

GCE

Biology A

H420/03: Unified biology

Advanced GCE

Mark Scheme for Autumn 2021

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

















Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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Annotations

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
()	Words which are not essential to gain credit
—	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Marking Annotations

Annotation	Use
	Benefit of Doubt
	Contradiction
	Cross
	Error Carried Forward
	Given Mark
	Extendable horizontal wavy line (to indicate errors / incorrect science terminology)
	Ignore
	Large dot (various uses as defined in mark scheme)
	Highlight (various uses as defined in mark scheme)
	Benefit of the doubt not given
	Tick
	Omission Mark
	Blank Page
	Level 1 answer in Level of Response question
	Level 2 answer in Level of Response question
	Level 3 answer in Level of Response question

Question		Answer	Marks	AO element	Guidance															
1	a	(A =) spiracle ✓ (B =) trachea ✓	2	2.3	ALLOW spiracles DO NOT ALLOW tracheoles ALLOW chitin (rings) / taenidia / tracheal tube / tracheae															
	b	i <table border="1" style="margin-left: 20px; margin-top: 10px;"> <thead> <tr> <th></th> <th>Mouth closes</th> <th>Buccal cavity floor lowers</th> <th>Operculum opens</th> <th>Oxygen diffuses into capillaries</th> </tr> </thead> <tbody> <tr> <td>Water moves into the buccal cavity</td> <td></td> <td style="text-align: center;">✓</td> <td></td> <td></td> </tr> <tr> <td>Water moves across the gills and out of the buccal cavity</td> <td style="text-align: center;">✓</td> <td></td> <td style="text-align: center;">✓</td> <td style="text-align: center;">✓</td> </tr> </tbody> </table> All 4 columns correct ✓✓		Mouth closes	Buccal cavity floor lowers	Operculum opens	Oxygen diffuses into capillaries	Water moves into the buccal cavity		✓			Water moves across the gills and out of the buccal cavity	✓		✓	✓	2	1.2	3 columns correct = ✓
	Mouth closes	Buccal cavity floor lowers	Operculum opens	Oxygen diffuses into capillaries																
Water moves into the buccal cavity		✓																		
Water moves across the gills and out of the buccal cavity	✓		✓	✓																
		ii remove operculum / described (rather than cutting up the ventral side) ✓ use pins to hold fish (rather than a hand) ✓ remove gills and observe under a microscope ✓	1 max	3.3	IGNORE 'remove gills' unqualified IGNORE 'use a microscope' unqualified															
	c	i 60 (cm ³) ✓	1	2.2	1.44 dm ³ = 1440 cm ³ 1440 / 24 = 60															
		ii inbreeding / AW, reduces genetic diversity ✓ (more) homozygous recessive alleles (for CPF) ✓ <i>idea of allele for CPF linked to gene for desirable trait (so inherited together)</i> ✓	1 max	2.5	ALLOW 'inbreeding creates smaller gene pool' ALLOW 'more homozygous recessive genotypes (for CPF)' ALLOW (leads to) inbreeding depression e.g. 'CPF gene on same chromosome as (named) desirable trait '															

Question		Answer	Marks	AO element	Guidance
	iii	<p><i>idea of compare genomes of, dog breeds / individual dogs ✓</i></p> <p><i>idea of identify, alleles / genotypes / base sequences (in WHTs), that are present (only) in dogs with CPF ✓</i></p> <p><i>idea of identify dogs that are carrying (the allele for) CPF ✓</i></p> <p><i>(use of) computational biology / bioinformatics, to link genes with CPF ✓</i></p> <p><i>idea of linking DNA sequences to specific proteins (i.e. proteomics) ✓</i></p>	2 max	2.5	<p>e.g. 'compare DNA of dogs with and without CPF'</p> <p>e.g. 'identify, allele / gene, that causes CPF'</p> <p>e.g. 'can identify mutated protein from DNA sequence'</p>
	iv	<p>weakened / dead / inactivated, (parvo)virus ✓</p> <p>antigens from the (parvo)virus ✓</p> <p>mRNA to produce (parvo)virus proteins ✓</p>	1 max	2.1	<p>IGNORE 'dormant form of virus'</p> <p>ALLOW 'attenuated form of virus'</p> <p>ALLOW viral coat proteins</p>
	v	memory cells have, reduced in number / AW ✓	1	2.5	<p>ALLOW to produce more memory cells (to improve immunity)</p> <p>DO NOT ALLOW 'no memory cells left'</p>

