesses are identified.

A conclusion is made with reference to more than one piece of evidence, demonstrating links to biological knowledge and understanding.</td></tr>
<tr><td>Level 3</td><td>7-9</td><td>Scientific judgements are made through detailed analysis and interpretation of relevant evidence including trends in results and several aspects of methodology. Both strengths and weaknesses are identified in both methods and results.

A conclusion is made, demonstrating sustained linkages to biological knowledge and understanding and drawing upon several strands of evidence.</td></tr>
</table>

Total for Question 9 = 13 marks

Question Number	Acceptable Answer	Additional Guidance	Mark
10(a)	An explanation that makes reference to the following: • substitution of val for glu, which has a different { R / residual } group (1) • val (R-group) has no positive charge (1) • therefore ionic bond lost (1) • therefore tertiary structure changes (1)	Allow glu has a positive charge	**(4)**

Question Number	Acceptable Answer	Additional Guidance	Mark
10(b)	An explanation that makes reference to the following: • calculated value > critical value at p=0.05 (1) • null hypothesis rejected so HbS is significantly more common in African Americans (1) • the difference is highly significant / p < 0.005 / chi squared greatly exceeds the critical value (1)		**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
10(c)(i)	An answer that makes reference to the following: • a small volume of blood is spread into a very thin layer and viewed under a microscope (1) • blood is examined to look for the presence of the malarial parasite *Plasmodium* (1) • use of appropriate personal protective equipment when handling human blood samples (1)	Ignore references to sickled cells	**(3)**

Question Number	Acceptable Answer	Additional Guidance	Mark
10(c)(ii)	An answer that makes reference to the following: • { selective pressure against / loss of } sickle cell alleles due to effects of sickle cell anaemia (1) • heterozygote advantage due to protection against malaria increases { HbS frequency / number of heterozygotes } (1) • heterozygote advantage increases with increased prevalence of malaria (1) • HbS frequency depends on whether malaria or sickle cell disease represents a greater risk to survival (1)		**(4)**

Total for Question 10 = 14 marks