Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2024

Biology

Higher level

Paper 3

33 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) in the "Notes" column.

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		lactase/enzyme activity;		1
1.	b		chitin as it has higher lactase activity (at data points/values shown) ***OR*** chitosan for activity at low mass of lactase ***OR*** chitosan when no data for lactase;	*A reason must be provided to award the mark.*	1
1.	c		a. enzymes require an optimum temperature to work ***OR*** at temperatures higher/lower than optimal the enzymes work less/denature ***OR*** temperature is a controlled variable as it affects enzyme activity; b. change in shape of active site (due to temperature); c. higher temperature increases number of collisions (allows reaction);		2 max

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Question 1 continued

Question			Answers	Notes	Total
1.	**d**		a. product (concentration) ***OR*** glucose/ galactose (concentrations/rate); b. substrate (concentration) **OR** lactose (concentration);		**1 max**

Question			Answers	Notes	Total
2.	a		1 ml 0.150 M solution with 1ml water ***OR*** 1 part of 0.150 M solution with 1 part water **OR** equal volumes of 0.150 M NaCl and (distilled) water;	*Accept any other correct volumes;*	**1**
2.	b		a. red blood cells are hypertonic/more concentrated/have lower water potential/higher solute concentration (than distilled water)/*vice versa*; b. water moves into cells by <u>osmosis</u>; c. water moves from an area of higher water potential/concentration/ solution (in water) to lower water potential/concentration (in cell) ***OR*** water moves from a more dilute solution to a more concentrated solution ***OR*** water moves from hypotonic to hypertonic solution; d. through a (selectively) permeable membrane; e. cells swell and (eventually) burst/ complete/100% hemolysis;		**3 max**

Continued…

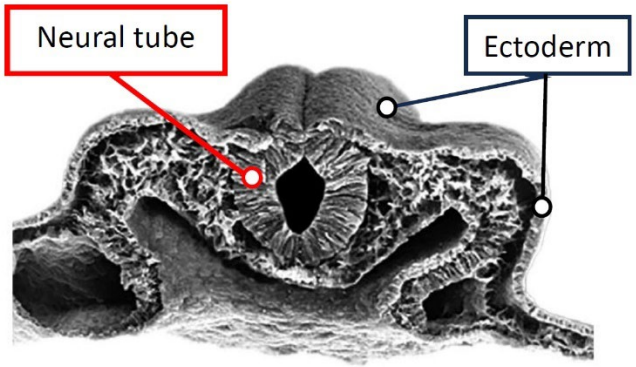
Question 2 continued

Question			Answers	Notes	Total
2.	**c**		0.150 M NaCl as no net water movement between RBC and the NaCl solution ***OR*** 0.150 M NaCl as hardly any hemolysis (yet);		**1**

Question			Answers	Notes	Total
3.	a		(β–) carotene;		1
3.	b		a. crush/blend algae with organic solvent/alcohol/other valid solvent; b. place drop of extracted algal pigments/ obtained liquid on thin layer ***OR*** mark the origin; c. place slide (with pigments) in solvent ensuring the pigment spot does not touch the solvent ***OR*** solvent moves up carrying pigments ***OR*** different pigments move at different rates/distances (so can be distinguished);	*Thin layer could be (chromatography) paper, slide, column, etc.*	3
3.	c		(Rf =) <u>distance pigment moved (from origin)</u> distance solvent moved (from origin) ***OR*** (Rf =) distance pigment moved (from origin) divided by distance solvent moved (from origin);		1

Section B

Option A — Neurobiology and behaviour

Question			Answers	Notes	Total
4.	a	i	label the neural tube (accept label extending into the black canal);	 [Source: Reproduced with the permission of UPV/EHU Press from Schoenwolf, G. (2018). Contributions of the chick embryo and experimental embryology to understanding the cellular mechanisms of neurulation. *Int. J. Dev. Biol.* 62, pp. 49–55. doi: 10.1387/ijdb.170288gs.]	1
4.	a	ii	label the ectoderm (on the surface or the outer layer of the cross section);		1
4.	b		a. (proliferation/mitosis of) cells of neural tube; b. differentiation/specialisation (leading to neurons) ***OR*** axons/dendrites develop from an immature neuron (in response to chemical stimuli); c. a developing neuron forms multiple synapses; d. immature neurons migrate to a final location;		**2 max**
4.	c		a. formation of new connections/synapses between neurons; b. pruning/elimination of synapses/ dendrites/ branches of axons /neurons; c. occurs after injury/stroke; d. other areas take over function of damaged areas/lesions;		**2 max**

