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International Education

Cambridge International AS & A Level

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2024**

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

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Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
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- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

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Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
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Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
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3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	‘List rule’ guidance For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Mark scheme abbreviations

;	separates marking points
/	alternative answers for the same point
A	accept (for answers correctly cued by the question, or by extra guidance)
R	reject
I	ignore
( )	the word / phrase in brackets is not required, but sets the context
AW	alternative wording (where responses vary more than usual)
underline	actual word given must be used by candidate (grammatical variants accepted)
max	indicates the maximum number of marks that can be given
ora	or reverse argument
mp	marking point (with relevant number)
ecf	error carried forward
AVP	alternative valid point

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>1(a)</td><td>
<table>
<tr><th>stage of respiration</th><th>letter</th></tr>
<tr><td>glycolysis</td><td>B</td></tr>
<tr><td>link reaction</td><td>D</td></tr>
<tr><td>Krebs cycle</td><td>D</td></tr>
<tr><td>oxidative phosphorylation</td><td>C</td></tr>
</table>
;;;
3 marks if all four letters are correct
2 marks if three letters are correct
1 mark if one or two letters are correct
</td><td>3</td></tr>
<tr><td>1(b)</td><td>any four from:
1 oxygen is the, <u>final / last / terminal</u>, electron acceptor ;
2 electron transport chain / ETC, stops ;

3 less / no, protons / H^+ / hydrogen ions, move,
into intermembrane space / across inner mitochondrial membrane ;
4 less / no, proton / electrochemical, gradient ;
5 less / no, protons move through ATP synthase ;
6 less / no, recycling / regeneration, of, NAD / FAD ;</td><td>4</td></tr>
<tr><td>1(c)</td><td>any three from:
1 <u>lactate</u> dehydrogenase ;
2 less / no, pyruvate → lactate ;
3 (so) less / no, NAD, regenerated / recycled ;
4 (so) less / no, triose phoshate / TP, → pyruvate ;
5 (so) less / no, ATP from substrate, linked / level, reactions / phosphorylation (in glycolysis) ;</td><td>3</td></tr>
</table>

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Question	Answer	Marks
2(a)(i)	**1** *similarity:* both involve a (signalling), chemical / ligand / molecule **;** **2** *difference:* endocrine chemical / hormone, travels in <u>blood / circulatory system</u> (but paracrine chemical travels by diffusion) **;**	**2**
2(a)(ii)	**1** (ACh) travels a short distance by <u>diffusion</u> **;** **2** across, synapse / synaptic cleft / neuromuscular junction **;**	**2**
2(b)	*any **three** conclusions from:* **1** palmitate-exposed cells, release / secrete, molecule / chemical / substance **;** **2** (this) molecule switches on stress genes in, new / other, muscle cells **;** **3** molecule is not, destroyed / denatured, by, boiling / high temperature **;** **4** (so) molecule is not a protein **;** **5** molecule is, lipid / lipid-soluble / hydrophobic / non-polar **;** **6** AVP **;**	**3**
2(c)	*any **three** from:* **1** less actin **;** **2** less myosin **;** **3** less troponin **;** **4** less tropomyosin **;** **5** fewer / smaller, sarcomeres / myofibrils / myofilaments / mitochondria / ribosomes **;** **6** less of other named protein **;**	**3**

Question	Answer	Marks
3(a)	*any **four** from*: **1** protons / H^+ ions, pumped, from <u>guard cells</u> / into <u>guard cell</u> wall **;** **2** *ref. to* negative potential (inside cell) **or** Cl^- ions enter (cell) **;** **3** (voltage-gated) K^+ channels open **or** K^+ ions enter (guard) cells **;** **4** water enters cell, by osmosis / down water potential gradient **;** **5** (guard) cells, become turgid / swell / increase in volume **;**	**4**

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Question	Answer	Marks
3(b)(i)	*any **two** from*: **1** as abscisic acid concentration increases stomatal conductance decreases **or** negative correlation / inverse correlation / inversely proportional **;** **2** two sets of *x y* figures to support mp 1 with units (at least once) **;** **3** steep decrease in conductance to 100–150 ABA **;** **4** no / little, effect on conductance above 250–425 ABA **;**	**2**
3(b)(ii)	*any **four** from*: **1** ABA causes stomata to close **;** **2** ABA binds to receptor on guard cell **;** **3** Ca^{2+} ions, enter (guard) cells / act as 2nd messenger **;** **4** K^{+} ions leave (guard) cells **;** **5** water leaves so cells become, flaccid / less turgid **;** **6** AVP **;**	**4**
3(c)	DNA / promoter **;**	**1**

Question	Answer	Marks
4(a)	*any **four** from:* **1** (random / spontaneous) mutation gave resistance **;** **2** pathogen / disease / plague, was selection pressure **;** **3** mutation, gave selective advantage / was selected for / allowed crayfish to survive (plague) **;** **4** survivors / resistant crayfish, bred / reproduced / passed on mutation **;** **5** frequency of, allele / mutation, (for resistance) increased **;** **6** natural / directional, selection **;** **7** AVP **;**	**4**
4(b)(i)	**1** (heat to) 90–98 °C so DNA, denatures / strands separate **;** **2** (cool to) 50–65 °C so primers, bind / base pair / anneal (to DNA) **;** **3** (heat to) 68–75 °C so, *Taq* / DNA, polymerase, makes DNA / (new) strand **;** **4** repeat cycles to amplify DNA **;**	**4**
4(b)(ii)	used, a (named) database / bioinformatics **;**	**1**

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Question	Answer	Marks
4(c)(i)	**A ;**	**1**
4(c)(ii)	$(2^3) = 8$ **;**	**1**
4(d)(i)	(named) plasmid / vector (used) **;** (containing) gene / DNA, for (green) fluorescent protein **;** (containing) a (prokaryotic) promoter **;**	**3**
4(d)(ii)	to act as a, marker / reporter, gene **or** to identify, recombinant / GM / transgenic, bacteria / organisms **or** to show expression of another transferred gene **;**	**1**

