

Mark Scheme (Results)

Summer 2022

Pearson Edexcel GCE
In Biology (9BI0)
Paper 3: General and Practical Principles in Biology

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question Number	Answer	Additional Guidance	Mark
1(a)(i)	resting potential (1)		**(1)**

Question Number	Answer	Additional Guidance	Mark
1(a)(ii)	A description including four of the following • {sodium / Na} channels open (1) • sodium **ions** flow into {axon / cell / neurone} (1) • this causes depolarisation (1) • {sodium / Na} channels close at {0.8ms / 30mV} (1) • {potassium / K} channels open at {0.8ms / 30mV} (1)		**(4)**

Question Number	Answer	Additional Guidance	Mark
1(b)	An answer that includes the following • there is no action potential until the stimulus is greater than 45 (mV) (1) • this is the threshold value (1)	Accept range between 45-55 (mV) / 46 -55 (mV) Accept threshold potential / threshold voltage	**(2)**

Total for Question 1 = 7 marks

Question Number	Answer	Additional Guidance	Mark
2(a)(i)	Calculation of number of dividing cells (1) Calculation of mitotic index (1)	8 8.2 / 8.16 (%) Correct answer with no working gains 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(a)(ii)	An explanation that includes the following • as distance (from root tip) increases, mitotic index decreases (1) • (because) cells {differentiate / become specialised / elongate} further from the root tip (1)	 Allow negative correlation between mitotic index and distance from root tip Accept converse Accept {meristem / stem cells} are close to tip	**(2)**

Question Number	Answer	Additional Guidance	Mark
2(b)	An answer including two of the following: • use {strong / concentrated} acid to {break down middle lamella / break down pectins / separate layers of cells} (1) • heat to intensify effect of {acid / stain} (1) • press (on cover slip) to form a single layer of cells (1) • view at high power to see details (of chromosomes) (1)	 Accept use of standardised length of root tip to ensure you include just the dividing area Accept view at high power to see chromosomes (clearly)	**(2)**

Total for Question 2 = 6 marks

Question Number	Answer	Additional Guidance	Mark
3(a)(i)	A description that includes the following: • tube (containing hydrogencarbonate indicator in light) with no gel beads (1) • tube (containing hydrogencarbonate indicator and gel beads) in light-proof cover (1)	Accept tube (containing only hydrogencarbonate indicator in light) with no algae Accept tube (containing hydrogencarbonate indicator and gel beads) in the dark	**(2)**

Question Number	Answer	Additional Guidance	Mark
3(a)(ii)	An explanation that includes three of the following: • {at 5cm and 15cm / at high light intensity / close to lamp} (indicator is purple) there is more photosynthesis, so carbon dioxide being taken in (1) • (at 5 and 15cm) there is more photosynthesis than respiration so net uptake of carbon dioxide (1) • at 25cm (indicator is red) the carbon dioxide used in photosynthesis equals the carbon dioxide produced in respiration (1) • {at 35 or 45cm / at low light intensity / far from lamp} (indicator is orange) there is more respiration than photosynthesis, so {carbon dioxide released / more carbon dioxide is present} (1)	Allow ref to LDR or carbon fixation for photosynthesis Accept at 5 and 15 cm light is not a limiting factor for photosynthesis, so carbon dioxide is taken in. Accept converse Accept reference to compensation point Accept rate of photosynthesis equals rate of respiration Accept there is less light for photosynthesis so less carbon dioxide is used than is produced in respiration Accept net increase in carbon dioxide linked to photosynthesis and respiration	**(3)**

Question Number	Answer	Additional Guidance	Mark
3(b)	A description that includes three of the following: • **Up to two examples** of standardisation (2) **and** **a maximum of two from**: • set up a reference set of solutions at different carbon dioxide concentrations (1) • compare by {colour matching / using a colorimeter} (1) • time taken for gel beads to rise {a known distance / to the surface of the tube} (as oxygen is being produced in photosynthesis) (1)	eg equal volume of (sodium hydrogencarbonate) indicator / equal {number of gel beads / mass of algae / mass or volume of beads} / same temperature Accept control as eq to same Accept measurement of {position of / distance moved by} gel beads in tube	**(3)**

