SimpleStudy

PRACTICE MARKING SCHEME

LEAVING CERTIFICATE · HIGHER LEVEL · SAMPLE PAPER 2 · 2027

Biology

Total marks	Duration	Structure
300	2 hr 30 min	7 questions

About this document

A practice marking scheme produced by SimpleStudy to help students and teachers prepare for the Leaving Certificate examination in Biology. The State Examinations Commission has published this sample paper without a marking scheme; the mark allocations and answers set out here are indicative.

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Marking Scheme

This marking scheme accompanies the State Examinations Commission's Sample Paper 2 in Leaving Certificate Biology, Higher Level. It is intended to support candidates and teachers preparing for the examination. It is not an official State Examinations Commission document.

General Marking Guidelines

- Accept all reasonable responses; the lists in this scheme are indicative, not exhaustive.
- Credit content that is correct even where it is poorly expressed.
- No penalty for spelling or grammar unless the meaning is unclear.
- Where a candidate contradicts themselves, award the lower mark.
- Credit accurate labelling on diagrams, and credit a correct answer given as a labelled diagram where the question does not require prose.
- Where a candidate offers more points than the number asked for, mark the first *n* presented, unless a later point is clearly labelled as a replacement.

Seven additions for this paper:

- There are seven questions, each worth 50 marks. Question 1 is compulsory and candidates answer any five of Questions 2 to 7, so six questions make up the 300 marks. Where a candidate answers all seven, mark all seven and credit the best six.
- **Named examples and terminology.** Where a part asks the candidate to name a structure, process or organism, the accepted biological term is required. A description that makes the identification unambiguous earns the mark; a vague term that could apply to several structures does not.
- **Diagrams.** Where a part asks for a labelled diagram, the marks divide between the drawing and the labels, and a label is credited only where it points to the correct structure.
- **Supporting work.** The paper warns that marks may be lost where solutions do not include relevant supporting work, and that marks may be lost where units are omitted.
- **Error carried forward.** Where a candidate uses an incorrect value or answer from an earlier part correctly in a later one, award the later marks in full. An error is penalised once only.
- **Graphical answers.** Where a part asks the candidate to draw on a printed graph or diagram, the marks are for the construction itself and are available whether or not any later reading is correct. Where a blank grid is supplied, marks for axes and scale are properly available; where the grid arrives already labelled and scaled, they are not.
- **Data questions.** Where a part asks the candidate to draw a conclusion or describe a change, the answer must be supported by something read from the data or the graph; a correct statement made without reference to the evidence supplied earns the stating marks only.

How the marks are set

The paper prints a total of 50 marks for each question and no sub-part marks, so every internal split is indicative. The splits reconcile upward to each question total and to the paper total of 300 marks, and follow one set of rates:

- **Naming a structure from a printed diagram** carries **2 marks**.
- **A term supplied from the candidate's own knowledge** carries **2 or 3 marks**, according to the printed answer space.

- **A row of a tick, matching or completion table** carries **2 marks**, or more where the row requires two separate answers.
- **Developed points** are priced on the printed answer space, with the command verb as a tie-breaker.

Marking at Higher Level

This paper is assessed at Higher Level. The specification differentiates the two levels through the learning outcomes themselves: Higher level covers all of the learning outcomes, including those presented in bold type, while Ordinary level covers only those in normal type. Table 1 of the specification describes Higher level students as engaging with a broad range of knowledge, including theoretical concepts and abstract thinking with significant depth in some areas, and as demonstrating and using a broad range of specialised skills to evaluate and use information, to plan and develop investigative strategies, and to determine solutions to varied problems.

Paper Structure

Question 1	**50 marks**	Compulsory. Mitosis and the cell cycle, a vaccine trial, the fluid mosaic membrane, plant stem tissues, and prions.
Question 2	**50 marks**	Species diversity index, symbiosis and the nitrogen cycle, and systemic insecticides in plants.
Question 3	**50 marks**	The polymerase chain reaction, gel electrophoresis, a phylogenetic tree, and genome databases and inheritance.
Question 4	**50 marks**	Bacteria and fungi compared, the bacterial growth curve, bioreactors, and an investigation of microbial growth.
Question 5	**50 marks**	The heart and its vessels, the two circulatory circuits, an arterial pressure trace, and muscle.
Question 6	**50 marks**	The Venus flytrap and its habitat, carbon sinks and the carbon cycle, light intensity and photosynthesis, and the non-cyclic pathway.
Question 7	**50 marks**	Biomolecules, glucose test strips, the digestive system, and enzyme action.
Total	**300 marks**	Question 1 and any five of Questions 2 to 7.

