CAMBRIDGE
International Education

Cambridge International AS & A Level

BIOLOGY **9700/41**

Paper 4 A Level Structured Questions **May/June 2025**

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

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- 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:

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- marks are awarded when candidates clearly demonstrate what they know and can do
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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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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.

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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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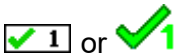
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The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
	correct point or mark awarded
	correct awarding one mark from marking point or marking group 1. similar numbered ticks are used for marking point or marking groups 2, 3, 4 etc.
	incorrect point or mark not awarded
	working towards marking point
	information missing or insufficient for credit
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	allow or accept
	benefit of the doubt given

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BP	blank page
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ECF	error carried forward applied
GM	mark already given
I	incorrect or insufficient point ignored while marking the rest of the response
MAX	maximum number of marks for a marking point has been awarded
NBOD	benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied
O	or reverse argument
R	incorrect point or mark not awarded
SEEN	point has been noted, but no credit has been given or blank page seen

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Mark scheme abbreviations

;	separates marking points
/	alternative answers for the same point
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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

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Question	Answer	Marks
1(a)	*any **two** from:* glucose (phosphate) **;** fructose (phosphate / bisphosphate) **;** triose phosphate **;** (named) fatty acid / keto-acid **;** glycerol **;** amino acid **;**	**2**
1(b)	*any **four** from:* **1** breaks down / hydrolyses to, ADP / AMP, and Pi **;** **2** releases, energy / 30.5 kJ mol^{-1} **;** **3** reversible reaction / high turnover / can be regenerated **;** **4** small / soluble, so can, diffuse / move (freely), in cell **;** **5** AVP **;**	**4**
1(c)	substrate-linked / substrate-level (phosphorylation) **;**	**1**
1(d)(i)	oxygen **;**	**1**
1(d)(ii)	*presence of oxygen:* **1** (ATP yield) increases / is higher **;** *plus any **two** from:* **2** oxygen acts as final, electron / proton, acceptor **;** **3** oxidative phosphorylation / chemiosmosis (occurs) **;** **4** energy from, reduced NAD / reduced FAD / electron transport chain **;** **5** proton gradient / H^+ → into intermembrane space **;** **6** ATP made in Krebs cycle **;**	**3**

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Question	Answer	Marks
2(a)	*any **four** from:* **1** sodium hydroxide absorbs, carbon dioxide / CO_2, released by, woodlice / respiration **;** **2** oxygen / O_2, taken in reduces pressure (in boiling tube) **;** **3** drop of liquid moves towards, boiling tube / bung / woodlice / left **;** **4** measure, distance / length, moved by drop, in set time **;** **5** rate = distance divided by time **;** **6** detail of calculation of volume of O_2 used **;**	**4**
2(b)	*rate at 5 °C:* lower / slower and less / lower, kinetic energy **or** fewer enzyme-substrate, collisions / complexes **or** fewer, enzyme-catalysed / respiration / glycolysis / link reaction / Krebs cycle, reactions **;**	**1**

Question	Answer	Marks
3(a)	dominant **;** 3 / daughter, has disease but, 2 / father, does not **or** 3 / daughter, could not have the disease if allele were recessive **;**	**2**
3(b)	*any **three** from*: **1** founder effect **;** **2** allele / variegate porphyria, present in, migrants / settlers / founding population **;** **3** higher frequency than in, Dutch / Europeans / original population **;** **4** genetic drift has large effect in small, population / gene pool **;** **5** inbreeding / migrants married within their own population **;** **6** high frequency of allele maintained over, time / generations **;** **7** AVP **;**	**3**

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Question	Answer	Marks
3(c)	*any **four** from*: **1** use mRNA (from person's cells) to make, cDNA / ssDNA **;** **2** add fluorescent, label / tag / dye / chemical / marker, to (this ss) DNA **;** **3** cDNA / ssDNA, hybridises with / binds to / complementary base pairs with, probe(s) / microarray **;** **4** fluorescence shows, disease / mutant, gene / allele, expression / transcription **;** **5** AVP **;**	**4**
3(d)	*any **one** from:* **1** find out / diagnose, person's disease **;** **2** so can, choose / develop, right treatment **;** **3** global, research resource / access **;**	**1**
3(e)	*any **three** from:* **1** change from **T** to **C** **or** replacement / substitution, of **T**, with / by, **C** **or** substitution of **C** for **T ;** **2** functional / working / correct / normal, enzyme / protein, produced **;** **3** gRNA, is specific to / only finds / just alters, CEP /disease / mutant, allele / gene **or** gRNA does not bind to genes other than CEP **;** **4** AVP **;**	**3**

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Question	Answer	Marks
4(a)	*any **three** from:* *(both processes)* **1** use / require, carbon dioxide / CO_2 **;** **2** use / require, water / H_2O **;** **3** use / require, (sun) light energy / source of energy is light **;** **4** make an organic, molecule / product **;** **5** produce / release, oxygen / O_2 **;** **6** involve transduction of energy (from one form to another) **;** **7** involve electron flow **;**	**3**
4(b)	**A** starch, grain / granule **;** **B** thylakoid (membrane) / lamella / granum **;**	**2**
4(c)(i)	ATP and reduced NADP (and oxygen) **;**	**1**
4(c)(ii)	*any **four** from:* **1** electron carriers / electron transport chain / to carry electrons **;** **2** to release energy to, move / pump, protons (into, thylakoid space / lumen) **or** to release energy to generate proton gradient **;** **3** oxygen-evolving, complex / enzyme **;** **4** (to catalyse) splitting / photolysis, of water **;** **5** LHC / antenna complex / photosystem, proteins hold pigments **;** **6** ATP synth(et)ase to make ATP **;**	**4**
4(d)	triose phosphate **;**	**1**

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Question	Answer	Marks
4(e)	*any **two plus one** opposing arguments based on correct ref. to:* **1** percentage / amount, of sunlight, absorbed / used **;** **2** absorption / action, spectrum **or** wavelengths / colours of light, used **;** **3** respiration of organism **;** **4, 5** stage/transition, where, energy lost **; ;** **6, 7** (named) limiting factor(s) **; ;** **8** energy storage capability **or** night / dark, process **;** **9** quality / nutrition in / palatability, of food product **;** **10** proportion edible **;** **11,12** additional energy inputs **; ;** **13, 14** additional resources needed **; ;** **15** labour / maintenance, needed **;** **16** amount of space needed **;** **17** plant, hormones / coordination **;** **18** evolutionary adaptation **;**	**3**

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Question	Answer	Marks
5(a)(i)	directional (selection) ;	**1**
5(a)(ii)	curve with starting point (on *x*-axis), peak and end point (on *x*-axis) all to the right of the original positions ;	**1**
5(b)	*any **four** from*: **1** disruptive / diversifying (selection) ; **2** selection pressure is, seed / food (availability / size) ; **3** competition for, food / seeds ; **4** (birds with) intermediate bills cannot eat small and large seeds ; **5** extreme / small and large, phenotypes / bills, more likely to survive / have selective advantage / selected for ; **6** correct description of change in allele frequency ;	**4**
5(c)(i)	*r* / 0.930 / calculated value, is greater than critical value for n = 5 ; at (probability level) 0.05 ;	**2**
5(c)(ii)	*any **four** from*: *invasive alien species / they, may:* **1** change / disrupt, food, chains / webs ; **2** compete for food with / feed on same food as / occupy same niche as, native, species / organisms ; **3** prey on / graze / eat, native, species / organisms ; **4** introduce (new), disease / parasites ; **5** change / damage, the habitat ; **6** be toxic / threaten human health ; **7** damage, tourism / agriculture ;	**4**
5(c)(iii)	*any **two** from:* **1** climate change ; **2** hunting by humans ; **3** degradation / loss, of habitat ; **4** (named) pollution ; **5** disease ; **6** (named) natural disasters ;	**2**