Question	Answer	Marks
5(a)(i)	**A** = stroma **;** **B** = thylakoid, lumen / space **;**	**2**
5(a)(ii)	**1** cyclic photophosphorylation **;** **2** ATP synth(et)ase **;**	**2**
5(a)(iii)	**1** **D** = reduced NADP **;** **2** reduces / gives hydrogen to, glycerate (3) phosphate / GP **;** **3** forming, triose phosphate / TP **;**	**3**
5(b)(i)	*any **three** from:* **D1** rate of energy transfer, higher / highest, for tropical **or** rate of energy transfer, lower / lowest, for snow forest **;** **D2** paired data quote with units (at least once) **;** **S3** tropical forest has, high(er/est) temperature / hot(ter) **;** **S4** tropical forest has high(er/est) light, intensity / duration **;** **S5** temperature / light intensity, is a limiting factor (on photosynthesis) **;**	**3**

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Question	Answer	Marks
5(b)(ii)	*any **three** from:* **1** more, transpiration / water loss (from leaves) **;** **2** stomata shut reducing, carbon dioxide (entry) / gas exchange **;** **3** (so) carbon dioxide (concentration) is a limiting factor **;** **4** (grassland / desert) fewer plants / less plant cover / smaller plants **;** **5** (so smaller surface area) less light absorbed **;** **6** AVP **;**	**3**

Question	Answer	Marks
6(a)(i)	*any **one** from:* **1** same / equal, size / length **;** **2** same, shape / position of centromere **;** **3** same banding pattern **;**	**1**
6(a)(ii)	*any **three** from*: **1** recessive / mutation = faulty / inactive / no, tyrosinase **;** **2** (melanocytes) do not produce, melanin / pigment **;** **3** *ref. to* skin / hair / iris **;** **4** AVP **;**	**3**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(b)</td><td>
gametes (on Punnett square)
1 BF Bf bF bf ;

Punnett square
<table>
<tr><td></td><td>BF</td><td>Bf</td><td>bF</td><td>bf</td></tr>
<tr><td>BF</td><td>BBFF
black</td><td>BBFf
black</td><td>BbFF
black</td><td>BbFf
black</td></tr>
<tr><td>Bf</td><td>BBFf
black</td><td>BBff
white</td><td>BbFf
black</td><td>Bbff
white</td></tr>
<tr><td>bF</td><td>BbFF
black</td><td>BbFf
black</td><td>bbFF
brown</td><td>bbFf
brown</td></tr>
<tr><td>bf</td><td>BbFf
black</td><td>Bbff
white</td><td>bbFf
brown</td><td>bbff
white</td></tr>
</table>
2 correct offspring genotypes on Punnett square ;
3 phenotypes matching genotypes ;

offspring phenotype ratio
4 9 black : 3 brown : 4 white ;
</td><td>4</td></tr>
</table>

Question	Answer	Marks
7(a)(i)	as mutation rate increases lifespan decreases **;**	**1**
7(a)(ii)	*any **three** from:* **1** high(er) mutation rate gives more, genetic diversity / genetic variation / alleles / chance of beneficial allele **;** **2** short(er) lifespan gives more generations (per year / per unit time) **;** **3** with, high(er) mutation rate / short(er) lifespan, they, adapt / evolve, better / more easily / faster **;** **4** mouse (and ferret) may, adapt / evolve, faster **;** **5** AVP **;**	**3**

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Question	Answer	Marks
7(b)(i)	*comparison:* **C1** genetic engineering faster / selective breeding slower **;** *any **one** reason from:* **R2** selective breeding occurs over (many) generations **;** **R3** all cows could be surrogate mothers for engineered embryos (giving large increase in allele frequency in one generation) **;** **R4** AVP **;**	**2**
7(b)(ii)	*any **two** from:* **1** (improve named) quality of, animal / milk **;** **2** (improve) quantity / yield, of milk **;** **3** AVP **;**	**2**

Question	Answer	Marks
8(a)	*any **three** from:* **1** assess / categorise / rank, species, threat level / conservation status **;** **2** *ref. to* Red List (of Threatened Species) **3** influence / advise, countries / governments / policy makers **;** **4** educate / raise awareness **;** **5** promote sustainable, use / management, of (natural) resources **;**	**3**

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Question	Answer	Marks
8(b)	*any **six** from*: *biological species (concept)* **1** no / not separate species / same species **;** **2** as can, interbreed / breed together, to produce, fertile offspring / pizzly bears **or** they are not reproductively isolated **;** *morphological species (concept)* **3** yes / separate species / different species **;** **4** as have different, colours / mass / size / hump size **;** *ecological species (concept)* **5** yes / separate species / different species **;** **6** as have different, niches / diets / habitats **;** *genetic / phylogenetic, species (concept)* **7** unsure / don't know **;** **8** as no information about genetic similarity **;** **9** AVP **;**	**6**
8(c)(i)	*G. hapalotricha* $\frac{n}{N} = 0.194$ **and** $\left(\frac{n}{N}\right)^2 = 0.037$ **;** $\left(\frac{n}{N}\right)^2$ total = 0.272 **;** $D = 0.728$ **;**	**3**
8(c)(ii)	undisturbed / higher D, has, larger / higher / more, (food), diversity / variation **;**	**1**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>9(a)</td><td>any two from:

<table>
<tr><th>discontinuous</th><th>continuous</th></tr>
<tr><td>(forms / phenotypes / categories)
distinct / discrete / categoric / do not overlap / do not form a (gradual) range / no intermediates / two or few different forms</td><td>(forms / phenotypes / categories) not distinct / not discrete / overlap / form a (gradual) range / include intermediates / many different forms / many values on a spectrum ;</td></tr>
<tr><td>not a normal distribution / few bars (on bar chart)</td><td>normal distribution or normal / bell-shaped curve (on graph) ;</td></tr>
<tr><td>no / little, effect from environment
A genes only</td><td>some / large, effect from environment ;</td></tr>
</table></td><td>2</td></tr>
<tr><td>9(b)</td><td>any two from:
1 one / two, genes (control colour pattern) ;
2 different alleles of a gene have a large effect ;
3 multiple / three, alleles ;
4 gene interaction / epistasis ;
5 AVP ;</td><td>2</td></tr>
<tr><td>9(c)</td><td>any two from:
1 temperature / food (supply) ;
2 of larva / during larval development ;
3 egg size / diet of mother / size of mother ;</td><td>2</td></tr>
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Question	Answer	Marks
10	*any **six** from:* **1** sucrose binds to, receptor <u>protein</u> / (chemoreceptor) cell surface receptor **;** **2** *ref. to* second messenger **;** **3** (chemoreceptor cell) Na^+ entry / membrane depolarises **;** **4** receptor / generator, potential **;** **5** Ca^{2+} ions enter (chemoreceptor cell) **;** **6** (named) neurotransmitter vesicles, move towards / fuse with, (presynaptic) membrane **;** **7** (named) neurotransmitter, release / exocytosis, into (synaptic) cleft **;** **8** (named) neurotransmitter binds to receptor on, sensory neurone / postsynaptic membrane **;** **9** Na^+ enters (through ligand-gated channel) → depolarisation **;** **10** *ref. to* threshold for action potential **;** **11** AVP **;**	**6**

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Question	Answer	Marks
1(a)(i)	hypothalamus **;**	**1**
1(a)(ii)	(changes in) water potential (of blood) **; A** ψ	**1**
1(a)(iii)	posterior pituitary (gland) **;**	**1**
1(b)(i)	61.5(%) **;;** 61.538461 *allow one mark for not rounding to one decimal place*	**2**
1(b)(ii)	*any **three** from:* 1 (increase in ADH results in) aquaporins added to, cell surface membrane / luminal membrane / plasma membrane **;** 2 more water leaves, filtrate / collecting duct **or** more water reabsorbed / more water enters blood or tissue fluid **;** 3 so urine, **volume** decreases / **concentration** increases **;** 4 AVP **;** e.g. ADH binds to receptor / increase in permeability of (cell surface) membrane / *ref. to* water moving, down a water potential gradient or by osmosis **I** descriptions	**3**

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Question	Answer	Marks
2(a)	1 genetic / genotype / alleles **or** example **;** mutation / crossing over / independent assortment / random fertilisation / random mating 2 environmental **or** example **;** climate / disease / food availability / soil pH / selection pressure 3 combination / interaction, of genes <u>and</u> environment **or** example **;** gene (expression) is modified by environment	**3**
2(b)(i)	*any **three** from:* 1 formation of new species from, pre-existing species / common ancestor **;** 2 change in, characteristics / phenotypes **;** 3 over, time / generations **;** 4 <u>natural selection</u> **;** 5 changes in, gene pools / allele frequencies **or** genetic drift **;**	**3**

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Question	Answer	Marks
2(b)(ii)	*any **three** from:* 1 compare sequences (of DNA) **;** 2 the more similar the sequences the more, closely related the species / recent the common ancestor **; ora** 3 over time mutations accumulate **or** less time fewer mutations occurred **;** 4 *ref. to* bioinformatics / software / database **;** 5 AVP **;** e.g. molecular clock / constant rate of mutation e.g. mtDNA has no crossing over e.g. the percentage similarity can be used to build a phylogenetic tree	**3**

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Question	Answer	Marks
3(a)	(gene ***L*** has) four alleles / L^V, L^T, L^R and L^r ; **A** a gene which has more than two alleles	**1**
3(b)	parental genotypes: $L^T L^R$ x $L^T L^R$ gametes: L^T L^R L^T L^R ; offspring genotypes: $L^T L^T$ $L^T L^R$ $(L^T L^R)$ $L^R L^R$; offspring phenotypes: dfm-a dfm-b (dfm-b) rufipennis ; linked to genotypes ratio of offspring phenotypes: 1 : 2 : 1 ; *accept correct phenotype descriptions*	**4**
3(c)	L^T and L^R ; L^T and L^R > L^V > L^r ;	**2**
3(d)(i)	(female) $L^V L^r$ and (male) $L^r L^r$; $L^V L^r$ (and $L^V L^r$) ;	**2**
3(d)(ii)	there are similar numbers of male and female offspring produced (for each phenotype) **or** female metallic offspring are produced **or** if linked to X chromosome no female metallic offspring are produced ;	**1**
3(d)(iii)	chi-squared test ; **A** χ^2	**1**

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Question	Answer	Marks
4(a)	*any **five** from:* 1 a gene codes for a protein which determines the phenotype **;** 2 *F8* gene **;** 3 located on X chromosome / sex-linked **;** 4 *ref. to* recessive allele **;** 5 non-functioning factor VIII (protein) **or** less factor VIII (protein) **or** no factor VIII (protein) **;** 6 (so) blood does not clot quickly enough / excessive bleeding occurs (after an injury) **;** 7 link the phenotype to the genotype **;** e.g. $X^F X^F$ = normal female $X^F X^f$ = normal female $X^f X^f$ = affected female $X^F Y$ = normal male $X^f Y$ = affected male 8 AVP **;** e.g. prevents activation of thrombin / fibrinogen not converted to fibrin / *ref. to* mostly males affected / different mutations cause a range of severity of haemophilia	**5**