Total for Question 3 = 8 marks

Question Number	Answer	Additional Guidance	Mark
4(a)	An answer that includes the following: Feature: shape (of abdomen / body) • pointed in female, rounded in male (1) OR Feature: banding pattern (on abdomen) • five bands on female, three bands on male / more bands on female (1)	Refer to both or use a comparative term Accept longer in female / shorter in male Accept description of pattern eg 2 narrow bands and one wide in male and five narrow in female / spots on female / dark tip on male	**(1)**

Question Number	Answer	Additional Guidance	Mark
4(b)(i)	An answer that includes the following: • genetic diagram showing (parents), gametes and genotypes of offspring (1) • ratio of **named phenotypes** of offspring (1)	Accept any letter with upper and lower case symbol eg Gg, not Gb / GB 3 grey (bodied) : 1 black (bodied) 75% grey (bodied) : 25% black (bodied) ¾ grey (bodied) : ¼ black (bodied)	**(2)**

Question Number	Answer	Additional Guidance	Mark
4(b)(ii)	An answer that includes the following: • each parent produces four types of gametes; LA, La, lA, la (1) • correctly laid out Punnett square (1) • ratio of **named phenotypes** given (1)	 Accept 4 x 4 grid with gametes shown and 16 cells 9 Long winged, normal antennae (accept 9/16) 3 long winged, bushy antennae (accept 3/16) 3 vestigial winged, normal antennae (accept 3/16) 1 vestigial winged, bushy antennae (accept 1/16)	**(3)**

Question Number	Answer	Additional Guidance	Mark

4(b)(iii)	An explanation that includes the following: • gene for eye colour is sex linked (1) • females have two alleles for eye colour and males have only one (1) • cross 1: Parents are RR / $X^R X^R$ rY / X^r Y (1) • cross 2: Parents are rr / $X^r X^r$ RY / X^R Y (1)	Accept gene for eye colour is only on X chromosome Accept from diagram Accept allele for eye colour is sex linked Accept description or symbols in genetic diagram eg RR and RY / $X^R X^R$ and X^R Y Accept as part of answer for mp3 or 4 Accept males have one X chromosome, females have two and gene for eye colour is on X chromosome	**(4)**

Total for Question 4 = 10 marks

Question Number	Answer	Additional Guidance	Mark
5(a)	• length of pollen tube measured from photo (1) • magnification calculated (1)	Example calculation Length = 33 (mm) Accept 31 – 34 (mm) / 3.1 – 3.4 (cm) Magnification = $\frac{\text{photo size}}{\text{actual size}} = \frac{33\,000}{136}$ = 243 / 242.7 / 242.65x Accept values in the range 227.9 to 250.0 x Do not accept units Correct answer with no working gains 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(i)	A: generative nucleus (1) B: (pollen) tube nucleus (1)		**(2)**

Question Number	Answer	Additional Guidance	Mark
5(b)(ii)	A description including three of the following • {one male nucleus / one male gamete} fuses with the two polar nuclei • to form a {triploid / 3n} nucleus (1) • {one male nucleus / one male gamete} fuses with the {egg cell / ovum / female gamete / female nucleus} • to form a {diploid / 2n} zygote (1)	Do not accept polar bodies Do not accept fertilises Accept triploid endosperm **nucleus** Accept fertilises	**(3)**

Question Number	Answer	Additional Guidance	Mark
5(c)	An answer that includes five of the following: • at least 5 different pH values tested (1) • sucrose solution added (1) • suitable time before pollen tube measured (1) • method of measurement of pollen tube with a microscope described (1) • method of calculation of rate of growth (1) • method of control of one relevant variable (1) • a repeat at each pH and calculate {mean / standard deviation} (1)	If intervals eg every 10 minutes or single measurement. If single measurement must be minimum of 30 mins and max of 24 hours eg use of stage micrometer and {graticule / scale bar} / calibrated graticule eg length divided by time / gradient on a graph eg. (temperature) – use of waterbath / incubator sucrose concentration – described / named (humidity) - environmental chamber / lid on petri dish / coverslip on cavity slide (species) of flower – collect from same flower / plant (ripeness of pollen) – collect from same anther mineral salt concentration – stock solution / named	**(5)**

