Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

May 2024

Biology

Higher level

Paper 3

27 pages

Subject Details: Biology HL Paper 3 Markscheme

Candidates are required to answer **all** questions in Section A and **all** of the questions from **one** option in Section B. Maximum total = **45 marks**.

1. Each row in the "Question" column relates to the smallest subpart of the question.

2. The maximum mark for each question subpart is indicated in the "Total" column.

3. Each marking point in the "Answers" column is shown by means of a semi colon (;) at the end of the marking point.

4. A question subpart may have more marking points than the total allows. This will be indicated by "**max**" written after the mark in the "Total" column. The related rubric, if necessary, will be outlined in the "Notes" column.

5. An alternative word is indicated in the "Answers" column by a slash (*/*). Either word can be accepted.

6. An alternative answer is indicated in the "Answers" column by "***OR***". Either answer can be accepted.

7. An alternative markscheme is indicated in the "Answers" column under heading ***ALTERNATIVE 1*** *etc*. Either alternative can be accepted.

8. Words inside brackets ( ) in the "Answers" column are not necessary to gain the mark.

9. Words that are <u>underlined</u> are essential for the mark.

10. The order of marking points does not have to be as in the "Answers" column, unless stated otherwise in the "Notes" column.

11. If the candidate's answer has the same "meaning" or can be clearly interpreted as being of equivalent significance, detail and validity as that in the "Answers" column then award the mark. Where this point is considered to be particularly relevant in a question it is emphasized by ***OWTTE*** (or words to that effect).

12. Remember that many candidates are writing in a second language. Effective communication is more important than grammatical accuracy.

13. Occasionally, a part of a question may require an answer that is required for subsequent marking points. If an error is made in the first marking point then it should be penalized. However, if the incorrect answer is used correctly in subsequent marking points then **follow through** marks should be awarded. When marking, indicate this by adding **ECF** (error carried forward) on the script.

14. Do **not** penalize candidates for errors in units or significant figures, **unless** it is specifically referred to in the "Notes" column.

Section A

Question			Answers	Notes	Total
1.	a		temperature;		1
1.	b		a. mass of urease powder; b. starting pH; c. volume of aqueous urea/urea solution; d. concentration of urea; e. reaction time;	*a, c, d. Do not accept 'amount'. Must use mass/weight, concentration, volume.* *If more than two variables are suggested, mark only the first two.*	2 max
1.	c		a. use smaller temperature increments to increase precision ***OR*** use smaller temperature increments to allow optimum temperature to be found; b. repeat measurements to improve reliability/calculate mean; c. use control without urease to show urease is catalysing the reaction ***OR*** use control without urea to show enzyme does not change pH on its own; d. measure pH at more time intervals to allow rate to be calculated;	*As this is an "explain" question a reason is required.* *OWTTE for all marking points.* *If more than two improvements are suggested, mark only the first two.*	2 max

Question			Answers	Notes	Total
2.	a	i	*research question (RQ) including independent (IV) / dependent variables (DV);*	*This does not have to be in the form of a question.*	**1**

Continued…

Question 2 continued

Question			Answers	Notes	Total
2.	**a**	**ii**	a. temperature of the environment ***OR*** same room/gym; b. time spent exercising/resting; c. time of day when the investigation is conducted; d. diet/food/drink/caffeine intake of the participants; e. level of fitness/participation in sport of the participants;	*Accept other reasonable variables but do not accept age or gender as these are given in the stem.* *If more than two controlled variables are suggested, mark only the first two.*	**2 max**
2.	**b**		a. signed consent form by participant/student/parent explaining investigation ***OR*** take steps to ensure confidentiality of data/data availability/access to data; b. questionnaire/interview on health status of participants / ensure all participants are healthy; c. responsible adult present/available; d. inform participants they can stop if they feel uncomfortable/unwell; e. check safety of equipment / participants wearing appropriate clothing;		**2 max**

Question			Answers	Notes	Total
3.	a		a. increase in growth rate; b. (increases) with both CO_2 alone and CO_2 combined with green algae; c. may not be significant as error bars (CO_2 alone and CO_2 combined with green algae) overlap ***OR*** significant increase compared to the natural environment/control;		**2 max**
3.	b		a. less competition in mesocosm; b. fewer organisms feeding on it; c. valid named factor may limit growth in their natural environment ***OR*** more carbon dioxide so more photosynthesis (in mesocosm);	*Accept converse* *Do not accept added nutrients* *c.* e.g. temperature variation/light/pollution	**1 max**
3.	c		a. pigments separated by chromatography; b. measure R_f values ***OR*** distance travelled by pigments; c. compare to standards (colour chart/R_f values);		**2 max**