Grading Descriptors (all parts carrying a development element)

High (H)	Point accurately stated and developed with correct biological reasoning, applied to the organism, data or diagram the part supplies. Full marks for the point.
Mid (M)	Relevant point stated with partial development, or biologically correct but not applied to the material the part supplies. Award the stating marks in full plus roughly half the development marks, rounded up to a whole mark.
Low (L)	Point stated or asserted only; vague, or development that does not follow from the point stated. Stating marks only.

No criterion grid is used on this paper. *The extended parts — for example 4(d), 6(c) and 7(d)(ii) — are marked by required elements rather than holistically.*

Question 1 — 50 marks

Compulsory. Candidates answer all parts.

Indicative mark allocation: (a)(i) 4 · (a)(ii) 2 · (a)(iii) 2 · (a)(iv) 4 · (b)(i) 2 · (b)(ii) 3 · (b)(iii) 3 · (b)(iv) 3 · (c)(i) 2 · (c)(ii) 2 · (c)(iii) 2 · (c)(iv) 2 · (d)(i) 6 · (d)(ii) 2 · (d)(iii) 2 · (e)(i) 3 · (e)(ii) 2 · (e)(iii) 2 · (e)(iv) 2 = 50 marks.

Part	Acceptable Answer(s)	Marks
(a)(i) The two stages ***2 marks each***	A: **anaphase** C: **prophase**	**4**
(a)(ii) The stage at B	**Interphase.** The nucleus is intact and granular with no individual chromosomes visible, so the cell is not in mitosis at all.	**2**
(a)(iii) The letter X	Written on any of the clear boundaries between adjacent cells — the pale line separating one cell from its neighbour.	**2**
(a)(iv) Two risk factors ***2 marks each***	Tobacco smoke; ultraviolet radiation from the sun or sunbeds; ionising radiation such as X-rays or radon; asbestos or other industrial chemicals; alcohol; a diet high in processed meat; viruses such as HPV.	**4**
(b)(i) Why test worldwide	So that the sample includes people of many different ethnicities, ages, diets, climates and health backgrounds, and the result can be generalised to the whole population rather than to one group.	**2**
(b)(ii) Placebo-controlled	One group received an injection containing no vaccine — a harmless substitute that looks identical (2) — so that the effect of the vaccine itself can be separated from the effect of simply being injected and observed, the two groups then being compared (1).	**3**
(b)(iii) Sample size and reliability	43 448 is a very large sample (1), so the results are highly reliable: random variation and individual differences are averaged out, and any difference found between the groups is far less likely to have arisen by chance (2).	**3**
(b)(iv) Conclusion about children	**No** (1). Everyone in the trial was aged 16 or older, so there is no data at all on children (1); children's immune systems and body sizes differ from adults', and the vaccine would have to be trialled separately in that age group before any such conclusion could be drawn (1).	**3**
(c)(i) The part labelled C	The **phospholipid bilayer**.	**2**
(c)(ii) Molecule A	A **glycoprotein** — a branched carbohydrate chain attached to a protein.	**2**
(c)(iii) The essential function	**Selective permeability**: the membrane controls what enters and leaves the cell, and molecule B is a channel or transport protein through which substances that cannot cross the lipid bilayer are carried.	**2**

Part	Acceptable Answer(s)	Marks
(c)(iv) A technological development	The **electron microscope**, whose far greater magnification and resolution revealed detail the light microscope could not. Accept the freeze-fracture technique, or the transmission electron microscope named specifically.	**2**
(d)(i) The three tissues *2 marks each*	X: **phloem** Y: **xylem** Z: **parenchyma** (accept ground tissue or packing tissue)	**6**
(d)(ii) A function of Y	Xylem transports water and dissolved minerals from the roots upwards to the leaves; it also provides support to the stem.	**2**
(d)(iii) An adaptation of Y	The cells are dead and hollow with their end walls broken down, forming continuous open tubes through which water flows freely; the walls are thickened with lignin, which supports the plant and stops the vessels collapsing under the tension of the transpiration stream.	**2**
(e)(i) Why prions are pathogens	A pathogen is any agent that causes disease (1). Prions are transmitted from one organism to another and cause the degenerative disease of the nervous system described, so although they are only misfolded proteins and are not living cells, they meet the definition (2).	**3**
(e)(ii) Transmission to humans	People ate meat or other products from infected cattle, particularly tissue from the brain, spinal cord or nervous system, and the prion passed into them through the digestive system.	**2**
(e)(iii) Importance of folding	A protein's function depends on its three-dimensional shape, which folding produces (1); if it folds incorrectly the shape is wrong and the protein cannot do its job — and in this case the misfolded form causes damage and induces other proteins to misfold as well (1).	**2**
(e)(iv) Another non-cellular pathogen	A **virus**. Accept a viroid.	**2**