Total for Question 5 = 12 marks

Question Number	Answer	Additional Guidance	Mark
6(a)	An explanation that includes four of the following: • collection acts as a selection pressure (1) • (random) mutation (in gene) for pigment / colour (1) • greyish brown plants are less likely to be {collected / found} as harder to see (1) • more likely to reproduce, passing on new **allele** (1) • **allele** frequency increases (1)	Accept collection of plants results in natural selection Accept genetic variation for colour exists (in population) Accept greyish brown plants {better camouflaged / blend in} so not picked Accept converse for brightly coloured plants Accept more likely to pass on allele to offspring Accept converse for brightly coloured plants Accept allele increases in gene pool Accept converse for brightly coloured plants	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(b)(i)	A description that includes four of the following: • obtain DNA (from the two types of plants) (1) • use of {restriction enzymes / endonuclease} to cut DNA into fragments (1) • {DNA / fragments} (loaded) on (agarose) gel with {current passed through / voltage or potential difference applied} (1) • fragments (of DNA) are separated (1) • {same / similar} (banding) pattern suggests they are the same species (1)	Accept use of PCR to amplify DNA Accept use of {taq / DNA} polymerase to sequence DNA Accept movement of (negatively charged) DNA moves to positive electrode Accept description / diagram of banding pattern Accept shorter fragments travel further Accept converse Accept {same / similar} sequence suggests they are the same species	**(4)**

Question Number	Answer	Additional Guidance	Mark
6(b)(ii)	An explanation that includes two of the following: • (if leaf is green it contains) chlorophyll / photosynthetic pigments (1) • so more light absorbed for photosynthesis (1) • so more glucose produced for growth (1) **OR** • (if flower is brightly coloured) it attracts {pollinators / insects} (1) • so (more likely to) reproduce (successfully) (1) • to produce seeds / pass trait on (1)	Accept more wavelengths of light absorbed for photosynthesis Accept more light absorbed leads to higher rate of photosynthesis Accept more GALP / TP / GP for growth Accept so increased genetic variation (as less self-pollination) Accept asexual reproduction (through bulb) still possible if pollination does not occur	**(2)**

Total for Question 6 = 10 marks

Question Number	Answer	Additional Guidance	Mark
7(a)(i)	A description that includes three of the following: • moved {across membrane / into cell / into root} by carrier proteins (1) • against a concentration gradient (1) • using ATP (1)	 Ignore channel proteins Accept from a low to a high concentration	**(3)**

Question Number	Answer	Additional Guidance	Mark
7(a)(ii)	A description that includes the following • suitable mineral ion named (1) • appropriate function given (1)	 eg **nitrate / (ammonium)** – formation of amino acids / proteins / enzymes / nucleic acids / nucleotides / DNA / RNA / chlorophyll **phosphate** – formation of nucleotides / nucleic acids / DNA / RNA / ATP / ADP / amino acids **calcium** – formation of middle lamella / calcium pectate **magnesium** – formation of chlorophyll Accept other correct mineral ions with correct functions	**(2)**

Question Number	Answer	Additional Guidance	Mark
7(b)(i)	there is no difference in the (mean) height of {*Galium verum* / Lady's bedstraw} growing in meadows and dunes (1)	Accept no significant difference in the (mean) height of {*Galium verum* / Lady's bedstraw} growing in meadows and dunes	**(1)**

Question Number	Answer	Additional Guidance	Mark
7(b)(ii)	An answer that includes the following: • use of random numbers to select sampling site (1) • use of (frame or point) quadrat (to define sampling area) in meadow and dune (1) • measurement of {height / length} of {*Galium verum* / Lady's bedstraw} (1) • large sample size or use of running mean (1) • attempt to control relevant named variable (1)	Accept description of setting up grid and using co-ordinates for random sampling Accept closest plant to point selected in meadow and dune eg at least 10 plants in each place eg shading / slope / grazing / trampling / time of year / use of herbicide Ignore soil type / pH / temperature / time of day	**(5)**

Question Number	Answer	Additional Guidance	Mark
7(b)(iii)	An explanation that includes the following • t-test (1) • (because it) tests for the difference between the means of two sets of values (1)	Accept other suitable test eg Mann Whitney U test Accept it tests for a (significant) difference between two sample sets	**(2)**