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Question	Answer	Marks
6(a)(i)	**P:** selective reabsorption ; **Q:** osmoregulation ; **R:** ultrafiltration ;	**3**
6(a)(ii)	**P**: proximal convoluted tubule ; **Q**: collecting duct / distal convoluted tubule ; **R**: Bowman's capsule ;	**3**
6(b)	**1** **B** / interstitial fluid / tissue fluid / medulla, has more, salt / sodium chloride / Na^+ / Cl^-; *plus **one** from:* **2** salt gradient helps reabsorb water from collecting duct ; **3** AVP ;	**2**

Question	Answer	Marks
7(a)	*any **four** from:* **1** insulin / it, is a hormone ; **2** (described) stimulus causes insulin to be secreted from (named) endocrine, gland / tissue / cells ; **3** insulin travels in blood ; **4** binds to receptors on (named) target cells ; **5** to cause (described) response ; **6** AVP ;	**4**
7(b)(i)	*any **four** from:* **1** at 21 min, blood glucose concentration / it, rises to 110 mg 100 cm^{-3} ; **2** (high / increase in, blood glucose concentration) detected by pancreas / causes response in pancreas ; **3** insulin rises to 500 pmol dm^{-3} ; **4** (insulin) increase GLUT proteins in membrane / increases glucose uptake into cells / increases cell permeability to glucose **or** (insulin) increases rate of respiration of glucose ; **5** (insulin) causes / stimulates, glycogenesis / lipogenesis ; **6** (mean) blood glucose concentration / it, falls, to normal / within normal range / below starting point / to set point ;	**4**

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Question	Answer	Marks
7(b)(ii)	*any **three** from:* **1** blood glucose concentration falls as glucose is respired **;** **2** blood glucose concentration falls below, set point / normal **;** **3** insulin, secretion / release, stops **;** **4** glucagon (secreted / released / rises) **;** **5** glycogen, (in cells) converted to glucose **or** glycogenolysis **;** **6** (stored) protein / fat, converted to glucose **or** gluconeogenesis **or** (stored) protein / fat, used for respiration **;**	**3**

Question	Answer	Marks
8	*any **six** from:* **1** gibberellin binds to (gibberellin) receptor (-enzyme-complex) **;** **2** DELLA (protein) destroyed **;** **3** transcription factor / PIF, released / free / no longer bound to DELLA **;** **4** transcription factor / PIF / RNA polymerase, binds to, DNA / promoter **;** **5** growth / expansion / XET / xyloglucan endotransglucosylase, gene, switched on / expressed / transcribed **;** **6** loosens cell walls / breaks bonds between cellulose **;** **7** water enters (cells) by osmosis causing cell elongation **;** **8** AVP **;**	**6**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>9(a)</td><td>any three from:
1 (domains are) Archaea <u>and</u> Bacteria ;
2 membrane lipids ester-linked (Bacteria) vs. ether-linked / not ester-linked (Archaea) ;
3 single type of rRNA (Bacteria) vs. 3 types (Archaea)
or
Archaea, rRNA / ribosomal subunit, similar to eukaryotic ;
4 peptidoglycan (Bacteria) vs. not peptidoglycan / different (Archaea) ;
5 AVP ;</td><td>3</td></tr>
<tr><td>9(b)</td><td><table><tr><th>taxon</th><th>name</th></tr><tr><td>domain</td><td>Eukarya ;</td></tr><tr><td>kingdom</td><td>Animalia ;</td></tr><tr><td>phylum</td><td>Chordata</td></tr><tr><td>class</td><td>Mammalia</td></tr><tr><td>order</td><td>Carnivora</td></tr><tr><td>family</td><td>Felidae</td></tr><tr><td>genus</td><td>Panthera ;</td></tr></table></td><td>3</td></tr>
</table>

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Question	Answer	Marks
10(a)	**causing X / –70 (mV)** *any **three** from:* **1** active transport / sodium-potassium pump **;** **2** moves three Na^+ out of and two K^+ in (to neurone) **;** **3** more K^+ diffuses out than Na^+ diffuses in **;** **4** makes outside of membrane (relatively) more positive **;** **5** maintaining / establishing, resting potential **;** **causing Y / +40 (mV)** *any **two** from:* **6** depolarisation **;** **7** Na^+ / sodium ion, channels open **;** **8** Na^+, moves / diffuses, in (to neurone) **;** **causing Z / –90 (mV)** *any **two** from:* **9** hyperpolarisation **;** **10** (voltage-gated) K^+ / potassium ion, channels open **;** **11** K^+, moves / diffuses, out (of neurone) **;**	**7**
10(b)	**1** local, circuit / current **;** **2** from, depolarised / positive, area to, resting / negative, area **;**	**2**
10(c)	*any **three** from:* **1** speeds up (nerve) impulse / impulse transmission faster **;** **2** (as) myelin sheath / Schwann cells, act(s) as an insulator **;** **3** (as) local circuits flow between, nodes of Ranvier / gaps in sheath **;** **4** saltatory conduction **;** **5** fast(er), (described) response / muscle contraction **;**	**3**

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1(a)(i)	2 **;**	**1**
1(a)(ii)	pumps / actively transports, protons / hydrogen ions, into intermembrane space **;** *ref. to* proton gradient **;**	**2**
1(a)(iii)	*any **three** from:* 1 ATP synthase **;** 2 protons / hydrogen ions, move (from intermembrane space) to matrix **;** 3 by facilitated diffusion **;** 4 ATP synthesised from ADP + Pi **; A** ADP is phosphorylated to ATP 5 *ref. to* chemiosmosis **;**	**3**

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Question	Answer	Marks
1(b)	*any **four** from:* 1 electron transport chain / ETC, stops / reduced **;** 2 oxygen does not act as (final) electron acceptor **;** 3 no / less , protons pumped into intermembrane space **or** no / less steep, proton gradient **;** 4 build-up of, reduced NAD / reduced FAD **or** no / less, reduced NAD / reduced FAD, oxidised / recycled **or** no / less, NAD / FAD, regenerate / recycled **;** 5 no / less, ATP production **or** no / fewer, protons pass through ATP synthase **;** 6 Krebs cycle / link reaction / oxidative phosphorylation, stops / reduced **;** 7 *ref. to* glycolysis / anaerobic respiration / lactate produced / ethanol produced / substrate level phosphorylation **;**	**4**

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Question	Answer	Marks
2	*any **six** from:* *for either* 1 random / chance (event) **;** 2 not (natural) selection / not caused by selection pressure **;** 3 loss of (some) alleles **; I** loss of gene 4 (so) increase in frequency of, one / small number of, allele(s) **or** increase in homozygosity / decrease in heterozygosity **;** 5 small(er) gene pool / reduction in genetic variation **;** *genetic drift* 6 (random), fusion of gametes / mating / death of individual / mutation **;** 7 larger effect in small population **;** *founder effect* 8 small number of individuals, isolated / start new population / migrate **;** 9 not all alleles present from original population / alleles not representative of original population **;** 10 AVP **;** e.g. *ref. to* bottleneck effect genetic drift occurs gradually over time founder effect is a one-off event	**6**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>3(a)(i)</td><td>F1 genotypes: AaBb x AaBb ;

gametes: AB Ab aB ab (AB Ab aB ab) ;