Section B

Option A — Neurobiology and behaviour

Question			Answers	Notes	Total
4.	**a**		*Must have a similarity for full marks:* a. both male phenotypes elicit reproductive behaviour/digging/egg-laying in females; *Max 2 marks for differences:* b. females dig more (frequently) with jack than with hooknose; c. females spend more time egg-laying with jack than with hooknose; d. phenotypes differ more on digging than egg-laying (behaviour);		**3 max**
4.	**b**		a. strategy appears to work since females will spawn/mate with jacks; b. less energy invested in competition/fighting with other males; c. less obvious behaviour leading to less predation;		**1 max**
4.	**c**		(Presence of two phenotypes) ensures reproductive success (for the species) / reproduction occurs even when conditions vary/become unfavourable for one phenotype;	*Answer needs to make reference to reproduction.*	**1**

Question			Answers	Notes	Total
5.	**a**		positive correlation ***OR*** as body mass increases, brain mass increases;		**1**
5.	**b**		*1 mark for each function stated:* memory / language / speech / receive sensory input / learning / thinking / reasoning / planning / decision-making / voluntary or skeletal muscle control / emotions;	*If more than two functions are suggested, mark only the first two.*	**2 max**
5.	**c**		a. larger <u>proportion</u> of overall brain mass; b. more neurons/synapses; c. more extensive folding ***OR*** larger surface area;		**2 max**
5.	**d**		a. learning is acquiring a (new) skill/knowledge (through experience); b. memory is storing/encoding/accessing of (learned) information/knowledge;	*Accept reference to formation of new synapses /specific neural pathways/particular pattern of neuronal activity.*	**2 max**
5.	**e**		a. ability of the central nervous system to change over time ***OR*** neural organization changes with experience/exposure to stimuli; b. used neurons develop more/multiple synapses/become more interconnected; c. unused neurons/synapses do not persist/neural pruning;		**2 max**

Question			Answers	Notes	Total
6.	**a**		a. transmit sound waves/vibrations; b. amplify sound from outer ear;		**1 max**
6.	**b**		a. sound wave passed through cochlear fluid/cochlear fluid moves; b. receptors/hair cells attached to membrane (within cochlea); c. (sensory) hair cells vibrate and stimulate nerve endings; d. (hair cells) detect/resonate to different wavelengths/frequencies; e. nerve impulses transmitted via auditory/cochlear nerve; f. to brain for processing;		**3 max**
6.	**c**		a. (3) semicircular canals are at right angles/in different planes; b. movement of head causes fluid in different canals to move; c. moving/stimulating sensory hair cells; d. allows brain to deduce direction of movement;		**2 max**

Question			Answers	Notes	Total
7.	a		a. MDMA causes decrease in number of axons compared to control; b. (fewer axons) suggest serotonin production inhibited by MDMA; c. only partial recovery of axon numbers / continued low levels of serotonin after seven years;	*Accept long-lasting effect for only partial recovery.*	**2 max**
7.	b		*behavioural:* a. mood changes/feeling of euphoria/increased sociability ***OR*** detachment from reality/hallucinogenic effects; *physiological:* b. stimulates dopamine/serotonin/neurotransmitter release ***OR*** mimics the effect of natural stimulants;		**2**

Question			Answers	Notes	Total
8.			a. impulses transmitted between neurons across synapses; b. (presynaptic membrane) depolarization/arrival of action potential causes release of neurotransmitter; c. neurotransmitters may be excitatory or inhibitory; d. (neurotransmitters) diffuse across synapse/synaptic cleft / bind to receptors (in postsynaptic membrane); e. postsynaptic membrane responds to sum effect/summation of all neurotransmitters; f. nerve impulse generated (in postsynaptic neuron) if threshold potential reached; g. neurotransmitter (in synaptic cleft) broken down to prevent continuous synaptic transmission ***OR*** excess neurotransmitter reabsorbed; h. slow-acting neurotransmitters can affect groups of neuron ***OR*** slow-acting neurotransmitters release secondary messengers ***OR*** slow-acting neurotransmitters can modulate fast synaptic transmission; i. example of fast acting neurotransmitter e.g. acetylcholine / example of slow acting e.g. dopamine/serotonin/norepinephrine; j. psychoactive drugs affect brain by altering function of some synapses / by preventing breakdown of neurotransmitters / by mimicking action of neurotransmitters;		**6 max**