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Question	Answer	Marks
4(b)	*any **three** from:* 1 *lele* is, homozygous recessive / two recessive alleles **;** 2 *le* (allele) / *lele*, codes for a non-functional <u>enzyme</u> **;** 3 no, active gibberellin / GA_1 **or** *ref. to* gibberellin inactive **;** 4 no / less, cell elongation **or** no / less, stem elongation / increase in internodal length **;** 5 AVP **;** e.g. *ref. to* GA 3β-hydroxylase / GA3-oxidase / last enzyme in the pathway that produces, active gibberellin / GA_1 *le* allele codes for alanine instead of threonine (in the enzyme)	**3**
4(c)	*any **three** from:* 1 (DELLA proteins) bind to, PIF / transcription factor **;** 2 PIF / transcription factor, cannot bind to, DNA / promoter **;** 3 RNA polymerase cannot bind to <u>promoter</u> **;** 4 no transcription / mRNA not made **;**	**3**

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Question	Answer	Marks
5(a)	1 family history of, breast / ovarian, cancer **;** *plus any **three** from:* 2 (mutation causes) change of primary structure (of tumour suppressor protein) **;** 3 changes, folding / bonding / 3D shape / tertiary structure (of tumour suppressor protein) **;** 4 non-functional (tumour suppressor) protein formed **;** 5 DNA is not repaired / cells with damaged DNA do not die **;** 6 (so) increases number of mutations / mutations accumulate **;** 7 (some mutations) cause uncontrollable, cell division / mitosis (of breast cells) **;**	**4**
5(b)	1 only small amount of DNA available **; A** gene 2 amplify, DNA / (*BRCA1*) gene **;**	**2**
5(c)	6.1×10^4 **;; A** 6.125×10^4 *for two marks* *allow one mark for* 61 250 **or** $\frac{3.5 \times 10^7}{400} = 8.75 \times 10^4$ or 87 500	**2**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>5(d)</td><td>
any two from:

supports:
1 (women with BCRA1) have a higher <u>probability</u> of survival ; ora

2 (for women with BRCA1) the probability of survival decreases less
or
there is a smaller rate of decrease of probability of survival
or
bigger difference between the two groups over time for the probability of survival ;
ora

3 data quote to show differences between the survival of the two groups at a particular time ;

<table>
<tr><th rowspan="2">time / months</th><th colspan="2">probability of survival</th></tr>
<tr><th>with mutation</th><th>without mutation</th></tr>
<tr><td>30</td><td>0.975
range 0.975 – 0.988</td><td>0.85</td></tr>
<tr><td>60</td><td>0.95</td><td>0.75</td></tr>
<tr><td>90</td><td>0.85</td><td>0.675
range 0.675 – 0.688</td></tr>
<tr><td>120</td><td>0.75</td><td>0.63
range 0.613 – 0.625</td></tr>
<tr><td>150</td><td>0.75</td><td>0.55</td></tr>
<tr><td>180</td><td>0.7 / 0.70
range 0.7 – 0.71</td><td>0.475 / 0.474 / 0.47
range 0.46 – 0.475</td></tr>
</table>
4 study carried out for, a long time / 15 years ;

does not support:
5 no statistical test carried out / ref. to sample size ;
</td><td>2</td></tr>
</table>

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Question	Answer	Marks
6(a)	an arrow through phospholipid layer in outer membrane and an arrow through phospholipid layer in inner membrane **;** **R** arrows through proteins or **A**, **B**, **C** or **D**	**1**
6(b)	1 **D** = ATP synthase / ATP synthetase **; R** ATPase 2 **A**, **B** and **C** = ETC / electron transport chain / electron carriers / electron acceptors **;** *plus any **five** from:* *role of, ETC proteins / **A**, **B** and **C*** 3 electrons travel along ETC **;** 4 energy released **;** 5 (use energy released) to pump / actively transport, H^+ / protons, into intermembrane space **;** 6 increases concentration of H^+ / protons (in intermembrane space) / creates proton gradient **;** *role of **D*** 7 H^+ / protons, diffuse through, ATP synthase / **D** **;** 8 (from intermembrane space) to matrix **;** 9 synthesis of ATP from ADP and Pi **;** 10 chemiosmosis **;**	**7**

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Question	Answer	Marks
6(c)	*any **three** from:* 1 (named) enzyme for, Krebs cycle / link reaction **;** 2 ETC <u>proteins</u> / cytochromes / electron carriers / electron acceptors / **A** / **B** / **C** **;** 3 ATP synthase / **D** / described **;** 4 membrane / channel / transport / carrier / structural, **proteins** **;** 5 (make) tRNA / rRNA / ribosomes **;**	**3**

Question	Answer	Marks
7(a)(i)	1 rate of oxygen produced / rate of photosynthesis, is low / stays constant **or** small decrease in, rate of oxygen produced / rate of photosynthesis **;** 2 light <u>intensity</u> was the limiting factor / AW **;** 3 (so) less / little, light energy absorbed / photolysis (of water) / photoactivation (of chlorophyll)/ light-dependent reactions / photophosphorylation **; R** no light energy absorbed	**3**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>7(a)(ii)</td><td>
any three from:

1 rate of oxygen produced / rate of photosynthesis, decreased ;

2 two paired data quotes with units ;

<table>
<tr><th>temperature / °C</th><th>rate of oxygen production / $mm^3\ h^{-1}$</th></tr>
<tr><td>30</td><td>4 / 4.00</td></tr>
<tr><td>40</td><td>2.55</td></tr>
<tr><td>50</td><td>0.65 (A 0.62-0.65)</td></tr>
</table>
3 because, enzyme / ATP synthase / NADP reductase / oxygen evolving complex, <u>denatured</u> ; A rubisco

4 change in active site / fewer ESCs ;
</td><td>3</td></tr>
<tr><td>7(b)</td><td>
any three from:

1 light absorbed by, photosystem II / P680
or
photoactivation / photoionisation (of chlorophyll) ;

2 photolysis (of water) ;

3 water-splitting enzyme / oxygen evolving complex ;

4 water splits into protons, electrons and oxygen ; A equation
</td><td>3</td></tr>
</table>