F2 genotypes:

<table>
<tr><th></th><th>AB</th><th>Ab</th><th>aB</th><th>ab</th><th></th></tr>
<tr><td>AB</td><td>AABB
awn</td><td>AABb
awn</td><td>AaBB
awn</td><td>AaBb
Awn</td><td></td></tr>
<tr><td>Ab</td><td>AABb
awn</td><td>AAbb
awn</td><td>AaBb
awn</td><td>Aabb
awn</td><td></td></tr>
<tr><td>aB</td><td>AaBB
awn</td><td>AaBb
awn</td><td>aaBB
awn</td><td>aaBb
awn</td><td></td></tr>
<tr><td>ab</td><td>AaBb
awn</td><td>Aabb
awn</td><td>aaBb
awn</td><td>aabb
no awn</td><td>;</td></tr>
</table>

F2 phenotypes linked to genotypes (see Punnet Square) ;

ratio of F2 phenotypes: 15:1
awn: no awn ;</td><td>5</td></tr>
<tr><td>3(a)(ii)</td><td>autosomal dominant / epistasis ;
I dihybrid</td><td>1</td></tr>
</table>

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Question	Answer	Marks
3(b)	*any **one** from:* for seed dispersal **;** idea of protection **;** anchor into the ground **;** obtain more, nutrients / water **;**	**1**
3(c)(i)	*any **four** from:* 1 artificial selection / selective breeding / humans act as selection pressure **;** 2 select (rice) plants / seeds / grains, with no awns **;** 3 *idea of* breeding (selected) plants / self pollination of (selected) plants **;** 4 seeds germinate / plants grow / offspring grow **;** 5 repeat (selection and breeding) over generations **;** 6 AVP **;** e.g. *ref. to* genetic technology detail of pollination	**4**

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Question	Answer	Marks
3(c)(ii)	*any **three** from:* 1 mutation / change in base sequence, (in *An-1*) **or** *An-1* not expressed **;** 2 transcription factor has different, primary structure / tertiary structure / 3D shape **or** transcription factor not, produced / functional **or** transcription factor faulty **;** 3 transcription factor does not bind to, the promoter / DNA **;** 4 decrease in expression of gene(s) for awn development **;** 5 increase in expression of gene(s) for number of grains produced **;**	**3**

Question	Answer	Marks
4(a)	*any **three** from:* 1 (diploid) cell formed from (two) haploid gametes **;** 2 (diploid) cell has two sets of chromosomes / one set of chromosomes from each gamete **;** 3 (homologous chromosomes) maternal and paternal chromosomes **;** 4 (homologous chromosomes) has same, genes / loci / banding pattern / centromere position / size / length **;**	**3**
4(b)	anaphase 1 / telophase 1 **;** separation of, homologous chromosomes / bivalent **;**	**2**

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Question	Answer	Marks
4(c)(i)	*Fig. 4.1* metaphase 2 **;** **A** anaphase 2 *Fig. 4.2* telophase 1 **;** **A** anaphase 1	**2**
4(c)(ii)	48 **;**	**1**

Question	Answer	Marks
5(a)	*any **four** from:* 1 find, nucleotide / base / gene / DNA, sequence **;** 2 from database / using bioinformatics / from gene library **;** 3 make the gene (chemically) using nucleotides **;** 4 extract mRNA from cell, making the protein / expressing the gene **;** 5 use reverse transcriptase (with mRNA) to make cDNA **;** 6 use DNA polymerase (with cDNA) to make dsDNA **;** 7 cut out / extract / isolate, the gene from DNA **;** 8 using restriction enzyme **;**	**4**

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Question	Answer	Marks
5(b)	*any **three** from:* **ora** for animal insulin 1 large scale supply / supply can match demand **;** 2 no / less, likely to cause, immune / allergic, response **or** fewer side-effects **;** 3 faster to act / smaller dose needed **;** 4 no / less, likely for (insulin) tolerance to occur **;** 5 no / less, risk of infection / disease **;** 6 no / less, ethical / religious objections **or** suitable for, vegetarians / vegans **;** 7 AVP **;** e.g. cheaper to produce / easier to purify	**3**
5(c)	DNA from two different sources (joined together) **or** DNA from (human) gene joined to DNA from, bacteria / plasmid **;**	**1**

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Question	Answer	Marks
5(d)	*any **four** from:* 1 find, nucleotide / base / gene / DNA, sequence (of human insulin gene) **;** 2 from database / using bioinformatics / from gene library **;** 3 gene editing **;** 4 insertion / deletion / replacement, of nucleotide(s) **;** 5. at specific sites (of the gene) **;** 6 (results in) changes to the, (DNA) triplet / codon **;** 7 (so codes for a) different amino acid **;** 8 AVP **;** e.g. detail of gene editing / CRISPR / Cas9	**4**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(a)</td><td>any four from:
1 variable thickness of cell wall described ;

2 no plasmodesmata (between guard cell and other epidermal cells) ;

3 many, chloroplasts / mitochondria ;

4 chloroplasts have few grana ;

5 mitochondria have many cristae ;

6 cell surface membrane, often folded / contains many transport proteins ;

7 AVP ; e.g. cellulose microfibrils arranged in bands / shape description has several small vacuoles nucleus is relatively larger than in mesophyll cells</td><td>4</td></tr>
<tr><td>6(b)(i)</td><td>1 (more) stomata open at (mid)day
<u>and</u>
(more) stomata closed, at (mid)night / in darkness – ora ;

2 data quote – two values of time of day and percentage of stomata open ;

<table>
<tr><th>time of day</th><th>percentage of stomata open (± 0.5)</th><th>mean percentage</th></tr>
<tr><td>06:00</td><td>90 / 80 / 64</td><td>78</td></tr>
<tr><td>12:00 / midday</td><td>93 / 70 / 90</td><td>84.3</td></tr>
<tr><td colspan="3"><u>and</u></td></tr>
<tr><td>18:00</td><td>25 / 35</td><td>30</td></tr>
<tr><td>24:00 / midnight</td><td>10 / 15 / 10</td><td>11.7</td></tr>
</table>
</td><td>2</td></tr>
</table>

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Question	Answer	Marks
6(b)(ii)	*any **two** from:* 1 water stress / drought ; 2 high temperature ; 3 low humidity / dry (atmosphere); 4 high carbon dioxide concentration in leaf (air spaces) ; 5 low light intensity ; 6 high wind speed ;	**2**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>6(c)</td><td>
<table>
<tr><th>correct order</th><th>letter of event</th></tr>
<tr><td>1</td><td>D</td></tr>
<tr><td>2</td><td>E</td></tr>
<tr><td>3</td><td>G</td></tr>
<tr><td>4</td><td>B</td></tr>
<tr><td>5</td><td>F</td></tr>
<tr><td>6</td><td>J</td></tr>
<tr><td>7</td><td>I</td></tr>
<tr><td>8</td><td>A</td></tr>
<tr><td>9</td><td>H</td></tr>
<tr><td>10</td><td>C</td></tr>
</table>
E G B between D and F ;
E G B in correct order throughout table ;

J I A H between F and C ;
J I A H in correct order throughout table ;
</td><td>4</td></tr>
</table>