Total for Question 7 = 13 marks

Question Number	Answer	Additional Guidance	Mark
8(a)	An explanation that contains three of the following: • higher **kinetic** energy so more enzyme-substrate complexes formed (1) • at very high temperatures the rate decreases due to **denaturation** (1) • because of bond changes in the enzyme altering the **active site** (1) • so substrate no longer fits **active site** (and rate of product formation decreases)	Accept higher kinetic energy increases number / rate of collisions (between enzyme and substrate) Accept at temperatures above the optimum the rate decreases due to denaturation Accept changes to tertiary structure change the shape of the active site Accept bonds break in the enzyme altering the active site Do not accept peptide bonds Accept substrate no longer complementary to active site	**(3)**

Question Number	Answer	Additional Guidance	Mark
8(b)(i)	A description including two of the following variables with suitable methods of control: • appropriate named variable (1) • description of how the variable is controlled (1) • appropriate named second variable (1) • description of how second variable is controlled (1)	eg • volume of hydrogen peroxide / accept stated volume - measuring cylinder / syringe / pipette (to measure same volume) • concentration of hydrogen peroxide / accept stated concentration – dilute / make up solution to same % concentration / use of stock solution • temperature / accept stated temperature - flask in **thermostatically controlled** waterbath / accept descriptions • pH / accept stated pH – buffer (in flask)	**(4)**

Question Number	Answer	Additional Guidance	Mark
8(b)(ii)	Initial rate of reaction calculated (1)	Answer uses **seconds** 0.33 cm^3 s^{-1} **Accept:** values in range: 0.28 to 0.35 cm^3 s^{-1} **Accept:** cm^3 /s ; cm^3 per second Answer uses **minutes** 19.8 cm^3 min^{-1} **Accept:** values in range 16.8 to 21.0 cm^3min^{-1} **Accept**: cm^3 /min ; cm^3 per min	**(1)**

Question Number	Answer	Additional Guidance	Mark
8(b)(iii)	An explanation including the following • {hydrogen peroxide / substrate / reactant} is {converted to products / used up} (1) • so less substrate to collide with the enzyme (1)	Accept {hydrogen peroxide / substrate / reactant} becomes a limiting factor Accept concentration of {hydrogen peroxide / substrate / reactant} decreases Accept less substrate so fewer enzyme-substrate complexes form	**(2)**

Question Number	Answer	Additional Guidance	Mark
8(c)	An explanation including the following • (as more potato is added) more oxygen is produced because more {enzyme is / active sites are} present (1) • (as more potato is added) increase in volume of oxygen is expected as surface area increases (1) • (as more cubes are added) {volume of oxygen produced / graph / rate of reaction} may level off as substrate {is not in excess / is used up} (1)	Accept rate of reaction would increase because there is more enzyme available Accept increased rate of reaction is expected as surface area increases Accept at a higher number of cubes, concentration of hydrogen peroxide may be a limiting factor	**(3)**

Total for Question 8 = 13 marks

Question Number	Answer	Additional Guidance	Mark
9(a)	An answer including at least one similarity • both tissues contain tubes (1) • both have cell walls containing cellulose (1) **<u>and</u>** at least one difference • xylem vessels contain lignin, but phloem does not (1) • in xylem, end walls of cells break down completely (to leave hollow tubes), but in phloem there are sieve plates (1) • phloem (sieve tubes) have companion cells, but xylem does not (1) • phloem (sieve tubes) contains cytoplasm, but xylem does not (1)	Accept both have vessels which are cylindrical Accept xylem has thicker walls / xylem vessels have pits in (side) walls and phloem does not Accept phloem has sieve plates, but xylem does not Accept phloem contains plasmodesmata but xylem does not / phloem contains organelles but xylem does not	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(i)	A calculation that shows the following stages • manipulation of units (to mm) (1) • calculation of volume of cylinder (1) • rate per minute calculated to 2sf (1)	Example of calculation: eg mean is 64 (mm) 4.522 / 4.524 (this gets mp1 and 2 if 64 not seen) 0.90 Correct answer with no working gains 3 marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(ii)	An explanation that includes three of the following • {water uptake / transpiration} is fastest in moving air in the light (1) • {water uptake / transpiration} {is very slow / stops / decreases} in the dark as stomata close (1) • {water uptake / transpiration} is faster in moving air (than still air) as the diffusion gradient is {maintained / steeper} (1) • comment on decline in rate (of transpiration / water uptake) as trials continue in darkness with explanation (1) • effect of light is greater than effect of moving air (1)	Accept {water uptake / transpiration} is slowest in still air in the dark Accept concentration gradient / water potential gradient / diffusion shells around stomata or leaf Accept converse Accept stomata do not close completely until trial 3	**(3)**