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Question	Answer	Marks
8(a)(i)	receptor **;**	**1**
8(a)(ii)	intermediate neurone **; A** relay neurone / motor neurone	**1**
8(a)(iii)	Schwann **;**	**1**
8(b)	*any **four** from:* *differences* *myelinated neurone* 1 faster (impulse transmission) **; ora** *explanation* 2 myelin (sheath), insulates (the axon) / prevents movement of ions **;** 3 nodes of Ranvier / gaps with no myelin sheath, have voltage-gated channels **or** nodes of Ranvier / gaps with no myelin sheath, allow movement of ions **;** 4 depolarisation / action potential, occurs only at nodes of Ranvier / gaps with no myelin sheath**; ora** 5 action potentials jump from node to node / saltatory conduction **; ora** 6 longer local circuits / local circuits occur between nodes **; ora**	**4**
8(c)(i)	1 **A** voltage-gated <u>and</u> **B** ligand-gated / not voltage-gated **or** **A** opens in response to, depolarisation / arrival of an action potential <u>and</u> **B** opens in response to binding of, acetylcholine / neurotransmitter **;** 2 **A** for calcium ions <u>and</u> **B** for sodium ions **;**	**2**

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Question	Answer	Marks
8(c)(ii)	*any **four** from:* 1 no Ca^{2+} enter (presynaptic, knob / neurone) **;** 2 vesicles do not, move towards / fuse with, presynaptic membrane **;** 3 no, ACh / neurotransmitter, released **or** no exocytosis of, ACh / neurotransmitter **;** 4 ACh / neurotransmitter, does not bind to, receptor / ion channel **B ;** 5 Na^{+} does not enter postsynaptic neurone / ion channel **B** does not open **;** 6 postsynaptic membrane not depolarised **or** no action potential generated **or** impulse not transmitted **;**	**4**
8(c)(iii)	*any **two** from:* 1 inside more negative (charge) **or** membrane hyperpolarised / membrane potential decreases / potential difference increases **;** 2 harder to / cannot, reach threshold **;** 3 no depolarisation of membrane / harder to depolarise membrane **or** no / fewer / harder to generate, action potentials / impulses **;**	**2**

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Question	Answer	Marks
9(a)	*any **four** from:* 1 not predated / predators killed (as toxic) **;** 2 eats / decreases numbers, of, native / local, species **;** 3 disrupts, food web / food chain / ecosystem **;** 4 can spread to other areas / numbers increase rapidly **;** 5 reduces <u>biodiversity</u> **;** 6 can cause extinction (in, native / local**,** species) **;** 7 competes (with native species) for, space / breeding areas / food / water / resources **;** 8 introduces / new, disease **;**	**4**

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Question	Answer	Marks
9(b)	***A*** *eggs for ova / oocytes* *any* ***four*** *from:* 1 (females) given, hormones / FSH, to stimulate maturation of, ova / oocytes **or** (females) given, hormones / FSH, to stimulate superovulation **;** 2 ova / oocyte, collection / harvesting **;** 3 sperm added to, ova / oocytes **or** *ref. to* fertilisation **;** 4 sperm from genetically distant male / AW **;** 5 embryos, checked / selected **;** 6 embryo placed into uterus **;** 7 some embryos can be frozen **;**	**4**

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Question	Answer	Marks
10(a)	negative feedback **;**	**1**
10(b)	*any **three** from:* 1 (blood) glucose concentration decreases due to increased respiration **or** (blood) glucose concentration decreases due to glucose used to generate ATP for, muscle contraction / movement / exercise **;** 2 glucagon released (from pancreas) **;** 3 glucagon acts on liver cells **;** 4 glycogenolysis occurs / description **;** 5 glucose released into blood so (blood) glucose concentration, increases / returns to set point **;** 6 AVP **;** e.g. gluconeogenesis / ref. cell signalling	**3**
10(c)(i)	**A** – gluconic acid / gluconolactone **;** **B** – chromogen **;**	**2**
10(c)(ii)	*any **two** from:* 1 measures, current / direct, blood glucose concentration **;** 2 accurate reading / quantitative / numerical / digital **;** 3 reusable **;** 4 AVP **;** e.g. can use regularly / convenient digital store of data / connected to phone or surgery	**2**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2024**

MARK SCHEME

Maximum Mark: 100

Published

This mark scheme is published as an aid to teachers and candidates, to indicate the requirements of the examination. It shows the basis on which Examiners were instructed to award marks. It does not indicate the details of the discussions that took place at an Examiners' meeting before marking began, which would have considered the acceptability of alternative answers.

Mark schemes should be read in conjunction with the question paper and the Principal Examiner Report for Teachers.

Cambridge International will not enter into discussions about these mark schemes.

Cambridge International is publishing the mark schemes for the May/June 2024 series for most Cambridge IGCSE, Cambridge International A and AS Level and Cambridge Pre-U components, and some Cambridge O Level components.

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PUBLISHED

Generic Marking Principles

These general marking principles must be applied by all examiners when marking candidate answers. They should be applied alongside the specific content of the mark scheme or generic level descriptions for a question. Each question paper and mark scheme will also comply with these marking principles.

GENERIC MARKING PRINCIPLE 1:

Marks must be awarded in line with:

- the specific content of the mark scheme or the generic level descriptors for the question
- the specific skills defined in the mark scheme or in the generic level descriptors for the question
- the standard of response required by a candidate as exemplified by the standardisation scripts.

GENERIC MARKING PRINCIPLE 2:

Marks awarded are always **whole marks** (not half marks, or other fractions).

GENERIC MARKING PRINCIPLE 3:

Marks must be awarded **positively**:

- marks are awarded for correct/valid answers, as defined in the mark scheme. However, credit is given for valid answers which go beyond the scope of the syllabus and mark scheme, referring to your Team Leader as appropriate
- marks are awarded when candidates clearly demonstrate what they know and can do
- marks are not deducted for errors
- marks are not deducted for omissions
- answers should only be judged on the quality of spelling, punctuation and grammar when these features are specifically assessed by the question as indicated by the mark scheme. The meaning, however, should be unambiguous.