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Question	Answer	Marks
7(a)	*any **six** from:* 1 sodium–potassium pumps (in axon membrane) **;** 2 transport, sodium ions / Na^+, out and, potassium ions / K^+, in **;** 3 by active transport / uses ATP **;** 4 three, sodium ions / Na^+, and two, potassium ions / K^+ **;** 5 sets up an electrochemical gradient **;** 6 potassium ions / K^+, diffuse out through channels **;** 7 membrane more permeable to K^+ / membrane has more K^+ channels **;** 8 (so) more, potassium ions / K^+, move out of axon than, sodium ions / Na^+, move in **;** 9 *ref. to* anions / negatively charged ions / negatively charged proteins, inside **;** 10 inside negative (relative to outside) **;** 11 -60 mV to -70 mV **;**	**6**

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

hypokalaemia ora for normal
1 longer, action potential / depolarisation / repolarisation
or
larger depolarisation ;

2 longer hyperpolarisation
or
more negative / smaller, hyperpolarisation ;

3 longer refractory period ;

4 more negative / lower, resting potential ;

5 data quote ;

<table>
<tr><th></th><th>normal</th><th>hypokalaemia</th></tr>
<tr><td>mp1 longer action potential
mp1 longer depolarisation
mp1 longer repolarisation
mp1 larger depolarisation</td><td>2.6 ms
1.0 ms
1.0 ms
110 mV</td><td>3.25 ms
1.25 ms
1.3 ms
140 mV</td></tr>
<tr><td>mp2 longer hyperpolarisation
mp2 more negative hyperpolarisation
mp2 smaller hyperpolarisation</td><td>0.7 ms
–92 mV
–22 mV</td><td>1.0 ms
–112 mV
–12 mV</td></tr>
<tr><td>mp4 resting potential</td><td>–70 mV</td><td>–100 mV</td></tr>
</table>
</td><td>3</td></tr>
</table>

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Question	Answer	Marks
7(b)(ii)	*any **two** from:* 1 harder stimulus / larger stimulus / larger depolarisation, needed, to reach threshold required / to generate an action potential **;** 2 fewer, impulses / action potentials, transmitted **or** lower frequency of impulses **;** 3 slower, nervous coordination / reaction times / responses / cognition **or** weaker, sensation / muscle contraction **;** *allow named examples*	**2**

Question	Answer	Marks
8(a)	*any **four** from:* 1 eukaryotic / have nucleus **;** 2 no, chlorophyll / chloroplasts **;** 3 heterotrophic / saprophytic / saprotrophic / parasitic / described **;** 4 cell wall made of, chitin / mannoproteins / glucans **;** 5 reproduce by spores **;** 6 hyphae / mycelium **;** 7 cells may be multinucleate **;** 8 either unicellular or multicellular **;**	**4**
8(b)	fungus receives, (named) organic compounds / nutrients / food / oxygen **;** alga receives, support / stability / protection / water / minerals / carbon dioxide **;**	**2**

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Question	Answer	Marks
8(c)(i)	(photosystem) II / 2 / 680 **;**	**1**
8(c)(ii)	***A** to **B*** (occurs in very low light conditions) respiration (rate) greater than photosynthesis (rate) **;** (so) oxygen, consumed / not released **;** *after **C*** light intensity not limiting **;** carbon dioxide concentration / temperature, is limiting **;**	**4**

Question	Answer	Marks
9(a)	*any **four** from:* 1 *ref. to* quadrat of, known / same / standard, area / size **;** 2 *ref. to* setting out a grid **;** 3 random number generator (to produce coordinates) for quadrat placement **;** 4 use a key **;** 5 count number of species / numbers of individuals of each species / abundance / percentage cover / ACFOR / Braun-Blanquet **;** 6 *ref. to* large sample size / repeats **;** 7 (use results to calculate) Simpson's Index of Biodiversity / species density **;**	**4**

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Question	Answer	Marks
9(b)(i)	– 0.923 **;;;** *allow 2 marks if no minus* *allow 2 marks if not three decimal places* *allow 2 marks if incorrect value of n used* if n is 10 answer = – 2.333 if n is 120 answer = 0.998	**3**
9(b)(ii)	r_s > critical value **or** 0.923 > 0.504 **;** null hypothesis rejected as there is a, significant / strong / negative, correlation **or** null hypothesis rejected as correlation not due to chance / probability that correlation due to chance is less than 5% **;** ***ecf*** *from 9(b)(i)*	**2**

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Question	Answer	Marks
10(a)	*any **four** from:* *during – increase in lactate concentration* 1 (initially) lactate concentration low due to aerobic respiration **;** 2 no / less, oxygen available so (increase in) anaerobic respiration **;** 3 pyruvate, reduced / converted, to lactate **;** *after – decrease in lactate concentration* 4 (more) oxygen available so aerobic respiration occurs **;** 5 lactate, oxidised / converted, to pyruvate **;** 6 idea that lactate is processed by liver **;** 7 AVP **;** e.g. *ref. to* oxygen debt / EPOC	**4**
10(b)	*any **three** from:* 1 (captive) breeding programs / described / frozen zoos **;** 2 marine reserves / protected areas **;** 3 ban on hunting / trade, (of seals) **;** 4 *ref. to* education / awareness **;** 5 research **;** 6 reduce, ocean / sea, pollution / described **;** 7 reduce fishing **;** 8 reduce climate change **;**	**3**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

BIOLOGY **9700/43**

Paper 4 A Level Structured Questions **May/June 2025**

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 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level 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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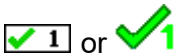
Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
	correct point or mark awarded
	correct awarding one mark from marking point or marking group 1. similar numbered ticks are used for marking point or marking groups 2, 3, 4 etc.
	incorrect point or mark not awarded
	working towards marking point
	information missing or insufficient for credit
	used to highlight part of an extended response
	used to highlight part of an extended response
	allow or accept
	benefit of the doubt given

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Annotation	Meaning
BP	blank page
CON	contradiction in response, mark not awarded
ECF	error carried forward applied
GM	mark already given
I	incorrect or insufficient point ignored while marking the rest of the response
MAX	maximum number of marks for a marking point has been awarded
NBOD	benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied
O	or reverse argument
R	incorrect point or mark not awarded
SEEN	point has been noted, but no credit has been given or blank page seen

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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
AV	alternative valid point

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Question	Answer	Marks
1(a)	**A** – GLUT / carrier **;** **I** channel **B** – glycolysis **;** **C** – intermembrane space **;** **A** intermembranal **R** inner membrane	**3**
1(b)	*any **four** from:* 1 (pyruvate) decarboxylation / decarboxylase / carbon dioxide released **;** 2 (pyruvate) dehydrogenation / dehydrogenase / oxidation **;** 3 formation of, acetyl group / acetate **;** 4 reduced NAD produced / described **;** 5 acetyl group / acetate, combines with coenzyme A **or** formation of acetyl CoA **;**	**4**
1(c)	*any **three** from:* 1 little / no, link reaction / Krebs cycle / oxidative phosphorylation **;** 2 ATP, mostly / only, produced by, glycolysis / process **B** / substrate-linked phosphorylation **;** 3 (so) less ATP produced **;** 4 anaerobic respiration / production of lactate **;**	**3**