Examiner note on (a)(i). *In A the chromosomes have separated into two groups moving to opposite poles, the centromeres leading and the arms trailing behind in V-shapes, which is anaphase. In C the chromosomes are fully condensed and distinct but lie at many different angles, overlapping one another and projecting arms across a broad area of the cell: that is late prophase, after the nuclear envelope has broken down but before the chromosomes are arranged. Metaphase would show them aligned in a single file across the centre of the cell, and no cell in the image is arranged that way.*

Question 2 — 50 marks

Candidates answer any five of Questions 2 to 7. Each carries 50 marks.

Indicative mark allocation: (a)(i) 2 · (a)(ii) 3 · (a)(iii) 6 · (a)(iv) 3 · (a)(v) 3 · (b)(i) 2 · (b)(ii) 2 · (b)(iii) 3 · (b)(iv) 3 · (b)(v) 4 · (b)(vi) 4 · (b)(vii) 3 · (c)(i) 4 · (c)(ii) 4 · (c)(iii) 4 = 50 marks.

(a) Species diversity (17 marks)

Part	Acceptable Answer(s)	Marks
(i) Species	A group of organisms of the same kind that can interbreed with one another to produce fertile offspring.	**2**
(ii) Species diversity index	A number that measures the variety of species in a habitat, taking account both of how many different species are present and of how evenly the individuals are spread among them.	**3**
(iii) Calculating the index	N = 46 + 30 + 27 + 23 + 10 + 9 = **145** (1) Σn(n − 1) = 2070 + 870 + 702 + 506 + 90 + 72 = **4310** (3) N(N − 1) = 145 × 144 = 20 880 (1) Index = 1 − (4310 ÷ 20 880) = 1 − 0.206 = **0.79** (1) Accept 0.794 or 0.8. A candidate who omits the subtraction from 1 and gives 0.21 earns 5.	**6**
(iv) Significance of the number	The index runs from 0 to 1, and the closer it is to 1 the greater the diversity (1). A value of 0.79 is reasonably high, showing a good variety of species with no single species overwhelmingly dominant, which suggests a relatively healthy and stable habitat (2).	**3**
(v) Agree or disagree	**Agree** (1). The figures cover January to May only, and different plants flower and are recorded at different times of year, so species flowering in summer or autumn would be under-represented and the totals for all six would change over a full year (2). Recording effort by the public also varies with the season.	**3**

(b) Clover, symbiosis and nitrogen (21 marks)

Part	Acceptable Answer(s)	Marks
(i) The specific relationship	**Mutualism**	**2**
(ii) Another symbiotic relationship	**Parasitism** (accept commensalism)	**2**
(iii) Significance of symbiosis	Symbiotic relationships allow organisms to obtain resources they could not get alone, so each partner survives where it otherwise might not (2); they are a major influence on which species can live together in a habitat, and in this case they make nitrogen available to the whole community (1).	**3**

Part	Acceptable Answer(s)	Marks
(iv) Importance of nutrient cycles	Elements such as nitrogen and carbon exist in a finite quantity on Earth (1), so they must be recycled continuously between the living and non-living parts of the ecosystem; without the cycles the supply available to producers would be exhausted and life could not continue (2).	**3**
(v) Nitrogen fixation	Nitrogen gas from the atmosphere is converted into ammonia or ammonium compounds that plants can absorb and use (2). It is carried out by nitrogen-fixing bacteria such as *Rhizobium* living in the root nodules of legumes, and by free-living soil bacteria such as *Azotobacter*; lightning also fixes a small amount (2).	**4**
(vi) Effect on plant diversity	*2 marks for the prediction, 2 for the explanation.* **Prediction:** diversity may **decrease**. **Explanation:** the clover enriches the soil with nitrogen, which favours fast-growing, nitrogen-demanding species such as grasses; these outcompete the slower-growing plants adapted to poorer soils, and those species are lost from the habitat. Accept the opposite prediction where it is argued coherently, for instance that clover adds a flowering species that supports pollinators.	**4**
(vii) Clover and sustainability	Because the clover fixes its own nitrogen, the farmer needs to apply far less artificial nitrogen fertiliser (2). That saves the fossil fuel used in manufacturing fertiliser, reduces greenhouse gas emissions, cuts costs, and reduces the run-off of nitrates into rivers and lakes that causes eutrophication (1).	**3**