Option B — Biotechnology and bioinformatics

Question			Answers	Notes	Total
9.	**a**		a. DNA not present/mRNA not expressed in pre-treatment sample; b. distances of bands (after 32 days) correspond with marker band for DNA/mRNA; c. bright bands indicate presence of DNA/target gene/mRNA; d. increase in the DNA band indicates more gene is present/gene successfully replicated over time; e. increase in mRNA band indicates gene is being expressed/transcribed;		**3 max**
9.	**b**		a. increase in T-cells (overall); b. increase in T-cells producing/expressing surface protein; c. many cells not producing surface protein/producing low levels (similar to 1 month);		**2 max**
9.	**c**		a. target gene incorporated into viral DNA; b. (modified) viruses infect/enter host/target cells; c. Inserts the gene into host cells' chromosome/genome/DNA;		**2 max**

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>10.</td><td>a</td><td></td><td>a. temperature;
b. oxygen concentration/level;</td><td>Do not accept pH
If more than one variable is suggested, mark only the first one.</td><td>1 max</td></tr>
<tr><td>10.</td><td>b</td><td></td><td>a. substrate is used up so there is a lack of nutrients for growth/product formation;
b. inoculant/fermenting organism becomes less effective/senile over time;
c. waste products accumulate/pH/other chemical variable becomes less than optimum;</td><td></td><td>2 max</td></tr>
<tr><td>10.</td><td>c</td><td></td><td><table><tr><th></th><th>Continuous</th><th>Batch</th></tr><tr><td>a.</td><td>inoculant/microorganism can be added/refreshed</td><td>inoculant/microorganism only added at the start / it becomes less efficient (over time);</td></tr><tr><td>b.</td><td>substrate/medium/nutrients added on an ongoing basis</td><td>substrate/medium/nutrients is used up;</td></tr><tr><td>c.</td><td>product harvested throughout fermentation</td><td>product removed once/at end of process;</td></tr><tr><td>d.</td><td>metabolic waste removed continuously</td><td>waste products accumulate;</td></tr></table></td><td>Candidates do not need to answer this in a table format but must have both sides of the line to get the marking point.</td><td>2 max</td></tr>
</table>

Question			Answers	Notes	Total
11.	**a**		a. named example; b. advantage; *Example 1:* a. glyphosate resistance in soya plants; b. weeds can be controlled without damaging the crop/increase crop yield; *Example 2:* a. production of hepatitis B vaccine by tobacco plants; b. production of novel products in large quantities/lower cost;	*1 mark for named example and 1 mark for advantage.* *Look up examples to verify them.*	**2 max**
11.	**b**		a. uses a gene gun to inject DNA ***OR*** is a physical method of introducing genes (into plants); b. DNA is coated on inert metal/gold/tungsten; c. microparticle/microprojectile fired onto the surface of the leaf; d. high velocity so penetrates cell (wall); e. (recombinant) DNA taken up by cells; f. assimilated into chromosomes/chloroplast DNA/mitochondrial DNA;		**4 max**

Question			Answers	Notes	Total
12.	a		a. contain microorganisms/bacteria; b. cells held together by a carbohydrate/mucous matrix; c. have emergent properties/can resist antibiotics; d. exhibit quorum sensing/adapt to cell/population density;		**2 max**
12.	b		a. biofilms used on trickle filter beds / in secondary sewage treatment; b. (biofilm formation) ensures bacteria remain *in situ*/in large biomass/cover large surface area ***OR*** biofilms form on surface of rocks; c. digest organic matter / remove biodegradable matter/ metabolize some pollutants/oil/hydrocarbons;		**2 max**

Question			Answers	Notes	Total
13.			a. use DNA microarrays; b. metabolites that indicate the disease produced/released into/detected in blood/urine; c. cell surface proteins/markers may be distinguishable from healthy cells;		2 max

Question			Answers	Notes	Total
14.			a. sequence of amino acids determined for new protein; b. (large amount of) information easily accessed in databases; c. search database to see if sequence exists in another organism; d. BLASTp search used for amino acid/protein sequences; e. using sequence alignment software; f. (new) sequences compared to those with known function; g. finding a model organism narrows the search; h. model organisms have similar protein with similar genetic basis/code; i. coding nucleotide sequence can be established; j. target nucleotide sequence compared to different organisms using BLASTn;		6 max