Question	Answer	Marks	AO element	Guidance
2 a	<p>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</p> <p><i>In summary:</i> <i>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.</i> <i>Then, award the higher or lower mark within the level, according to the Communication Statement (shown in italics):</i></p> <ul style="list-style-type: none"> ○ <i>award the higher mark where the Communication Statement has been met.</i> ○ <i>award the lower mark where aspects of the Communication Statement have been missed.</i> <ul style="list-style-type: none"> • The science content determines the level. • The Communication Statement determines the mark within a level. 			
	<p>Level 3 (5-6 marks) Describes in detail, with no major errors, the stages of mitosis in all three cells.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3-4 marks) Describes, with few errors or omissions, the stages of mitosis in all three cells.</p> <p>OR Describes in detail, with no major errors, at least two cells.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1-2 marks) Describes the stages of mitosis, with some errors, in at least one cell.</p> <p>OR Describes stages of mitosis with no link to cells in question</p>	6	2.5 2.7	<p>Indicative scientific points (including details in bold) may include (but are not limited to):</p> <p><i>Cell C:</i></p> <ul style="list-style-type: none"> • Prophase • Chromosomes condense • Chromosomes have become visible (but are unordered) • Nuclear envelope and nucleolus have disappeared <p><i>Cell D:</i></p> <ul style="list-style-type: none"> • (Early) anaphase • Spindle fibres are shortening • Chromatids are separating and are being pulled to opposite sides of the cell

Question		Answer	Marks	AO element	Guidance	
		<p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>			<p><i>Cell E:</i></p> <ul style="list-style-type: none"> • (Late) telophase • Chromatids have been pulled to opposite sides of the cell • A new cell membrane is visible down the centre of the cell • Cytokinesis/ the cell is beginning to divide 	
	b	i	<i>idea that (some) cells contain incorrect number of chromosomes ✓</i>	1	3.1	e.g. cells do not contain the diploid number of chromosomes / cells contain different numbers of chromosomes
		ii	<p>G1 (checkpoint)AND <i>idea that</i> cells (with damaged DNA) should be stopped from entering the S phase ✓</p> <p>G1(checkpoint)AND <i>idea that</i> this is the point where DNA damage is checked ✓</p>	1	3.1	DO NOT ALLOW G2 (as if this was not working both replication and mitosis would occur)
	c		<p><i>Binary fission has</i></p> <p>chromosome(s) do not condense prior to separation ✓</p> <p>no lining up of chromosomes, in pairs / across equator ✓</p> <p>no separation of chromosomes into chromatids ✓</p> <p>chromatids not joined at centromere ✓</p> <p>no, centrioles / spindle fibres ✓</p> <p>one large chromosome rather than several smaller chromosomes ✓</p> <p>(replication of) circular DNA / plasmid(s) ✓</p>	2 max	2.5	<p>Mark as continuous prose</p> <p>ALLOW ora throughout</p> <p>IGNORE ref to nuclear membrane disappears</p> <p>ALLOW 'no lining up of DNA across equator'</p> <p>ALLOW 'no separation of chromatids'</p> <p>DO NOT ALLOW 'no chromosomes being pulled to opposite sides of cell'</p>