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Question	Answer	Marks
2(a)(i)	*any **four** from:* 1 antibiotic acts as selection pressure **;** 2 bacteria with antibiotic resistance (gene / allele) have selective advantage / selected for **; ora** 3 bacteria with antibiotic resistance (gene / allele), survive / reproduce **; ora** 4 pass on, gene / allele, (for antibiotic resistance) **or** increase in **allele** frequency (for antibiotic resistance) **;** 5 *ref. to* plasmids **;** 6 (horizontal gene transfer) by, transduction / transformation / conjugation **;** 7 (horizontal gene transfer) gives rapid increase of resistant bacteria **;**	**4**
2(a)(ii)	*any **two** from:* 1 drug prevents attachment of mRNA to ribosome **or** drug prevents attachment of tRNA to, amino acid / ribosome / mRNA **or** drug binds to ribosome **;** 2 protein (coded for by antibiotic resistance gene) not made **;** 3 so antibiotic able to work **;**	**2**

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Question	Answer	Marks
2(b)(i)	*any **three** from:* accept **ora** throughout *natural selection* 1 environment as selection pressure **; ora** human acts as selection pressure 2 random mating **; ora** humans select organisms to breed 3 takes more generations for effects to be seen / slower process / AW **;** 4 organisms <u>not</u> selected for desirable phenotypes **; ora** humans select features 5 can result in speciation **;** 6 does <u>not</u> decrease, genetic diversity / hybrid vigor **;** 7 inbreeding less likely to occur **;** 8 greater heterozygosity **;**	**3**
2(b)(ii)	1 offspring (from F1) will not be genetically similar / AW **;** 2 offspring (from F1) will produce variation in next crop / will not be true-breeding plants**;**	**2**

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Question	Answer	Marks
3(a)	1 enzymes produced when, allolactose / lactose / substrate, is present **or** enzymes only produced when required **;** 2 genes not, expressed / switched on / transcribed, continuously **or** genes, expressed / switched on / transcribed, when, allolactose / lactose / substrate, binds to repressor **;** **I** inducer	**2**
3(b)	*any **seven** from:* 1 lactose enters the bacterium **;** 2 lactose binds to the repressor **;** 3 causing a shape change **;** 4 the repressor detaches from the operator **;** 5 promoter unblocked / AW **;** 6 RNA polymerase binds to the promoter **;** 7 gene(s) transcribed **;** 8 β-galactosidase is made **;** 9 β-galactosidase breaks down lactose **;** *galactosidase activity levels off as:* 10 β-galactosidase activity at maximum / galactosidase active sites full **;**	**7**

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Question	Answer	Marks
4(a)	*any **four** from:* 1 geographical, isolation / barrier (caused by the, river / canyon walls) **;** 2 no gene flow between (isolated ancestral) populations **;** 3 different, selection pressures / environment **;** 4 different / random / independent, mutations (in each population) **;** 5 different changes in allele frequencies / different gene pools / different alleles selected for **;** 6 populations have different, morphological / physiological / behavioral, features **;** 7 leads to, reproductive isolation / inability to interbreed (to produce fertile offspring) **;** 8 allopatric speciation **;**	**4**
4(b)	*any **three** from:* *DNA sequencing **ora** for fossils* 1 provides more information (about the whole organism) **;** 2 more precise / more accurate **;** 3 only a small sample of DNA is needed **;** 4 can give estimate of when species diverged/how closely related two organisms are / molecular clock can estimate time of divergence **;** 5 quantitative **;** 6 AVP **;** e.g. *idea of.* avoids convergent evolution problems	**3**

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Question	Answer	Marks
4(c)	*any **one** from:* not enough fossils **;** small sample sizes **;** DNA degrades over time **;** this depends on an estimated mutation rate **;**	**1**

Question	Answer	Marks
5(a)	*any **three** from:* 1 cDNA has, no introns / only exons **or** genomic DNA has introns (and exons) **;** 2 introns are non-coding sequences / exons are coding sequences **;** 3 bacteria cannot, remove introns / carry out splicing **;** 4 with cDNA, functional mRNA is made / translation occurs **or** with genomic DNA, functional mRNA is not made / translation does not occur **;**	**3**
5(b)(i)	bond together / anneal, with hydrogen bonds **;** formation of phosphodiester bonds / joins sugar phosphate backbone **;**	**2**
5(b)(ii)	1 so RNA polymerase can bind **;** 2 so, transcription / gene expression, occurs **;**	**2**

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Question	Answer	Marks
5(c)	*any **three** from:* 1 marker gene is added to plasmid **;** 2 positioned downstream of promoter **;** 3 positioned alongside, GOI / insulin gene**;** 4 when marker gene is expressed fluorescent proteins are made **;** 5 *ref. to* (fluorescent proteins) fluoresce / glow, with exposure to, UV / blue, light **;** 6 shows which, bacteria / cells, are transformed / AW **;**	**3**
5(d)	*any **two** from:* *advantages of using yeast:* 1 easier / cheaper, to culture yeast cells **;** 2 more productive / higher productivity **;** 3 easier, to extract / processing / to purify, (insulin) **;** 4 yeast cell similar to β-cells / named example **;** e.g. have Golgi apparatus	**2**

Question	Answer	Marks
6(a)(i)	urea **;**	**1**
6(a)(ii)	deamination **/** ornithine cycle / urea cycle / converts ammonia (to urea) **;**	**1**
6(a)(iii)	liver **;**	**1**

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Question	Answer	Marks
6(b)	*any **seven** from:* 1 blood enters glomerulus via afferent arteriole **;** 2 afferent arteriole (lumen) diameter larger than efferent **;** 3 (so) high, blood / hydrostatic, pressure **;** 4 blood / hydrostatic, pressure greater than water potential gradient (between Bowman's capsule and glomerulus) **;** 5 fluid forced through pores / fenestrations in (blood vessel) endothelium **;** 6 basement membrane acts as a filter **;** 7 stops, large proteins / blood cells / molecules larger than 68 000–70 000 RMM **;** 8 water / glucose / amino acids / urea / mineral ions, pass through **;** 9 slit pores between podocytes **;** 10 AVP **;** e.g. GFR 125 cm^{-3} min^{-1}	**7**
6(c)	*any **two** from:* 1 collecting duct in medulla **;** 2 thicker medulla has lower water potential **;** 3 (so) more water reabsorbed **;** 4 AVP **;** e.g. *ref. to* loop of Henle	**2**

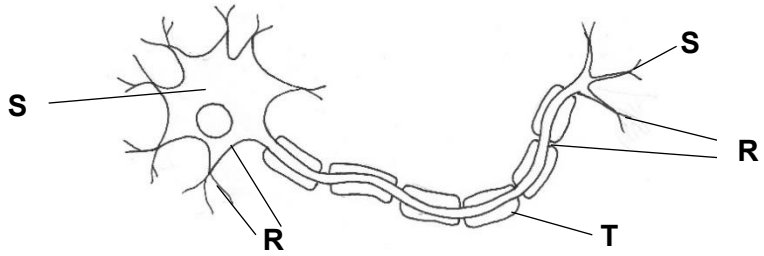
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Question	Answer	Marks
7(a)(i)	DNA **;** ribosome **;**	**2**
7(a)(ii)	thylakoid space **;**	**1**
7(b)	xanthophyll **;** 3.4 **;** 0.92 **;**	**3**
7(c)	*any **four** from:* 1 absorbs light between 400 and 500 nm **/** peak at 450 nm **;** 2 accessory pigment **;** 3 absorbs light wavelengths not absorbed by, reaction centre / primary pigment / chlorophyll a **; A** harvest 4 so extends the range of wavelengths absorbed **;** 5 pass energy to, reaction centre / primary pigment / chlorophyll a **;** 6 *idea* improves efficiency of light-dependent stage **;**	**4**