Option C — Ecology and conservation

Question			Answers	Notes	Total
15.	**a**		amino acids/dipeptides/polypeptides/protein/nucleotides/polynucleotides/DNA/RNA;	*Award [1] for **two** types listed.*	**1**
15.	**b**		a. both (phenotypes) assimilate nitrogen ***OR*** both release ammonium and nitrate ***OR*** both release less ammonium than nitrate; b. red phenotype assimilated nitrogen more rapidly into tissues (than white) ***OR*** red phenotype released ammonium more rapidly/nitrate less rapidly;	*b. Accept converse.*	**2 max**
15.	**c**		a. converts nitrate (NO_3^-) to (molecular) nitrogen (N_2); b. carried out by (symbiotic) denitrifying bacteria; c. in low O_2 concentrations;	*c. Accept anaerobic conditions.*	**2 max**
15.	**d**		a. nitrogen-fixing bacteria provide usable source of nitrogen for coral ***OR*** nitrogen-fixing bacteria convert (molecular) nitrogen to ammonia; b. other/organic sources of nitrogen limited ***OR*** nitrate is soluble and easily lost so constant source needed; c. no light so no symbiotic autotroph/algae;	*a. Accept related nitrogenous compounds instead of ammonia.*	**1 max**

Question			Answers	Notes	Total
16.	**a**		a. other species as predators/food sources/competitors for resources; b. timing of feeding cycle / time when active; c. (timing of) life cycle; d. preferred breeding sites/microhabitats; e. tolerance to environmental chemicals/pesticides;	*If more than two differences are suggested, mark only the first two.*	**2 max**
16.	**b**		mosquitoes may migrate north / extend range / to areas occupied by *A. japonicus*;		**1**
16.	**c**		a. competition will result; b. competitive exclusion/one species will be replaced/become dominant; c. realized niches will change;		**2 max**
16.	**d**		*Benefits [max 2 marks]:* a. DDT kills/repels (adult) mosquitoes (and larvae); b. DDT prevents/reduces the spread of malaria; *Risks [max 2 marks]:* c. accumulation in (fat) tissues may harm humans ***OR*** have adverse human health effects; d. biomagnification (of DDT) higher up food chains damages organisms/top predators; e. is harmful to other useful insects; f. mosquitoes become resistant over time;	*For **[3 max]** at least one benefit and one risk needed* Accept example such as eggs of birds of prey.	**3 max**

Continued…

Question 16 continued

Question			Answers	Notes	Total
16.	**e**		a. persistent/accumulates in oceans; b. may be consumed/mistaken for food ***OR*** Laysan albatrosses feed plastic to chicks/chicks unable to regurgitate plastic; c. damages internal organs/intestines ***OR*** animals become entangled in plastic; d. degrades/broken into <u>microplastics</u> that can be toxic/ bioaccumulate;		**2 max**

Question			Answers	Notes	Total
17.	a		a. energy enters as organic matter in food/energy rich organic molecules; b. energy lost as heat/not all energy present in food will be converted to biomass; c. energy not cycled/constant supply needed; d. conversion of energy to biomass will depend on respiration rate; e. optimum conditions of temp/pH/O_2/other named condition needed for efficient energy transfer;		**3 max**
17.	b		a. may act as a food source for disease-causing/harmful bacteria/microorganisms; b. (excess food) chemically decomposed so reduces O_2/increases BOD; c. may escape into environment causing pollution/eutrophication;		**2 max**

Question			Answers	Notes	Total
18.			a. takes place outside original/natural habitat ***OR*** in artificial/controlled habitat; b. aimed at conservation of individual species; c. may involve captive breeding; d. followed by reintroduction; e. seed/gene banks/botanical gardens/zoos/research stations;		**3 max**

Question			Answers	Notes	Total
19.			a. fish stocks are sustainable when numbers extracted do not exceed numbers added; b. to avoid overfishing need to find size of population/fish stocks; c. sampling/monitoring techniques are used since cannot count entire population; d. example of sampling technique such as echo sounders / data from catches on number and age; e. age structure determined / find reproductive status of individuals / proportion of mature individuals compared to juveniles; f. more young fish shows population is growing ***OR*** more adults show population in decline; g. migration patterns/breeding grounds/breeding seasons must be considered; h. international cooperation/legislation on fishing needed; i. example of management such as licensing/ ban during breeding seasons/quotas;		**6 max**