Question		Answer	Marks	AO element	Guidance
d	i	<p><i>'For' statement:</i></p> <p>no lag phase (is shown) ✓ no (clear), stationary / death / decline, phase ✓</p> <p><i>idea that</i> decrease between day 3 and 4 is not typical of standard growth curve ✓</p> <p><i>'Against' statement:</i> <i>idea that</i> lag phase may be present but day 0 data are not shown ✓</p> <p>exponential / log / rapid growth, phase present (between day 1 and 2) ✓</p> <p><i>idea that</i> stationary / death / decline, phase may occur later ✓</p> <p><i>General point:</i> <i>idea that</i> presence of limited nitrate is responsible for the (non-standard) growth curve ✓</p>	4 max	3.1	<p>ALLOW clear descriptions of stages of growth curve e.g 'there is no fall in number of cells at end of growth curve'</p> <p>e.g. 'lag phase may occur between day 0 and day 1'</p> <p>ALLOW 'growth rate increases (between days 1-5) but then rate of growth slows down'</p> <p>e.g. 'reduction in nitrate could lead to fall in cell numbers between day 3 and 4' / 'as nitrate levels fall bacterial cell numbers are still increasing'</p>

Question		Answer	Marks	AO element	Guidance
	ii	<p>FIRST CHECK ON ANSWER LINE If answer = 2.5×10^6 award 3 marks</p> <p>$10^{4.7} = 50,118.72336 \checkmark$</p> <p>$\times 50 (= 2,505,936.168) \checkmark$</p> <p>standard form = $2.5 \times 10^6 \checkmark$</p>	3	2.4	<p>ALLOW any value between $10^{4.5}$ and $10^{4.8}$ i.e. $1.6 - 3.2 \times 10^6$ award 3 marks ALLOW 31,622.7766 – 63,095.73445 ALLOW any correct rounded value</p> <p>This mark should be awarded to 'x50' seen anywhere in the working, regardless of the value being multiplied This mark should be awarded for correctly converting to standard form, regardless of the value being converted as ECF MAX 2 for correct answer not converted to standard form</p>
	iii	<p>serial dilution \checkmark <i>idea of</i> grow colonies (on agar plate) and count number of colonies \checkmark <i>idea of scale up / multiply up, count (to estimate population size)</i> \checkmark</p>	2 max	2.7	<p>ALLOW <i>idea of</i> flow cytometry / described</p>
	e	<p>Short /AW \checkmark pollutants / contaminants \checkmark</p> <p>metabolites \checkmark</p>	3	1.1	<p>ALLOW pollution / contamination / waste / oil / solvents / pesticides / benzene / plastics / chemicals</p> <p>IGNORE impurities / faeces / toxins / bacteria / pathogens</p>
3	a	<p><i>callose...</i> (has) 1-3 and 1-6 glycosidic bonds \checkmark</p> <p>(is) branched \checkmark</p> <p>(is) helical \checkmark</p> <p><i>idea of</i> alternate glucose molecules are not rotated $180^\circ \checkmark$</p>	2 max	2.1	<p>ALLOW cellulose (has only) 1-4 glycosidic bonds ALLOW cellulose is, not branched / straight chains ALLOW cellulose is not helical IGNORE callose is more compact ALLOW <i>idea of</i> alternate glucose molecules rotated 180° in cellulose</p>

Question	Answer	Marks	AO element	Guidance
b	<p>Please refer to the marking instructions on page 4 of this mark scheme for guidance on how to mark this question.</p> <p><i>In summary:</i> <i>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):</i></p> <ul style="list-style-type: none"> ○ <i>award the higher mark where the Communication Statement has been met.</i> ○ <i>award the lower mark where aspects of the Communication Statement have been missed.</i> <p>• The science content determines the level. • The Communication Statement determines the mark within a level.</p>			
	<p>Level 3 (5-6 marks) A valid plan for testing the effect of temperature on callose production, including details of control variables and some details of callose measurement.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 2 (3-4 marks) A valid plan, with some details, for testing the effect of temperature on callose production, including either details of control variables or some details of callose measurement.</p> <p><i>There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.</i></p> <p>Level 1 (1-2 marks) A plan that mentions observing callose production or controlling variables.</p>		3.3 3.4	<p>Indicative scientific points may include (but are not limited to):</p> <p><i>General experimental details to improve validity:</i></p> <ul style="list-style-type: none"> • a suitable range of temperatures (e.g. 0, 10, 20, 30, 40° C) • a suitable sample size or the idea of repeats (e.g. 50 plants) • idea of a baseline measure of callose levels before the experiment <p><i>Control variables:</i></p> <ul style="list-style-type: none"> • same species / size / genetics of plant (e.g. using cloned plants) • light intensity and duration (e.g. 12 hours of light and 12 hours of dark)