GENERIC MARKING PRINCIPLE 4:

Rules must be applied consistently, e.g. in situations where candidates have not followed instructions or in the application of generic level descriptors.

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GENERIC MARKING PRINCIPLE 5: Marks should be awarded using the full range of marks defined in the mark scheme for the question (however; the use of the full mark range may be limited according to the quality of the candidate responses seen).
GENERIC MARKING PRINCIPLE 6: Marks awarded are based solely on the requirements as defined in the mark scheme. Marks should not be awarded with grade thresholds or grade descriptors in mind.

Science-Specific Marking Principles

1	Examiners should consider the context and scientific use of any keywords when awarding marks. Although keywords may be present, marks should not be awarded if the keywords are used incorrectly.
2	The examiner should not choose between contradictory statements given in the same question part, and credit should not be awarded for any correct statement that is contradicted within the same question part. Wrong science that is irrelevant to the question should be ignored.
3	Although spellings do not have to be correct, spellings of syllabus terms must allow for clear and unambiguous separation from other syllabus terms with which they may be confused (e.g. ethane / ethene, glucagon / glycogen, refraction / reflection).
4	The error carried forward (ecf) principle should be applied, where appropriate. If an incorrect answer is subsequently used in a scientifically correct way, the candidate should be awarded these subsequent marking points. Further guidance will be included in the mark scheme where necessary and any exceptions to this general principle will be noted.
5	‘List rule’ guidance For questions that require ***n*** responses (e.g. State **two** reasons …): • The response should be read as continuous prose, even when numbered answer spaces are provided. • Any response marked *ignore* in the mark scheme should not count towards ***n***. • Incorrect responses should not be awarded credit but will still count towards ***n***. • Read the entire response to check for any responses that contradict those that would otherwise be credited. Credit should **not** be awarded for any responses that are contradicted within the rest of the response. Where two responses contradict one another, this should be treated as a single incorrect response. • Non-contradictory responses after the first ***n*** responses may be ignored even if they include incorrect science.

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6 Calculation specific guidance

Correct answers to calculations should be given full credit even if there is no working or incorrect working, **unless** the question states 'show your working'.

For questions in which the number of significant figures required is not stated, credit should be awarded for correct answers when rounded by the examiner to the number of significant figures given in the mark scheme. This may not apply to measured values.

For answers given in standard form (e.g. $a \times 10^n$) in which the convention of restricting the value of the coefficient (a) to a value between 1 and 10 is not followed, credit may still be awarded if the answer can be converted to the answer given in the mark scheme.

Unless a separate mark is given for a unit, a missing or incorrect unit will normally mean that the final calculation mark is not awarded. Exceptions to this general principle will be noted in the mark scheme.

7 Guidance for chemical equations

Multiples / fractions of coefficients used in chemical equations are acceptable unless stated otherwise in the mark scheme.

State symbols given in an equation should be ignored unless asked for in the question or stated otherwise in the mark scheme.

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Mark scheme abbreviations

;	separates marking points
/	alternative answers for the same point
A	accept (for answers correctly cued by the question, or by extra guidance)
R	reject
I	ignore
( )	the word / phrase in brackets is not required, but sets the context
AW	alternative wording (where responses vary more than usual)
underline	actual word given must be used by candidate (grammatical variants accepted)
max	indicates the maximum number of marks that can be given
ora	or reverse argument
mp	marking point (with relevant number)
ecf	error carried forward
AVP	alternative valid point

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Question	Answer	Marks
1(a)	**A** – G protein **;** **B** – cyclic AMP / cAMP **;** **C** – aquaporin **; I** water channel	**3**
1(b)	*any **three** from:* 1 dehydration / not drinking enough water **;** 2 ingesting salty food / description **;** 3 more, ions / glucose / amino acids / solute, (in blood) **;** 4 sweating / perspiration / evaporation (of water) **;** 5 AVP **;** e.g. disease where ADH is not, made / secreted	**3**
1(c)	*any **two** from:* 1 increase in / large, urine volume **or** more frequent urination **or** dilute / less concentrated, urine **;** 2 fatigue **;** 3 feelings of thirst / dry mouth **;** 4 AVP **;** e.g. dehydration change in blood pressure	**2**

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Question	Answer	Marks
1(d)	*any **two** from:* 1 few / no, aquaporins added to membrane / **P ;** 2 reduced / low, permeability of, membrane / **P**, to **water ; R** impermeable to water 3 less water moves through, membrane / **P ;** **ecf** for mp1 if **C** named as water channels in 1(a)	**2**
1(e)	*(gene is on X chromosome)* X (chromosome with recessive allele) inherited from mother **;** Y (chromosome) inherited from father **;**	**2**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th>description of phenotypic variation</th><th>cause of variation</th></tr>
<tr><td>Tomato plants grown in a glasshouse and grown outside vary in the yield of tomatoes they produce. Seventeen genes associated with tomato yield have been identified.</td><td>$V_G + V_E$</td></tr>
<tr><td>New strawberry plants from the variety called Sweet Ann are made by asexual reproduction. The new plants grow to different sizes and produce different numbers of fruit.</td><td>V_E</td></tr>
<tr><td>The domestic cat has a blood group system with three possible blood types: A, B and AB. The blood types are determined by antigens present on the cell surface membrane of red blood cells.</td><td>V_G</td></tr>
<tr><td>Over 50 genes have variants that are associated with excessive weight-gain in humans. Other risk factors for excessive weight-gain include diet and exercise.</td><td>$V_G + V_E$</td></tr>
<tr><td>Resting heart rate in humans varies between different individuals. Some factors that influence resting heart rate include: biological sex, family history of heart disease, number of cigarettes smoked, medication taken.</td><td>$V_G + V_E$</td></tr>
</table>
five correct = 3 marks **;;;**

four or three correct = 2 marks

two or one correct = 1 mark</td><td>**3**</td></tr>
<tr><td>2(b)</td><td>mutation **;**</td><td>**1**</td></tr>
</table>