Question Number	Answer	Additional Guidance	Mark
9(b)(iii)	A description that includes four of the following: • cover one surface of leaves with {petroleum jelly / clear tape} (to prevent transpiration) • measure {rate / distance moved in 5 mins / volume of water taken up in 5 mins} (1) • ensure that covering is fully removed or use another shoot with same surface area (1) • repeat for other surface of leaves (and compare results) (1) • {**method of control of** one named variable / monitoring named variable which cannot be controlled} (1) • repeats for each set up and calculate standard deviation (1)	Accept clear nail varnish / clear wax / clingfilm Accept other times Accept time how long it takes to move a set distance Accept same number of leaves / similar surface area Accept calculate (rate of) water loss per unit area Accept eg. temperature – AC room / room temperature humidity - clear bag over plant light intensity – distance from lamp air movement - distance from fan Accept repeat and carry out appropriate stats test eg t-test, 95% confidence limits, Mann Whitney U test	**(4)**

Total for question 9 = 13 marks

Question Number	Answer	Additional Guidance	Mark
10(a)	An answer that includes the following • the rate at which producers make organic material (by photosynthesis) / the rate at which light energy is incorporated into organic matter (by plants / producers) / rate at which carbon is fixed into organic matter (by photosynthesis) (1) • suitable units of biomass per area per time or energy per area per time (1)	Accept organic matter / carbon compounds / biomass Accept plants / autotrophs Do not accept: energy produced Accept energy converted / turned into Accept eg g m^{-2} $year^{-1}$, kg m^{-2} $year^{-1}$, kJ m^{-2} $year^{-1}$ g (of carbon) m^{-2} $year^{-1}$ Accept cm^{-2} or min^{-1} as units Accept m^{-3}	**(2)**

Question Number	Answer	Additional Guidance	Mark

10(b)	A description that includes two of the following: • (energy passes) to other appropriate animals (1) • (energy remains) in plant biomass (1) • (energy) released in respiration (in plants) (1)	 Accept eaten by herbivores / primary consumers / insects / rabbits etc Accept plants grow / energy stored in plants (remain in the field and) broken down by decomposers remains in humus in the soil Accept lost as heat from respiration used for active transport / other correct metabolic processes	**(2)**

Level	**Marks**	
0	0	No awardable content

1	1-3	Demonstrates isolated elements of biological knowledge and understanding to the given context with generalised comments made. Vague statements related to consequences are made with limited linkage to a range of scientific ideas, processes, techniques and procedures. The discussion will contain basic information with some attempt made to link knowledge and understanding to the given context
2	4-6	Demonstrates adequate knowledge and understanding by selecting and applying some relevant biological facts/concepts. Consequences are discussed which are occasionally supported through linkage to a range of scientific ideas, processes, techniques and procedures. The discussion shows some linkages and lines of scientific reasoning with some structure.
3	7-9	Demonstrates comprehensive knowledge and understanding by selecting and applying relevant knowledge of biological facts/concepts. Consequences are discussed which are supported throughout by sustained linkage to a range of scientific ideas, processes, techniques or procedures. The discussion shows a well-developed and sustained line of scientific reasoning which is clear and logically structured.

Question Number	Answer	Mark
10(c)	Level 1: links information given to effect on dung beetles (up to 3 points from anywhere) Level 2: links information given to effect on dung beetles (up to 6 points from a minimum of two categories) Level 3: links information given to effect on dung beetles (up to 9 points with at least two from each of three categories) **Indicative content** **Threats to dung beetles (T points)** • (less grazing animals on land) so less dung available ie reduced food source • (farmland used for building / development) so reduced habitat • (animals kept in sheds overwinter) so food source unreliable / not constant • (routine use of anti-parasitic drugs) so drugs in animal faeces which kill dung beetles • (isolated populations of dung beetles) so genetic diversity is reduced • (isolated populations of dung beetles) - small populations of dung beetle species have a small gene pool, so allele frequencies can change rapidly • small populations are more vulnerable to disease • (many) dung beetles feed specifically on the dung of particular species, so reduction in species of grazing animals decreases diversity **Benefits of dung beetles (B points)** • (remove dung from fields) so more access for grazing by animals / plants get light for photosynthesis • (remove dung from fields) so less chance of parasites living in dung and reinfecting cattle • (bury dung underground) so decomposers can break it down • decomposition of dung is faster if dung beetles are present • (decomposed dung) increases mineral content of soil • (eaten by birds etc) so provide food for other animals / loss of dung beetles could lead to collapse of food chains	