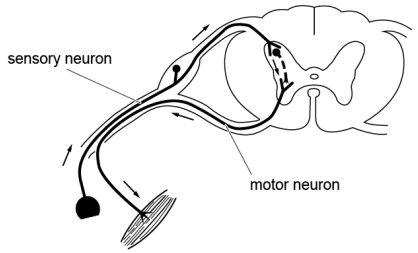
Continued…

Question 4 continued

Question			Answers	Notes	Total
4.	**d**		a. autonomic control; b. transports information from brain to spinal cord; c. (coordinates/regulates) swallowing / breathing / heart rate / other *valid example;*		**2 max**

5.	**a**		L Cone;		**1**
5.	**b**		a. difficulty seeing (different shades of) red, green (and yellow) objects / colours; b. pigment in L/red cones and M/green cones not functioning / missing/*OWTTE*; c. genes for red/green pigments carried on X chromosome / sex-linked; d. recessive inheritance; e. males have greater chances of inheriting the colourblind variant ***OR*** males have only one copy of the gene (while females have two);		**3 max**

Question			Answers	Notes	Total
6.	a		a. larger reward leads to greater change in pupil dilation/size (in both ON and OFF patients) ***OR*** positive relationship/correlation; b. larger mean change (pupil dilation/size) in the ON dopamine state for all reward levels /*vice versa*; c. difference between ON and OFF (dopamine) significant because error bars don't overlap/*OWTTE*;		**3**
6.	b		a. dopamine increases reward sensation/pleasure/euphoria/*OWTTE*; b. MDMA/ecstasy increases dopamine secretion (into synaptic cleft); c. prevents reabsorption in presynaptic neuron; d. more drug is taken to have the same effect;		**3 max**

Question			Answers	Notes	Total
7.	**a**		change in behaviour that involves forming new associations between stimuli ***OR*** learning to associate a neutral/conditioned stimulus with an unconditioned stimulus;		**1**
7.	**b**		*Similarities [2 max]* a. both young and old rabbits show improvement as more trials are done; b. both had similar results for the 600ms delay; c. all tend to plateau/level off; *Differences* d. young rabbits performed better than old rabbits when only 1 or 2 trials were done at both time delays; e. older rabbits performed worse than young in the 750 ms delay experiments/*OWTTE*;		**3 max**
7.	**c**	**i**	label any part of the motor neuron;	 [Source: Ruth Lawson Otago Polytechnic. https://commons.wikimedia.org/wiki/File:Anatomy_and_physiology_of_animals_A_reflex_arc.jpg. Licensed under CC BY 3.0 https://creativecommons.org/licenses/by/3.0. Image adapted.]	**1**
7.	**c**	**ii**	label any part of the sensory neuron;		**1**

Question			Answers	Notes	Total
8.			a. innate behaviour; b. mature salmon make journey back to (natal) river to reproduce; c. larger females have better nesting strategies/defend their nest better; d. males need to release sperm close to (egg-laying) female; e. many eggs are laid to increase chances of survival; f. different sized males have different breeding strategies; g. small-sized males are specialized at “sneaking” up to female; h. large-sized males are more likely to fight (other males); i. intermediate-sized males are at a competitive disadvantage ***OR*** intermediate-sized males are too small to fight and too large to sneak; j. breeding strategies lead to greater reproductive success;	*Mp f, g, h and i: size must be mentioned.* *Accept “jack” for mp g, and “hooknose” for mp h.*	**6 max**

Option B — Biotechnology and bioinformatics

Question			Answers	Notes	Total
9.	**a**		a. eubacteria/bacteria*;* b. archaea */* methanogens*;*		**1 max**
9.	**b**	**i**	a. number of microorganisms under microscope / haemocytometer; b. measuring OD / light absorption / reflection / with spectrophotometer; c. probe to measure cell density / number of cells; d. probe to measure gas pressure difference; e. probe to measure substrate concentration;	*Answer must include both method and variable.*	**1 max**
9.	**b**	**ii**	a. higher enzyme activity leads to more respiration; b. more respiration results in more energy; c. more energy for cell division/binary fission;		**2 max**
9.	**c**	i	(*pros: in favour of change in temperature*) a. 37 °C is optimum temperature so more microorganisms / so more biogas ***OR*** gain in yield due to higher growth rate ***OR*** gain in yield may be worth the extra energy cost; (*cons: against change in temperature*) b. (not much difference with 35 °C so) might be spending more energy than needed;		**2 max**