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Question	Answer	Marks
8(a)	1 prevents illegal, trading / poaching / hunting **;** 2 trading requires permits / trading is regulated **;** 3 *ref. to* awareness / education **;**	**3**
8(b)	*any **four** from:* 1 multicellular **;** 2 eukaryote / eukaryotic / (cells), contain a nucleus **;** 3 specialised cells / tissues / organs **;** 4 heterotrophic (nutrition) / described **;** 5 nervous system **;** 6 (some cells have) cilia / flagella **;** 7 mobile / motile / locomotion **;**	**4**

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Question	Answer	Marks
9(a)	*any **four** from:* 1 use (named) sense organs to detect prey **;** 2 faster transmission of, impulses / signals **;** 3 (so) faster reaction to stimuli **;** 4 *ref. to* control centre / brain / CNS (decision making) **;** 5 faster response **or** ref. reflexes **;** 6 (by) muscles **;**	**4**
9(b)	*(if a letter is used more than once, all must be correct)* *correct position of label and letter for:* **R ;** **S ;** **T ;**  	**3**

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Question	Answer	Marks
9(c)(i)	*any **three** from:* *increase in curve* 1 cross bridges form / myosin heads bind to actin **;** 2 power stroke / actin filaments slide over myosin filaments **;** 3 bands get, smaller / shorter **or** decrease in width of sarcomere **;** *decrease in curve* 4 breaking of cross bridges / detachment of myosin heads from actin **;** 5 bands get, bigger / longer **or** increases width of sarcomere **;**	**3**
9(c)(ii)	*increase* 1 calcium ions / Ca^{2+}, released by sarcoplasmic reticulum **;** 2 calcium ions / Ca^{2+}, bound to troponin **;** *decrease* 3 calcium ions / Ca^{2+}, pumped back into sarcoplasmic reticulum **;**	**3**

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Question	Answer	Marks
10(a)	*any **three** from:* 1 self-contained unit **;** 2 community of organisms **; A** idea of several species 3 biotic and abiotic factors / named **;** 4 *ref. to* interaction **;** 5 AVP **;** e.g. flow of energy and cycling of minerals / nutrients	**3**
10(b)(i)	*any **three** from:* 1 (frogs are) mobile ; 2 marking, not harmful / cannot be removed **;** 3 (sufficient time for) marked individuals to mix with rest of population **;** 4 no, births / deaths **or** no, immigration / emigration / migration **or** constant population size **;**	**3**
10(b)(ii)	69 **;;** *must be a whole number, one mark only if not whole number* $\frac{27 \times 33}{13}$ *credit working if wrong answer*	**2**

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CAMBRIDGE
International Education

Cambridge International AS & A Level

BIOLOGY **9700/44**

Paper 4 A Level Structured Questions **May/June 2025**

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 2025 series for most Cambridge IGCSE, Cambridge International A and AS Level 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.

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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.
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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Annotations guidance for centres

Examiners use a system of annotations as a shorthand for communicating their marking decisions to one another. Examiners are trained during the standardisation process on how and when to use annotations. The purpose of annotations is to inform the standardisation and monitoring processes and guide the supervising examiners when they are checking the work of examiners within their team. The meaning of annotations and how they are used is specific to each component and is understood by all examiners who mark the component.

We publish annotations in our mark schemes to help centres understand the annotations they may see on copies of scripts. Note that there may not be a direct correlation between the number of annotations on a script and the mark awarded. Similarly, the use of an annotation may not be an indication of the quality of the response.

The annotations listed below were available to examiners marking this component in this series.

Annotations

Annotation	Meaning
	correct point or mark awarded
	correct awarding one mark from marking point or marking group 1. similar numbered ticks are used for marking point or marking groups 2, 3, 4 etc.
	incorrect point or mark not awarded
	working towards marking point
	information missing or insufficient for credit
	used to highlight part of an extended response
	used to highlight part of an extended response
	allow or accept
	benefit of the doubt given

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Annotation	Meaning
BP	blank page
CON	contradiction in response, mark not awarded
ECF	error carried forward applied
GM	mark already given
I	incorrect or insufficient point ignored while marking the rest of the response
MAX	maximum number of marks for a marking point has been awarded
NBOD	benefit of doubt was considered, but the response was decided to not be sufficiently close for benefit of doubt to be applied
O	or reverse argument
R	incorrect point or mark not awarded
SEEN	point has been noted, but no credit has been given or blank page seen

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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)	*any **three** from:* **1** osmoreceptors detect (decrease) **or** osmoreceptors, shrink / decrease in volume **;** **2** *ref. to* hypothalamus **;** **3** hypothalamus produces (more) ADH **;** **A** neurosecretory cells produce ADH **R** secretion **4** <u>posterior pituitary</u> releases (more) ADH (into blood) **;** **A** secretes **R** produces	**3**
1(b)(i)	second(ary) messenger **;**	**1**
1(b)(ii)	adds aquaporins into, cell **surface** / luminal, membrane **;** (so) **more permeable** to water **;**	**2**
1(b)(iii)	arrow from lumen into cell **and** arrow from cell into capillary **or** one arrow from lumen through cell and into capillary **;**	**1**

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Question	Answer	Marks
1(c)	*any **two** from:* **1** no / less, water reabsorbed **or** no / less, water absorbed into, capillary / blood **;** **I** tissue fluid **2** water potential of **blood**, (remains) low / lower than set point **;** **3** large(r) **volume** of urine / **dilute** urine / low(er) **concentration** of urine **;** **I** amount / more water excreted / more urine **4** AVP **;** e.g. feelings of thirst / dehydration / dizzy / fatigue / ADH release continues / decreased blood volume	**2**

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Question	Answer	Marks
2(a)	*any **two** from:* *gene* **1** mutation of, *HTT* / huntingtin, gene **;** **2** *ref. to* dominant **or** only one, mutant / AW, allele, needed **or** heterozygote will have disease **;** **3** *ref. to* (more) CAG repeats **;** *plus any **three** from:* *protein* **4** non-functional / AW, huntingtin (protein) **;** *phenotype* **5** *idea of* cognitive / behavioural / personality / mood, changes **;** **6** coordination / movement, difficulties **;**	**4**
2(b)	**1** **only** males get the disease / females do not get the disease **;** **2** only males have a Y chromosome / males are XY **or** females, do not have a Y chromosome / only have (two) X chromosomes **;** **3** **all**, sons / male offspring, of affected, males / fathers, have the disease **or** **all** sons will not have the disease if father does not have the disease **;**	**3**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>2(c)</td><td>
parental genotypes X^AX^a x X^aY
and
gametes X^A X^a and X^a Y ;

correct offspring genotypes

<table>
<tr><td></td><td>X^A</td><td>X^a</td></tr>
<tr><td>X^a</td><td>X^AX^a

affected / AW female</td><td>X^aX^a

healthy / normal, female</td></tr>
<tr><td>Y</td><td>X^AY

affected / AW male</td><td>X^aY

healthy / normal, male</td></tr>
</table>
;

phenotypes linked to genotypes (see Punnet Square) ;

ratio of offspring phenotypes: 1 : 1 : 1 : 1 ;
</td><td>4</td></tr>
</table>

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Question	Answer	Marks
2(d)	*any **three** from:* **1** no repressor produced / no repressor binds to operator **or** altered / faulty, repressor produced **;** **2** (so) structural genes are, transcribed / expressed / switched on **;** **3** (structural gene) proteins / enzymes, produced **;** **4** (these) proteins / enzyme, damage cell / changes metabolism / causes disease **;** **5** altered repressor, binds more tightly / AW, to operator **;** **6** (so) structural genes, not transcribed / not expressed / switched off **;** **7** (structural gene) proteins / enzymes, not produced **;** **8** (so) lack of, protein / enzyme, causes, damage to cell / change to metabolism / disease **;**	**3**