	Wider points and consequences for farming (W points) • no evidence or stats to prove or disprove statement • if farming practices change animals will suffer eg may die if left outside over winter • if farming practices change, less economically viable to farm / yields may be lower • if farming practices change, less food produced for human consumption • climate change may have an effect on decline of dung beetles eg rise in temperatures, changed rainfall patterns • a new predator might be responsible for decline • urbanisation might be causing change, not farming practices • (routine use of anti-parasitic drugs) kill other beneficial invertebrates (as well as dung beetles) • pesticides (anti-parasitic drugs) may affect other animals in food chain: accumulation • adding fertilisers disrupts dung beetle life cycle • ploughing pasture disrupts dung beetle life cycle • (digging tunnels) improves soil structure by aeration • dung beetles may be involved in seed dispersal (seeds in faeces being moved around by beetles) • cattle contribute to global warming, so better not to farm cattle

Total for Question 10 = 13 marks

Question Number	Answer	Additional Guidance	Mark
11(a)(i)	• calculation of difference (1) • calculation of % increase (1)	Example of calculation 2400 – 400 = 2000 24 – 4 = 20 $\frac{2000}{400}$ x 100 = 500 (%) $\frac{20}{4}$ x 100 = 500 (%) Correct answer with no working gets 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(a)(ii)	• correct answer (1)	384 (x 10^2 per cm^3) Accept 360 to 400 (x 10^2 per cm^3)	**(1)**

Question Number	Answer	Additional Guidance	Mark
11(b)	A description that includes the following: Two relevant techniques to prevent bacterial growth described (2)	eg use of sterile / autoclaved equipment flaming neck of bottle / transfer loops working next to (lit) Bunsen burner disinfection of bench / work surface use of selective medium / antibiotics in medium	**(2)**

Question Number	Answer	Additional Guidance	Mark

11(c)(i)	• Correct calculation of number of cells (1) • Conversion to standard form (1)	Example of calculation 7 divided by 0.004 = 1750 per mm^3 8 2000 per mm^3 $1.75 / 1.8 / 2 \times 10^3$ Correct answer with no working gets 2 marks	**(2)**

Question Number	Answer	Additional Guidance	Mark
11(c)(ii)	An answer that includes two of the following: • {yeast cells may not be evenly distributed / sample may not be representative} (1) • yeast cells may be {reproducing / budding / undergoing cell division} (so hard to know whether to count one or two) (1) • difficult to decide if they are touching the sides of the counting square (1)	Accept clumping / overlapping of cells may occur Accept this method counts dead cells (as well as live) Ignore human error / miscounting unqualified	**(2)**

Question Number	Answer	Additional Guidance	Mark

11(d)(i)	• calculation of $\Sigma (x - \bar{x})^2$ (1) • divided by {4 / n-1} (1) • calculation of SD (1)	Example of calculation 31.2 7.8 2.8 Correct answer with no working gains 3 marks	**(3)**

Question Number	Answer	Additional Guidance	Mark
11(d)(ii)	An answer including the following: • SD for times 0, 1.5, 3 and 4.5 hours are non-overlapping, so this conclusion is likely to be valid (1) • SD for 6 hours overlaps with SD for 4.5 hours, so this conclusion is not likely to be valid (1) • description of possible error (1) • value of 43 may be an anomalous result (so this conclusion may not be valid) (1)	Accept SD for 6 hours overlaps with SD for 4.5 hours with comment on difference / significance Accept eg dilution error, measurement error, counting error, live and dead cells counted	**(3)**

Total for Question 11 = 15 marks

Total for Paper 3 = 120 marks

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