Option D — Human physiology

Question			Answers	Notes	Total
20.	**a**		a. both groups show negative correlation / % saturation of hemoglobin with O_2 decreases as CO_2 increases ***OR*** both groups show wider range of values for % saturation of hemoglobin with O_2 as partial pressure of CO_2 increases; b. % saturation of hemoglobin with O_2 decreases more/more steeply in Australian players ***OR*** high altitude natives/Bolivian players generally have higher % saturation of hemoglobin with O_2 (at all partial pressures CO_2);		**2**
20.	**b**		a. in solution/dissolves in blood plasma; b. CO_2 transformed to hydrogencarbonate/HCO_3^- in red blood cells; c. (small quantity) CO_2 is carried by hemoglobin;		**2 max**
20.	**c**		a. controlled by medulla/respiratory control centre; b. chemoreceptors detect change in blood pH; c. change in partial pressure/concentration of CO_2 causes rate of ventilation to change; d. impulses from respiratory centre to diaphragm/intercostal muscles changes rate of contraction;		**2 max**

Question			Answers	Total	Notes
21.	**a**		a. (essential) amino acids; b. (essential) fatty acids; c. minerals;		**2 max**
21.	**b**		a. named essential nutrient; b. role of this nutrient;	*Example:* *a. vitamin D* *b. affects bone development* *Example:* *a. essential fatty acid/omega-3/omega-6/linolenic acid* *b. affects lipid metabolism/ formation of other compounds* *Verify example.*	**2**

Question			Answers	Notes	Total
22.	a		a. acid secretion lowers the pH of the stomach contents; b. low pH causes hydrolysis of some proteins/nutrients; c. optimum pH for some digestive enzymes/conversion of pepsinogen to pepsin;	*Do not accept destruction of pathogens as question asks specifically about digestion.*	**2 max**
22.	b		a. controlled by both hormones **and** nervous signals; b. hunger/sight/smell of food cause brain to send impulse/signals to release gastric juice; c. food in the stomach/chemoreceptors/stretch receptors initiate nerve signals (to the brain); d. nerve signal/vagus nerve stimulates release of gastrin; e. gastrin stimulates release of gastric juice / acid /pepsinogen;		**2 max**
22.	c		a. nutrient-rich blood from the small intestine carried directly to the liver ***OR*** liver receives blood from the hepatic portal vein ***OR*** regulation of nutrients takes place before blood travels to other parts of the body; b. excess glucose stored as glycogen ***OR*** liver breaks down glycogen to release glucose if levels too low; c. excess amino acids deaminated; d. storage of surplus (fat soluble) vitamins/vitamin A/D; e. cholesterol converted to bile ***OR*** liver synthesizes cholesterol if not enough in diet; f. iron stored/recycled from hemoglobin/heme/red blood cells;		**3 max**

Question			Answers	Notes	Total
23.	a		regulate heartbeat / ensure steady rhythm;		1
23.	b		closing of semilunar valves;		1
23.	c		a. cardiac muscle can conduct (electrical) signals; b. sinoatrial/SA node emits electrical signals/initiates impulse/is the pacemaker; c. impulses from SA node to all parts of atria cause atria to contract; d. when signal arrives at AV node signal is delayed; e. (Purkinje) fibres transmit signal to ventricular walls/apex; f. causes simultaneous contraction of ventricles;		3 max

Question			Answers	Notes	Total
24.			a. involved in the control of appetite/body temperature/thirst/circadian rhythms; b. controls secretion of some hormones by (anterior and posterior) pituitary;		2

<table>
<tr><th colspan="3">Question</th><th>Answers</th><th>Notes</th><th>Total</th></tr>
<tr><td>25.</td><td></td><td></td><td>
similarities:
a. both bring about changes in cell metabolism;
b. both carried by blood;
c. from endocrine gland
OR
to target organ/cells;
d. both (act by) binding to receptors;

differences:
<table>
<tr><th></th><th>Peptide hormone</th><th>Steroid hormone</th></tr>
<tr><td>e.</td><td>remains outside (target)cell</td><td>enters (target) cell;</td></tr>
<tr><td>f.</td><td>receptor in/on plasma membrane</td><td>receptor in cytoplasm/nucleus/cell;</td></tr>
<tr><td>g.</td><td>does not form complex inside cytoplasm</td><td>forms receptor-hormone complex inside cell;</td></tr>
<tr><td>h.</td><td>involves secondary messenger/cAMP</td><td>does not involve a secondary messenger/cAMP;</td></tr>
<tr><td>i.</td><td>activates cascade of reactions within cell
OR
activates/inhibits enzymes</td><td>regulates transcription;</td></tr>
</table>
</td><td>
For [6 max] at least one similarity and one difference needed.

A table is not required by the candidate for differences, but the information in both columns must be included for the mark.
</td><td>6 max</td></tr>
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