(Question 9 continued)

Question			Answers	Notes	Total
9.	**c**	**ii**	a. pH; b. waste/metabolic products; c. oxygen; d. CO_2; e. space; f. nutrients; g. substrate;	*Other valid factor;*	**1 max**
9.	**d**		*Compare* a. conditions/pH/temperature/foam/oxygen closely monitored in both; *Contrast [1 max]* b. batch is a closed system, continuous is an open system; c. batch has nothing added during the process, continuous has nutrients continuously added; d. batch has products removed at end of the process, continuous has products continuously removed;	*Comparative statements needed for marking point*. *Allow a statement such as 'only batch has….' provided contrasting words have been used.*	**2 max**

Question			Answers	Notes	Total
10.	a		a. organisms that have DNA that was added artificially to their genome; b. organisms that produce proteins that were not previously part of their species' proteome;		1 max
10.	b		a. sample 1 because there is no production of antigen/(m)RNA; b. leaves from plants that were not genetically modified because there is no production of antigen/(m)RNA;		1 max
10.	c		a. (recombinant DNA) introduced indirectly by vector; b. (vector is) Ti plasmid/tobacco mosaic virus/TMV; *Ti plasmid* c. from *Agrobacterium tumefaciens*/*A.tumefaciens*; d. marker genes/antibiotic used to indicate successful uptake; e. recombinant DNA introduced into whole plant / leaf discs / protoplasts; *TMV* f. modified tobacco mosaic virus used to infect plant; g. the plant produces the protein/antigen;	*Only award marks associated with the named vector in mp b.*	3 max

(continued…)

(Question 10 continued)

Question			Answers	Notes	Total
10.	**d**		a. electroporation; b. biolistic/gene gun; c. microinjection;	*Other valid example.*	**1 max**

Question			Answers	Notes	Total
11.	**a**		cooperative aggregate/colonies of microorganisms/bacteria (that fix on surface);	*OWTTE*	**1**
11.	**b**		a. clogging/corrosion of pipes; b. transfer of microorganisms in ballast water; c. contamination of surfaces in food production; d. diseases such as cystic fibrosis/pneumonia; e. presence in catheters; f. plaque on teeth; g. *other valid example;*		**2 max**
11.	**c**		a. antibiotic cannot penetrate biofilm ***OR*** EPS/extracellular polymeric substance does not allow antibiotic to enter; b. high activity under the EPS could show that antibiotics have no effect/cannot penetrate ***OR*** high metabolic activity of cells/bacteria could represent the breakdown of the antibiotics ***OR*** low activity or dormant means low or no cell division ***OR*** low activity or dormant means antibiotic has no effect; c. quorum sensing allows synchronized gene expression (of resistance);		**2 max**

Question			Answers	Notes	Total
12.	**a**		a. BLASTn/Clustal (omega) W/ Coffee/software used to find regions of similarity between nucleotide sequences; b. program displays sequences alongside each other (sequence alignment); c. program highlights identical areas;		**2 max**
12.	**b**		a. (number of differences:) 11; b. 11 / 1062 x 100 = 1.03 *(%)* (difference);	*Award one mark for mentioning 11.* *Mp b: Allow ECF if mp a is incorrect.*	**2 max**

Question			Answers	Notes	Total
13.			a. disease caused by deficiency of adenosine deaminase/ADA; b. (ADA is) enzyme involved in purine/adenosine metabolism; c. retrovirus/vector is genetically modified to contain functional (ADA) gene; d. ADA defective lymphocytes are removed from SCID patient; e. cells infected with retrovirus / vector; f. functional gene is inserted in immune/stem cells; g. cells/lymphocytes selected (for a functional ADA); h. lead to a functional lymphocytes / OWTTE;		**6 max**