(c) Systemic insecticides (12 marks)

Part	Acceptable Answer(s)	Marks
(i) Two plant organs ***2 marks each***	The **roots**, which absorb the insecticide dissolved in soil water, and the **stem**, which transports it upwards to the flowers. Accept the leaves as the organ drawing the stream up by transpiration.	**4**
(ii) Two processes ***2 marks each***	**Osmosis** — water carrying the dissolved insecticide enters the root hair cells; **transpiration** — evaporation from the leaves pulling the stream upwards through the xylem. Accept active transport, diffusion, root pressure or the cohesion-tension mechanism.	**4**
(iii) Diagram of a flower	*1 mark per correctly drawn and labelled structure, to a maximum of 4.* Petal; sepal; stamen with anther and filament; carpel with stigma, style and ovary; ovule; nectary; receptacle. The diagram must be of an insect-pollinated flower, so large coloured petals and a nectary are appropriate, and at least three labels must point to correctly drawn structures.	**4**

Question 3 — 50 marks

Candidates answer any five of Questions 2 to 7. Each carries 50 marks.

Indicative mark allocation: (a)(i) 4 · (a)(ii) 2 · (a)(iii) 4 · (b)(i) 2 · (b)(ii) 5 · (b)(iii) 4 · (c)(i) 5 · (c)(ii) 4 · (c)(iii) 4 · (d)(i) 3 · (d)(ii) 3 · (d)(iii) 2 · (d)(iv) 5 · (d)(v) 3 = 50 marks.

(a) The polymerase chain reaction (10 marks)

Part	Acceptable Answer(s)	Marks
(i) Denaturation	The DNA is heated to 95 °C (1), which breaks the hydrogen bonds holding the two strands together (2), so the double helix separates into two single strands, each able to act as a template (1). No covalent bonds are broken, so the base sequence itself is unchanged.	**4**
(ii) Circling the temperature	A circle drawn around **72 °C**, the extension stage, where Taq polymerase builds the new strands.	**2**
(iii) The pH buffer	**Disagree** (1). Taq polymerase is an enzyme, and like all enzymes it works only within a narrow pH range; outside it the active site changes shape and the enzyme is denatured (2). The buffer holds the pH of the reaction mixture steady through the repeated heating and cooling cycles, so it is necessary (1).	**4**

(b) Separating the fragments (11 marks)

Part	Acceptable Answer(s)	Marks
(i) The final technique	**Gel electrophoresis**	**2**
(ii) How it separates them	The DNA fragments are loaded into wells cut at one end of a gel (1) and a voltage is applied across it (1). DNA carries a negative charge, so the fragments move through the gel towards the positive electrode (2); the smaller fragments move more easily through the mesh of the gel and travel further in the same time, so they are separated into bands according to size (1).	**5**
(iii) Why gloves are mandatory	The two steps that follow are DNA extraction and PCR (1). PCR amplifies even a tiny quantity of DNA into a large one, so a few skin cells or a trace of sweat from the investigator's hands would be copied along with the sample and could be mistaken for part of it (2), making the result unreliable or completely wrong. Gloves also protect the investigator from the sample (1).	**4**

(c) Evolution of DNA polymerase (13 marks)

Part	Acceptable Answer(s)	Marks
(i) The closest relative	***Thermus sediminis*** (2). Explanation (3): on the tree, *T. sediminis* and *T. aquaticus* branch from the same node, and that node is the most recent of any involving *T. aquaticus*. The two therefore share a more recent common ancestor than either does with any other species shown, so less time has passed for differences to accumulate and their DNA polymerases are the most similar in structure.	**5**
(ii) Two ways the gene evolved ***2 marks each***	Random mutation of the base sequence, with variants producing a more heat-stable enzyme favoured by natural selection in hot springs; gene duplication followed by divergence of the copy; horizontal gene transfer between bacteria; accumulation of small changes over many generations as populations became isolated in different habitats.	**4**
(iii) Two other sources of evidence ***2 marks each***	The fossil record; comparative anatomy, including homologous structures such as the pentadactyl limb; comparative embryology; comparative biochemistry and DNA sequence similarity; observed examples such as antibiotic resistance in bacteria; artificial selection; the geographical distribution of species.	**4**

(d) Genome databases (16 marks)