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Question	Answer	Marks
2(c)	*any **three** from:* 1 crossing over ; 2 independent / random, assortment ; 3 random, fusion of gametes / fertilisation ; 4 random mating ;	**3**
3(a)(i)	Ttdd and TTdd ;	**1**
3(a)(ii)	13:3 ;	**1**
3(a)(iii)	epistasis ;	**1**
3(a)(iv)	*any **five** from:* 1 dominant allele / T / D, results in a functional protein ; 2 two recessive alleles / tt / dd, results in a non-functional protein ; 3 *T* could code for an enzyme ; 4 (so enzyme catalyses) production of, malvidin / pigment ; 5 *D* could code for an inhibitor ; 6 (inhibitor) binds to enzyme (coded for by) gene *T*/*t* ; 7 (so) reaction to produce, malvidin / pigment, does not occur ; 8 protein (coded by T / t) could be a transcription factor ; 9 transcription factor allow the production of enzyme (needed in the metabolic pathway) ; 10 protein (coded by *D*/*d*) could cause the inhibition of transcription factor ;	**5**

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Question	Answer	Marks
3(b)	*any **four** from:* 1 located on X chromosome / sex-linked **;** 2 *ref. to* recessive allele **;** 3 non-functioning, factor VIII / protein **or** less, factor VIII / protein **or** no, factor VIII / protein **;** 4 (so) blood does not clot quickly enough / excessive bleeding occurs (after an injury) **;** 5 link the phenotype to the genotype **;** e.g. X^FX^F = normal female X^FX^f= normal female X^fX^f= affected female X^FY = normal male X^fY = affected male 6 AVP **;** e.g. prevents activation of thrombin / fibrinogen not converted to fibrin / *ref. to* mostly males affected /different mutations cause a range of severity of haemophilia	**4**
4(a)(i)	*restriction endonuclease* 1 cuts, DNA / plasmid **;** *DNA ligase* 2 joins DNA with the plasmid **;** *DNA polymerase* 3 forms dsDNA **or** makes a complementary DNA strand **;** r*everse transcriptase* 4 uses mRNA (as a template) to make, cDNA / complementary (ss)DNA **; R** converts	**4**

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Question	Answer	Marks
4(a)(ii)	*any **three** from* 1 for transcription factor(s) to bind **;** 2 for RNA polymerase to bind **;** 3 (so) gene is, expressed / switched on / activated / transcribed **;** 4 to, increase / control, transcription of the, gene of interest / marker gene**;** 5 to cause transcription with a specific environmental change **; A** inducible promoter 6 AVP **;** e.g. choose promoter to give transcription in, all tissues / all developmental stages	**3**
4(b)	plasmid **X** - no insulin because the gene is, inserted backwards / the wrong way around **;** plasmid **Y** - produces insulin because the gene, is inserted the correct way around / AW **;** plasmid **Z** - no insulin because, the gene was not inserted / the plasmid closed up / it is a non-recombinant plasmid **;**	**3**
5(a)	crossing over **; A** chiasma formation	**1**

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Question	Answer	Marks
5(b)(i)	*any **three** from:* 1 mutation occurred a long time ago **or** someone in original population had mutation **or** mutation in common ancestor **;** 2 *ref. to*. founder effect **;** 3 (original / current) population is small **;** 4 *idea that* much of the population is closely related **or** small gene pool / low genetic diversity **; A** inbreeding 5 *ref. to* isolated (population) **;** 6 (caused) increase in frequency of, mutation / 999del5 / *BRCA2* allele **;**	**3**
5(b)(ii)	*any **three** from:* 1 reduce worry if negative **;** *(if positive)* 2 lifestyle changes / described **;** 3 early treatment / breast removal / can have frequent checks **;** 4 informed decision about having children **;** 5 *ref. to* counselling **;** 6 could lead to lower death rates from breast cancer **;**	**3**

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Question	Answer	Marks
5(b)(iii)	*any **one** from:* 1 only screen for mutations that occur with high frequency in a population (as opposed to hundreds of mutations) **;** 2 cost effective **;** 3 early diagnosis / early treatment / targeted treatment **;** 4 identifies mutation known to increase the risk of developing breast cancer (as opposed to a neutral mutation) **;** 5 could lead to lower death rates from breast cancer **;**	**1**
5(c)(i)	*any **two** from:* 1 it, inserted / deleted / replaced, DNA (in, *Lcn2* / regulatory sequence) **;** 2 (so) transcription of, *Lcn2* / gene, prevented **;** 3 (replaced mutated section of DNA) with correct sequence **;**	**2**
5(c)(ii)	only specific, sites / sequences, (on DNA targeted) **or** target site on DNA only found in *Lcn2* **;**	**1**
6(a)	*any **three** from:* 1 need to open to obtain carbon dioxide for, photosynthesis / Calvin cycle **;** 2 need to close to prevent water loss by, transpiration / described **;** 3 can close, at night / when dark, (to save water) as no photosynthesis **;** AW 4 must close to prevent water loss when, high light intensity / high temperatures / high wind speed / water stress / drought conditions **;**	**3**