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Question	Answer	Marks
3(a)(i)	*any **two** from:* q^2 = 0.068 **;** *q* = 0.260768 **;** *p* = 0.739232 **;** 2*pq* = 0.385536 **;** **and** **38.6 / 39** (%) **;**	**3**
3(a)(ii)	*any **two** from:* **1** migration / AW, occurs **or** population is not isolated **or** gene flow, in / out, of population **;** **2** no **random** mating **;** **3** *ref. to* mutations **;** **4** *ref. to* **selection** **;**	**2**

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Question	Answer	Marks
3(b)	*any **three** from:* **1** inbreeding **;** **2** low genetic diversity / small gene pool **;** **3** founder effect / bottleneck **;** **4** genetic drift **;** **5** tailless (cat) has a selective advantage / is selected for **; ora** **6** tailless **allele** is dominant **;** **7** **allele** frequency for tailless (phenotype) increases **;**	**3**
3(c)	*any **three** from:* **1** mutation results in (black) spots (phenotype / allele) **;** **2** selection pressure is, ability to catch prey / AW **or** individuals with spots, have a selective advantage / are selected for **; ora** **3** spotted (cheetahs), survive / reproduce **; ora** **4** spotted, allele / mutation, passed on (to offspring) **;** **5** spotted, allele / mutation, frequency increased **;**	**3**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(a)</td><td>
<table>
<tr><th>Kingdom</th><th>species may be unicellular</th><th>species may have cell walls</th><th>species may show autotrophic nutrition</th></tr>
<tr><td>Animalia</td><td>no</td><td>no</td><td>no</td></tr>
<tr><td>Fungi</td><td>yes</td><td>yes</td><td>no</td></tr>
<tr><td>Plantae</td><td>no</td><td>yes</td><td>yes</td></tr>
<tr><td>Protoctista</td><td>yes</td><td>yes</td><td>yes</td></tr>
</table>
; ; ; ;

one mark per correct row
</td><td>4</td></tr>
<tr><td>4(b)</td><td>A = metaphase I ;

B = telophase I ;
A anaphase I

C = anaphase II ;
A telophase II</td><td>3</td></tr>
</table>

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>4(c)</td><td>1. Bacteria and Archaea ;

plus any two from:

<table>
<tr><th></th><th></th><th>Bacteria</th><th>Archaea</th><th></th></tr>
<tr><td>2</td><td>cell wall</td><td>peptidoglycan</td><td>no peptidoglycan</td><td>;</td></tr>
<tr><td>3</td><td>cell membrane</td><td>ester-linked lipids / unbranched hydrocarbon chains</td><td>ether-linked lipids / branched hydrocarbon chains</td><td>;</td></tr>
<tr><td>4</td><td>spores</td><td>form spores</td><td>do not form spores</td><td>;</td></tr>
<tr><td>5</td><td>DNA associated proteins</td><td>no histones</td><td>have histones</td><td>;</td></tr>
<tr><td>6</td><td>ribosomal RNA / rRNA (base sequences)
or
ribosomes (structure)</td><td colspan="2">are different</td><td>;</td></tr>
</table></td><td>3</td></tr>
<tr><td>4(d)</td><td>any two from:

1 RNA or DNA ;

2 single-stranded or double-stranded (nucleic acid) ;

3 AVP ; e.g. how mRNA is produced / enveloped or non-enveloped / linear or circular / which diseases they cause / capsid shape</td><td>2</td></tr>
</table>

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Question	Answer	Marks
5(a)	*any **five** from:* *Allow any temperature within the ranges given* **1** denaturation at 90–98 °C **;** **2** breaks hydrogen bonds (in DNA) to, produce single strands / separate the (two) strands **;** **3** annealing at 50–65 °C **;** **4** (so that) primers, anneal / bind, (ss)DNA / complementary bases **;** **5** (to provide) binding site / starting point (for Taq polymerase) **;** **6** extension or elongation at 65–75 °C **;** **7** Taq polymerase joins, (free) nucleotides / dNTPs, to (single) strands **or** Taq polymerase synthesises, complementary / new, strand (of DNA) **;**	**5**

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Question	Answer	Marks
5(b)(i)	*any **four** from:* *bacteria = E.coli and virus = herpes simplex throughout* **1** extract / isolate / cut, DNA (sequences) using restriction enzyme **or** make DNA (sequences) using mRNA using reverse transcriptase **or** make DNA (sequences) using nucleotides **;** **2** use DNA ligase to join together (the two sequences of) DNA (of bacteria and virus) **;** **3** add promoter **;** **4** add, *tTav* / recombinant DNA / gene, to, vector / virus / liposome **;** **5** infect egg with virus **or** (micro)injection into egg **;** **A** gene gun / DNA gun **6** virus adds, *tTav* / recombinant DNA / gene, into genome (of egg / *A. stephensi*) **;**	**4**
5(b)(ii)	*any **one** from:* **1** *idea that* prevents, transcription factor, functioning / binding to promoter **;** **R** repressor proteins / operator **2** stops RNA polymerase from binding to, DNA / promoter **;**	**1**
5(b)(iii)	(genetically modified males) develop into adults / survive beyond the larval stage **;**	**1**

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Question	Answer	Marks
6(a)	*any **three** from:* **1** self-contained / functional / specific (unit) **;** **2** community / **all** species / **all** populations **;** **3** *ref. to* interactions **;** **4** abiotic / physical / non-living, **and**, biotic / biological / living, factors / environment **;** ***5*** *idea that* linked by, energy flow / mineral cycling / food webs / food chains / nutrient cycle **;**	**3**
6(b)	if individuals can breed to produce fertile offspring **;**	**1**
6(c)	*any **three** from:* **1** allopatric speciation **;** **2** geographical, isolation / barrier / separation **;** **3** (so) no gene flow (between populations) **;** **4** (populations have) different, mutations / advantageous alleles / alleles increase in frequency **;** **5** (populations have) different, selection pressures / environments **;**	**3**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>7(a)(i)</td><td>
oxygenated
1 percentage (of root tissue as aerenchyma), remains low ;

any two from:

deoxygenated
2 percentage (of root tissue as aerenchyma), increases gradually / small increase, initially / until 24 hours ;

3 percentage (of root tissue as aerenchyma), larger / steeper / more rapid, increase after 24 hours ;

4 percentage (of root tissue as aerenchyma), stays the same / is constant / plateaus / levels off / reaches maximum, at, the end / 48 hours ;

5 data quote ; two times and two percentages with units

<table>
<tr><th>time / h</th><th>percentage of root tissue as aerenchyma when deoxygenated</th></tr>
<tr><td>0</td><td>0.1 – 0.3</td></tr>
<tr><td>12</td><td>0.5 – 0.6</td></tr>
<tr><td>24</td><td>0.8</td></tr>
<tr><td>36</td><td>2.5 – 2.6</td></tr>
<tr><td>48</td><td>6.5 – 6.6</td></tr>
<tr><td>60</td><td>6.5 – 6.6</td></tr>
</table>
</td><td>3</td></tr>
<tr><td>7(a)(ii)</td><td>
1 (aerenchyma is a tissue) with many / more / large, air spaces ;