Option C — Ecology and conservation

Question			Answers	Notes	Total
14.	**a**		*Stigeoclonium farctum / S. farctum;*		**1**
14.	**b**		a. eutrophication; b. algal bloom/algae proliferate ***OR*** algae/plants die ***OR*** bacteria proliferate; c. loss of oxygen due to bacterial activity (on the dead organic matter/sewage) ***OR*** increase in the biochemical oxygen demand/BOD; d. animals/fish die;		**3 max**
14.	**c**		a. *Cocconeis placentula;* b. as was present before the sewage discharge but absent after ***OR*** as do not tolerate anoxia ***OR*** as sensitive to pollution;	*OWTTE*	**2 max**

Question			Answers	Notes	Total
15.	**a**		a. parasite/tapeworm obtains its foods from more than one organism/host ***OR*** parasite/tapeworm belongs to more than one trophic level; b. hosts are at different trophic levels ***OR*** hosts can be primary, secondary or tertiary consumers;	*OWTTE* *Mp a is about parasites.* *Mp b is about hosts.*	**2 max**
15.	**b**		biomass as it is the main/larger store in tropical rain forests ***OR*** biomass as there is little/less store in deserts ***OR*** biomass in desert has large/greater flow leaving (to litter)/OWTTE;		**1 max**

Question			Answers	Notes	Total
16.	**a**		number of different species present;		**1**
16.	**b**		*Yes, as* *a.* high richness shows a positive correlation / vice versa; b. at high richness, the crop yield increases (as visits to flowers / high density increases) /vice versa; *No, as **[2 max]*** c. yield similar at low visitor density in both cases; d. (mean/overall) yield (slightly) higher at low visitor density with low richness; e. scattered data points / outliers make for a weak correlation/*OWTTE*; f. doesn't take crop species/weather/soil into account;	*Mp f: accept other valid variables.*	**3 max**

Question			Answers	Notes	Total
17.	**a**	**i**	diatoms;		**1**
17.	**a**	**ii**	a. with snails there is a smaller change in volume overall (than without snails) /vice versa; b. green algae don't change (much); c. with snails, change of diatoms decreases (greatly) / vice versa; d. with snails the change in blue-green bacteria decreases/half the change (than without snails);		**2 max**
17.	**a**	**iii**	a. bottom up by nutrients and top down by herbivorous snails; *Top-down* b. presence of snails reduces the overall change in volume; c. presence of snails has the greatest effect on the change of volume in diatoms; *Bottom-up* d. adding nutrients increases the overall change in volume; e. greatest (bottom up) effect when no snails are present;		**3 max**

Continued…

Question 17 continued

Question			Answers	Notes	Total
17.	**b**		a. mining/rock; b. detergents; c. fertilizers/manure; d. decomposition / saprotrophs;		**2 max**
17.	**c**	**i**	a. bacteria / archaea / *Azotobacter* / another named organism; b. convert atmospheric nitrogen to ammonia; c. some nitrogen-fixing bacteria have <u>symbiotic</u> relationships with plants / legumes ***OR*** *Rhizobium* associates with roots in a <u>mutualistic</u> relationship; d. nitrates result from lightning;	*Mp a: Accept Nitrobacter.*	**2 max**
17.	**c**	**ii**	process by which nitrates/nitrites (in soil) are transformed into atmospheric nitrogen in the absence of oxygen/anaerobic conditions;	*Allow chemical formula*	**1**

Question			Answers	Notes	Total
18.			a. (several species of) mosquitoes/*Anopheles* are vectors of / transmit malarial parasite/*Plasmodium*; b. DDT is an insecticide used to kill mosquitoes; c. DDT sprayed on water where mosquito larvae live / where mosquitoes breed ***OR*** DDT sprayed on walls and ceilings to repel mosquitoes; d. DDT use very effective in decreasing deaths from malaria ***OR*** malaria became less common where DDT was used /*OWTTE*; e. DDT (persists in environment so) is positive for control of malaria; f. DDT is fat soluble ***OR*** DDT accumulates in fatty tissues; g. DDT is biomagnified ***OR*** DDT increases up the food chain / in top carnivores; h. birds of prey (accept name such as osprey) have thinner eggs so they become frail can break easily ***OR*** failure of birds of prey to reproduce ***OR*** kill/harm beneficial species/pollinators; i. DDT persists in environment (so is negative for environmental concerns);		**6 max**