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Question	Answer	Marks
6(b)	*any **six** from:* 1 H^+, pumped / moved by active transport, out (of guard cells) **;** 2 decrease in H^+ inside (of guard cells) / proton gradient set up / AW **;** 3 K^+ channels open / K^+ enters (guard cells) **;** 4 water potential (in guard cells), decreases / lowers / becomes more negative **;** 5 water enters (guard cells) by, osmosis / down the water potential gradient **;** 6 cells, expand / become (more) turgid **;** 7 outer wall thinner to allow (more), stretching / bending **or** inner wall thicker to allow less, stretching / bending **;** 8 AVP **;** e.g. light activates, ATP production / proton pump sentry of, chloride ions / Cl^- (in addition to K^+) / entry of water via aquaporins *max 3 if stomatal closure described*	**6**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>7(a)(i)</td><td>
<table>
<tr><th>light intensity / lux</th><th>total CO_2 uptake after 20 seconds / µmol</th><th>rate of photosynthesis / $µmols^{-1}$</th></tr>
<tr><td>0</td><td>0</td><td>0.0</td></tr>
<tr><td>3</td><td>20</td><td>10</td></tr>
<tr><td>6</td><td>44</td><td>22 ;</td></tr>
<tr><td>9</td><td>72</td><td>36</td></tr>
<tr><td>12</td><td>80</td><td>40</td></tr>
</table>
</td><td>1</td></tr>
<tr><td>7(a)(ii)</td><td>five points plotted correctly ;

best fit curve drawn for plots ;

curve levels off from 12 lux to 18 lux
or
curve continues up at smaller gradient ;</td><td>3</td></tr>
<tr><td>7(a)(iii)</td><td>curve levels off from 12 lux to 18 lux
1 because light <u>intensity</u> no longer limiting ;

2 temperature / carbon dioxide <u>concentration</u>, now limiting ;</td><td>2</td></tr>
</table>

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Question	Answer	Marks
7(b)	*any **four** from:* 1 electrons, excited / emitted / described **;** 2 electrons travel along ETC **and** energy released **;** 3 (use energy released) to pump H^+ into thylakoid, space/ lumen **;** 4 increases concentration of H^+ / protons (in thylakoid space / lumen) / creates proton gradient **;** 5 H^+ / protons, diffuse through ATP synthase **;** 6 (from thylakoid space) to stroma **;** 7 chemiosmosis **;**	**4**

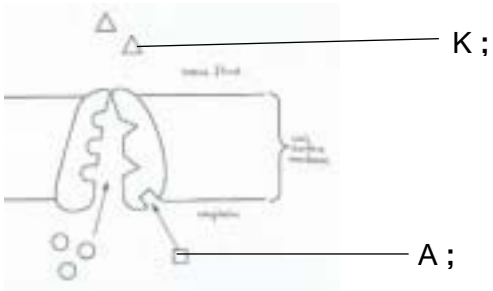
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Question	Answer	Marks
8(a)	*any **four** from:* *outer / inner membranes* 1 allow entry of, oxygen for oxidative phosphorylation / pyruvate for link reaction **;** **I** Krebs cycle 2 allow exit of carbon dioxide from, Krebs cycle / link reaction **;** 3 compartmentalisation / described **;** *inner membrane* 4 (location of) ETC to release energy to pump protons into intermembrane space **;** 5 (location of) ATP synthase for production of ATP **;** 6 cristae / infoldings, to increase surface area for many, ETCs / ATP synthases **;** 7 impermeable to, hydrogen ions / protons, to maintain proton gradient **or** impermeable to, hydrogen ions / protons, to maintain, high H^+ concentration in intermembrane space **;** 8 site of, oxidative phosphorylation / chemiosmosis **;**	**4**
8(b)(i)	*any **two** from:* 1 *ref. to* cells, metabolic rate / energy needs **;** 2 in cells about to undergo, mitosis / cell division **;** 3 AVP **;** e.g. to replace damaged mitochondria	**2**
8(b)(ii)	hydrolysed / bond broken, (to release energy) **or** G proteins bind to GTP rather than to ATP **;**	**1**
8(c)	1 degraded / broken down by, lysosomes / hydrolytic enzymes **;** 2 components of breakdown / AW, used to produce new mitochondria **;**	**2**

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Question	Answer	Marks
9(a)(i)	367 (%) **;;** allow 1 mark for: $\frac{(738-540)}{540} \times 100$ **or** 36.66666667	**2**
9(a)(ii)	*any **four** from:* 1 increase in temperature / global warming **;** 2 sea levels increase **;** 3 habitat change / example **;** e.g. forest fires / ocean acidification 4 food web / food chain / ecosystem, disrupted **;** 5 change in biodiversity **;** 6 *ref. to* extinction **;** 7 AVP **;**	**4**

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Question	Answer	Marks
9(b)	*any **four** from:* 1 may have future use ; 2 aesthetic / ethical / cultural, reasons ; 3 medical uses / example ; 4 ecotourism ; 5 *idea of* maintaining stability in, ecosystems / food chains / food webs ; 6 resource material ; e.g. wood for building / fibres for clothes / food (for humans) / agriculture 7 maintain / increase, gene pool / genetic diversity ; 8 *ref. to* soil stability / desertification ;	**4**
10(a)	 K ; A ;	**2**

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Question	Answer	Marks
10(b)	*any **four** from:* 1 sodium (ion) channels open **or** Na^+ enters (axon) **;** 2 (so) membrane <u>depolarised</u> **;** 3 *ref. to* threshold (potential) reached (for action potential to occur) **;** 4 potassium (ion) channels open **or** K^+ moves out (of axon) **;** 5 (causes) <u>repolarisation</u> (of membrane) **;** 6 *ref. to* <u>hyperpolarisation</u> (of membrane) **;** 7 return to resting potential **;** 8 AVP **;** e.g. entry of sodium ions causes more sodium channels to open	**4**
10(c)	*any **four** from:* *description* 1 myelinated axon / myelination, produces faster transmission speed (than unmyelinated) **;** 2 a larger the diameter (for unmyelinated) results in a faster transmission speed **; ora** 3 myelination has a greater effect on transmission speed than axon diameter **;** *explanation* 4 (myelinated faster due to) saltatory conduction **or** action potential jumps from node (of Ranvier) to node **;** 5 axons with wider diameter have, less ion leakage / larger surface area / lower resistance **;**	**4**

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