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	<p><i>There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.</i></p> <p>0 marks No response or no response worthy of credit.</p>			<ul style="list-style-type: none"> • pH / nutrients / water regime (e.g. using the same soil and water supply) • maintaining aseptic conditions and monitoring infections (and removing infected plants from the experiment) <p><i>Callose observation:</i></p> <ul style="list-style-type: none"> • use a microscope • take tissue samples • standardise the size and location of tissue samples • take samples from different sites • use of stain (e.g. aniline blue) • immunofluorescence

Question		Answer				Marks	AO element	Guidance																
	c	<table border="1"> <thead> <tr> <th>Type of pathogen</th> <th>Pathogen has membrane-bound organelles</th> <th>Pathogen has cell wall</th> <th>Example of a disease affecting plants</th> </tr> </thead> <tbody> <tr> <td>fungus</td> <td>yes</td> <td>yes</td> <td>black sigatoka</td> </tr> <tr> <td>bacterium</td> <td>no</td> <td>yes</td> <td>ring rot</td> </tr> <tr> <td>virus</td> <td>no</td> <td>no</td> <td>tobacco mosaic (virus) / TMV</td> </tr> </tbody> </table> <p>One mark per correct row; all correct = ✓✓✓</p>				Type of pathogen	Pathogen has membrane-bound organelles	Pathogen has cell wall	Example of a disease affecting plants	fungus	yes	yes	black sigatoka	bacterium	no	yes	ring rot	virus	no	no	tobacco mosaic (virus) / TMV	3	1.1	ACCEPT any other correct examples of viral diseases in plants
Type of pathogen	Pathogen has membrane-bound organelles	Pathogen has cell wall	Example of a disease affecting plants																					
fungus	yes	yes	black sigatoka																					
bacterium	no	yes	ring rot																					
virus	no	no	tobacco mosaic (virus) / TMV																					
	d	<p>example of chemical defence ✓</p> <p>example of physical defence ✓</p>				1 max	1.1	e.g. (production of) pheromones / poisons / toxic compounds / named examples (phenols, tannins, alkaloids, Bt toxin) e.g. folding in response to touch / thorns / spines																
	e	insects (may) develop resistance ✓				1	2.1	ALLOW 'insects become resistant' DO NOT ALLOW references to immunity DO NOT ALLOW insecticides cause mutations leading to resistance																
4	a	<p>(carry out) Benedict's test / described ✓</p> <p>(if test for reducing sugar negative) boil with (dilute) HCl and (re)test (with Benedict's) ✓</p>				2	2.7	ALLOW 'add Benedict's (solution)'																

Question		Answer	Marks	AO element	Guidance												
	b i	<table border="1"> <thead> <tr> <th>Description of amino acid</th> <th>Name of amino acid</th> <th>Justification</th> </tr> </thead> <tbody> <tr> <td>Converted to pyruvate with the fewest changes</td> <td>Alanine</td> <td>(Both have) 3 carbon 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> </tbody> </table> <p>First row correct ✓ Second row correct ✓ Aspartic acid ✓ Aspartic acid explanation ✓</p>	Description of amino acid	Name of amino acid	Justification	Converted to pyruvate with the fewest changes	Alanine	(Both have) 3 carbon atoms / Same number of carbon atoms	Converted to alpha-ketoglutarate with the fewest changes	Glutamic acid	(Both have) 5 carbon atoms / Same number of carbon atoms	The amino acid with the highest respiratory quotient (RQ)	Aspartic acid	Highest proportion of oxygen atoms (in its structure) / lowest proportion of C-H bonds (relative to other bonds)	4	3.1	<p>ALLOW (both have) 3C atoms DO NOT ALLOW 'same number of C and, H / O, atoms'</p> <p>IGNORE 'both have 2 carboxyl groups'</p> <p>ALLOW (both have) 5C atoms DO NOT ALLOW 'same number of C and, H / O, atoms'</p>
Description of amino acid	Name of amino acid	Justification															
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The amino acid with the highest respiratory quotient (RQ)	Aspartic acid	Highest proportion of oxygen atoms (in its structure) / lowest proportion of C-H bonds (relative to other bonds)															
	ii	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 ✓	2 max	1.2 2.5	ALLOW mp's from correct equations												