Option D — Human physiology

Question			Answers	Notes	Total
19.	**a**		a. altrono-(lactone); b. once injected the amount of vitamin C remains the same / does not increase /decreases (slightly) ***OR*** no peak after injection;		**2**
19.	**b**		a. humans have lost GULO gene (over the course of evolution); b. humans do not synthesize ascorbic acid / vitamin C ***OR*** it is an essential nutrient; c. prevents scurvy; d. synthesis of collagen ***OR*** antioxidant/cofactor **OR** contributes to immune system;		**2 max**

Question			Answers	Notes	Total
20.	**a**	**i**	hepatic <u>portal</u> vein;	*Accept hepatic <u>portal</u> vein on diagram properly labelled **AND** identified as (i).*	**1**
20.	**a**	**ii**	hepatic artery;	*Accept hepatic artery on diagram properly labelled **AND** identified as (ii).*	**1**

Continued…

Question 20 continued.

Question			Answers	Notes	Total
20.	**b**		a. cancer; b. cirrhosis; c. liver disease/failure / hepatitis; d. bilirubin buildup ***OR*** pancreatic/bile duct obstruction;	*Do not accept alcohol consumption.*	**1 max**
20.	**c**		a. both O_2 and CO_2 bind (reversibly) to hemoglobin; b. carries oxygen as oxyhemoglobin (in RBC) ***OR*** carries carbon dioxide as carboxyhemoglobin; c. binding of oxygen to hemoglobin increases affinity of hemoglobin for oxygen; d. lower pO_2 decreases the affinity for O_2/vice versa; e. fetal hemoglobin has greater affinity for oxygen than adult hemoglobin;		**2 max**

Question			Answers	Notes	Total
21.	**a**	**i**	pH in arteries is higher/less acidic;	*Accept vice versa.*	**1**
21.	**a**	**ii**	a. venous blood carries more carbon dioxide than arterial blood/*vice versa*; b. carbon dioxide in plasma/blood forms carbonic acid ***OR*** H_2CO_3 dissociates into H^+ and HCO_3^-;		**2**
21.	**b**		chemoreceptors;		**1**
21.	**c**		increased exercise lowers blood pH / inversely proportional;		**1**

Continued…

Question 21 continued

Question			Answers	Notes	Total
21.	**d**		a. more CO_2 concentration in blood due (increased) respiration/exercise ***OR*** high blood CO_2 concentration lowers pH; b. (high CO_2 concentration/low pH) lowers the affinity of hemoglobin for oxygen; c. the dissociation curve moves to the right; d. oxygen is more easily dissociated from hemoglobin; e. cells receive the oxygen they need;	*Accept answers in an annotated diagram.*	**3 max**

Question			Answers	Notes	Total
22.	**a**		the time delay allows time for the atria to pump the blood that they are holding into the ventricles;	*OWTTE*	**1**
22.	**b**		a. ventricular systole <u>and</u> diastole; b. QRS wave is ventricular systole/contraction/depolarisation; c. T-wave is ventricular diastole/relaxation/repolarisation;		**2**
22.	**c**		underweight <u>and</u> severely obese;		**1**
22.	**d**		a. overweight patients had lowest risk of CHD ***OR*** obesity has slightly higher risk than normal weight ***OR*** severe obesity has highest risk; b. high levels of fat usually increase chances of CHD in obese/overweight ; c. high blood pressure/atherosclerosis can contribute to CHD; d. error bars/SD too large to arrive to conclusion;	*OWTTE* *Mp c: accept other valid factors.*	**2 max**
22.	**e**		a. <u>type 2</u> diabetes; b. hypertension;	*Other valid example.*	**1 max**

Question			Answers	Notes	Total
23.			a. pituitary (gland) is under control of the hypothalamus; b. oxytocin and prolactin are produced under positive feedback; *Oxytocin* c. oxytocin is produced by the hypothalamus; d. (synthesis occurs) in neurosecretory cells; e. oxytocin is stored in / secreted by the posterior pituitary (gland); f. breastfeeding/suckling by an infant stimulates oxytocin release; g. oxytocin regulates the release of the milk; *Prolactin* h. prolactin is produced/secreted by the anterior pituitary (gland); i. breastfeeding/suckling (by infant) stimulates production of prolactin; j. prolactin stimulates mammary glands to grow ***OR*** prolactin stimulates the production of milk;		**6 max**