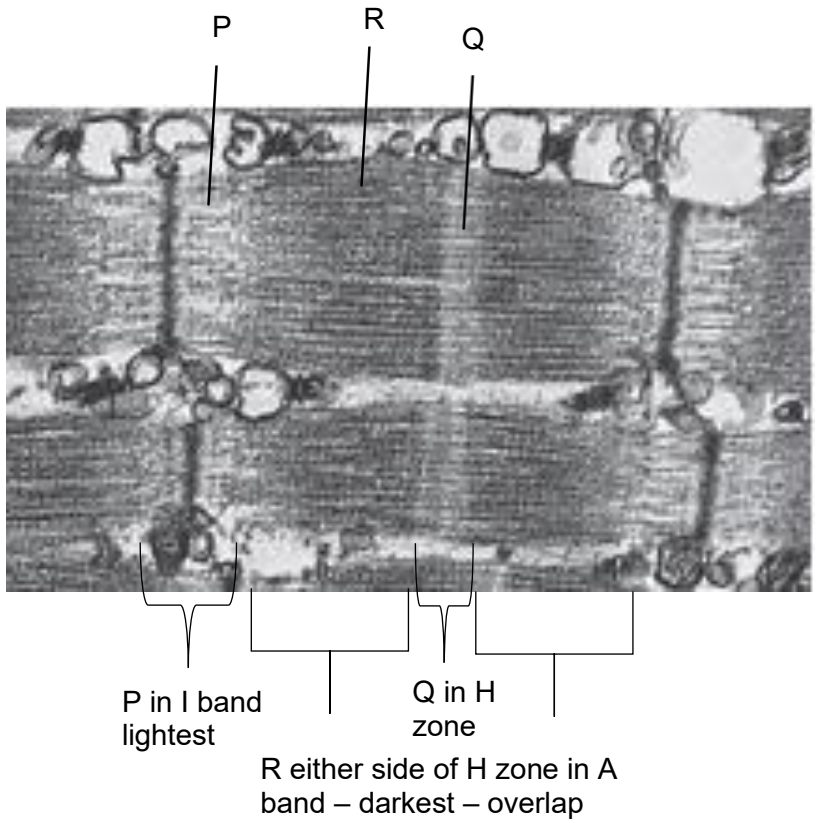
2 (so) <u>oxygen</u>, diffuses / moves, (from the aerial parts) to root (cells) / lower parts of the plant / AW ;

3 (for) <u>aerobic</u> respiration ;
</td><td>3</td></tr>
</table>

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Question	Answer	Marks
7(b)	*any **four** from:* **1** fast(er), stem / internode, growth **;** **2** (so) leaves / flowers, above water level **;** **3** (so) photosynthesis / gas exchange / reproduction, can occur **;** **4** (root cells) tolerant to (increased concentration of) ethanol **or** (root cells) have more ethanol dehydrogenase **;** **5** so, anaerobic respiration / ethanol fermentation, can occur **;** **6** AVP **;** e.g. leaves have ridges **7** AVP **;** e.g. to trap air (so oxygen can be taken in by plant)	**4**

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Question	Answer	Marks
8(a)	**P** to light area ; **A** on Z line **Q** to medium area ; **A** on M line **R** to darker area ;  	**3**

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Question	Answer	Marks
8(b)	*any **four** from:* **1** (at rest) tropomyosin, covers / AW, the binding sites on actin **;** **R** active sites **2** Ca^{2+} binds to troponin **;** **3** troponin changes shape **;** **4** (causing) tropomyosin to move **;** **5** (so) exposes binding site **;** **6** (so) myosin <u>head</u>, binds (to binding sites) / forms crossbridge **;**	**4**
8(c)	*any **two** from:* **1** no / less, Ca^{2+} **;** **2** no / less, ATP **;** **3** no / less, glucose / glycogen **;** **4** no / less, oxygen **;** **5** build-up / presence of, lactate / lactic acid **;** **6** AVP **;** e.g. no / less, creatine phosphate	**2**

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Question	Answer	Marks
9(a)	*any **seven** from:* **1** light absorbed by, chlorophyll / pigments (in PI and PII) **or** photoactivation of chlorophyll (in PI and PII) **;** **2** electrons, emitted (to higher energy levels) / excited, in **both** photosystems **;** **3** electrons pass along, electron transport chain / ETC / electron carriers **;** **4** detail **;** e.g. electrons releasing energy to pump H^+ into thylakoid, space / lumen *ref. to* proton gradient set up protons diffusing through ATP synthase **5** ATP synthesised from ADP and P_i / *ref. to* chemiosmosis **;** **6** (PII contains) oxygen-evolving complex **;** **A** water-splitting enzyme **7** *ref. to* photolysis (of water) **;** **8** oxygen **and** hydrogen ions **and** electrons produced **;** **A** $H_2O \rightarrow 2e^- + 2H^+ + ½O_2$ **9** electrons emitted from PI replaced by electrons from PII **or** electrons emitted from PII replaced by electrons from photolysis (of water) **;** **10** electrons (from PI) combine with H^+ to form reduced NADP **or** electrons (from PI) combine with NADP to form reduced NADP **or** electrons (from PI) combine with H^+ to form hydrogen that reduces NADP **;** **R** H^+ reduce NADP	**7**

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Question	Answer	Marks
9(b)	**1** increase in light intensity increases rate of photosynthesis until it levels off (at higher light intensities) **;** **2** (increase means) more, light dependent reaction / cyclic photophosphorylation / non-cyclic photophosphorylation / photoactivation **;** **3** (as rate levels off) carbon dioxide concentration / temperature, becomes limiting factor **or** light <u>intensity</u> is no longer a limiting factor **;**	**3**

Question	Answer	Marks
10(a)(i)	<u>molecules / moles / volume, carbon dioxide produced</u> molecules / moles / volume, oxygen taken in **;**	**1**
10(a)(ii)	25 **;**	**1**
10(a)(iii)	0.72 **;** **A** ecf 18 divided by their answer to ***10(a)(ii)***	**1**

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<table>
<tr><th>Question</th><th>Answer</th><th>Marks</th></tr>
<tr><td>10(b)</td><td>
any four from:

1 RQ (initially) at 1.0 as, carbohydrates / (named) sugar, respired / metabolised ;

2 RQ decreases (over time) as, carbohydrates / (named) sugar, running out / used up ;

3 RQ decreases (over time) as a mixture of carbohydrate and lipid respired ;
I proteins

4 RQ at, 0.65 / 0.7, as, fatty acids / fats / lipids, respired (as main respiratory substrate)
or
from 120 min onwards, fatty acids / fats / lipids, respired (as main respiratory substrate) ;

5 data quote ; RQ of 1.0 at 40 min plus any RQ value at any other time

<table>
<tr><th>Time after feeding / min</th><th>RQ ratio</th></tr>
<tr><td>40</td><td>1.0</td></tr>
<tr><td>80</td><td>0.75</td></tr>
<tr><td>120</td><td>0.7</td></tr>
<tr><td>160</td><td>0.65</td></tr>
<tr><td>200</td><td>0.7</td></tr>
<tr><td>240</td><td>0.7</td></tr>
</table>
</td><td>4</td></tr>
</table>

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