Question	Answer	Marks	AO element	Guidance								
c	<p><i>idea of establishment of H⁺ ion gradient</i> ✓</p> <p>H⁺ ions, flow down a concentration gradient / AW ✓</p> <p>from intermembrane space to matrix ✓ through ATP synthase ✓ energy, provided / AW, to join ADP and Pi (to form ATP) ✓</p>	3 max	1.1	<p>e.g. 'pumping protons into intermembrane space'</p> <p>DO NOT ALLOW 'H⁺ ions pumped (from intermembrane space / through ATP synthase)</p> <p>DO NOT ALLOW 'energy produced to join ADP and Pi'</p>								
d	<p>0 watts: (mainly) carbohydrates respired / AW ✓</p> <p>50 watts: (more) fats / lipids / amino acids / proteins, respired / AW ✓</p> <p>250 watts: (more) anaerobic respiration / AW ✓</p>	3	3.1	<p>ALLOW (mainly) glucose respired</p> <p>DO NOT ALLOW 'only, fats/amino acids / proteins, respired'</p>								
5	a	1	1.1									
<table border="1"> <thead> <tr> <th>Statement about amylose</th> <th>True or False?</th> </tr> </thead> <tbody> <tr> <td>Amylose is soluble</td> <td>False</td> </tr> <tr> <td>Amylose is branched</td> <td>False</td> </tr> <tr> <td>Amylose is formed by condensation reactions</td> <td>True</td> </tr> </tbody> </table>					Statement about amylose	True or False?	Amylose is soluble	False	Amylose is branched	False	Amylose is formed by condensation reactions	True
Statement about amylose	True or False?											
Amylose is soluble	False											
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All 3 correct = ✓												
b	<p><i>D. antarctica habitat:</i> lower (maximum) light levels ✓</p> <p><i>idea of reason for lower (maximum) light levels</i> ✓</p> <p><i>idea that optimum rate of photosynthesis (in its habitat) is at a lower light intensity than that of Z. mays</i> ✓</p>	2 max	3.2	<p>ORA <i>Z. mays habitat</i></p> <p>ALLOW less available light / darker habitat / more shaded e.g. more cloud cover / shorter day length / taller / competing, plants (shade fern)</p> <p>e.g. rate of photosynthesis is higher at lower light levels compared to <i>Z. mays</i></p>								

Question		Answer	Marks	AO element	Guidance
	c	i			
		<p>FIRST CHECK ON ANSWER LINE If answer = 0.943 award 3 marks</p> <p>$\Sigma d^2 = 2 \checkmark$</p> <p>$n(n^2 - 1) = 210 \checkmark$</p> <p>$1 - (6 \times 2) / 210 = 0.943 \checkmark$</p>	3	2.4	<p>ALLOW calculator value (0.942857) or any correctly rounded value</p> <p>ALLOW ECF final answer if incorrect values used for Σd^2 and / or $n(n^2 - 1)$ for mp3</p>
		ii			
		significant positive correlation (at 0.05 confidence) \checkmark	1	3.1	ALLOW ECF correct conclusion based on incorrect calculated value from c(i)
		iii			
		no significant (positive) correlation \checkmark	1	3.1	
	d	i			
		<p><i>idea of little (visible) light available / plants absorb most light available / only certain wavelengths of light available underwater \checkmark</i></p> <p><i>idea of it absorbs light, at different wavelengths, compared to aquatic plant species \checkmark</i></p> <p><i>idea of absorbs wider range of wavelengths (compared to chlorophyll A alone) \checkmark</i></p>	1	3.2	<p>e.g. 'longer wavelengths of light available in their aquatic environment'</p> <p>e.g. 'able to use, far red / longer, wavelengths compared to aquatic plants'</p> <p>e.g. 'able to absorb wavelengths of light that Chlorophyll A does not'</p>
		ii			
		Z \checkmark	1	2.8	
		Total	70		

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