Part	Acceptable Answer(s)	Marks
(i) Inheritance	The passing on of characteristics, carried as genes on chromosomes, from parents to their offspring through the gametes.	**3**
(ii) X-linked	The gene is carried on the X chromosome and not on the Y (2). Because males have only one X, a single recessive allele is enough to produce the condition in a male, while a female would need two, which is why such conditions are far more common in males (1).	**3**
(iii) The chromosome number	Chromosome **11**	**2**
(iv) A sector of society	*2 marks for naming the sector, 3 for the use.* **Medicine and healthcare:** doctors and genetic counsellors can identify the gene responsible for a patient's condition, advise couples on the risk of passing a condition to their children, and choose treatments matched to a patient's genotype. Accept research science, the pharmaceutical industry, agriculture and plant breeding, forensic science, or insurance, each with a coherent use.	**5**
(v) An ethical issue	Any one, discussed rather than merely named: whether insurers or employers should have access to genetic data, and the discrimination that could follow; privacy and consent, since a person's genome also reveals information about their relatives; whether embryos should be screened and selected; editing of the human germ line; who owns genetic information and who profits from it; unequal access to expensive genetic technologies.	**3**

Question 4 — 50 marks

Candidates answer any five of Questions 2 to 7. Each carries 50 marks.

Indicative mark allocation: (a)(i) 2 · (a)(ii) 6 · (a)(iii) 8 · (b)(i) 8 · (b)(ii) 2 · (b)(iii) 2 · (b)(iv) 2 · (c)(i) 4 · (c)(ii) 4 · (c)(iii) 4 · (d) 8 = 50 marks.

(a) Bacteria and fungi (16 marks)

Part	Acceptable Answer(s)	Marks
(i) The arrow from X	An arrow drawn from X to the **blotched or discoloured area on the cap of the mushroom** in image A — the brown marks absent from the unaffected mushrooms in image B.	**2**
(ii) Diagram of a bacterial cell	*1 mark per correctly drawn and labelled structure, to a maximum of 6.* Cell wall; cell membrane; cytoplasm; circular DNA or nucleoid; ribosomes; plasmid; capsule or slime layer; flagellum; pili. The drawing must show no nucleus and no membrane-bound organelles, and at least four labels must point to correctly drawn structures.	**6**
(iii) Bacteria against fungi ***2 marks per cell***	**Bacteria — cellular nature:** prokaryotic; unicellular, with no nucleus or membrane-bound organelles. **Bacteria — nutrition:** varied; some heterotrophic (saprophytic or parasitic), others autotrophic by photosynthesis or chemosynthesis. **Fungi — cellular nature:** eukaryotic, with a true nucleus; unicellular as in yeast, or multicellular and made of hyphae. **Fungi — nutrition:** heterotrophic; saprophytic or parasitic, digesting food externally and absorbing it.	**8**

(b) The bacterial growth curve (14 marks)

Part	Acceptable Answer(s)	Marks
(i) The four phases ***2 marks each***	1: **lag phase** 2: **log (exponential) phase** 3: **stationary phase** 4: **decline (death) phase**	**8**
(ii) Drawing the fifth phase	The line extended beyond the decline phase and **levelling off into a horizontal line at a low population size**, rather than continuing to fall to zero.	**2**
(iii) Name of the fifth phase	The **survival phase**. Accept **long-term stationary phase**, which is the other term in circulation; a candidate taught from a different textbook should not lose the mark.	**2**
(iv) The structure formed	An **endospore** (accept spore).	**2**

(c) The bioreactor (12 marks)

Part	Acceptable Answer(s)	Marks
(i) Two factors ***2 marks each***	**Temperature**; **pH**; the supply of nutrients or food; oxygen concentration; the removal of waste products or toxins; water availability.	**4**
(ii) How one factor affects growth	*Must follow from a factor named in (i).* **Temperature:** each species has an optimum at which its enzymes work fastest and growth is most rapid; below it reactions slow and growth falls off, and above it the enzymes begin to denature, so growth drops sharply and the cells eventually die.	**4**
(iii) Two other industries ***2 marks each***	The **food and drink industry** — brewing, baking, yoghurt, cheese; **agriculture** — silage, biological control, nitrogen fixation; **waste treatment and sewage processing**; the **biofuel industry** — ethanol and biogas; biotechnology producing enzymes for detergents.	**4**

(d) An investigation into microbial growth (8 marks)

Part	Acceptable Answer(s)	Marks
Required elements	*Marked by required elements; a labelled diagram earns the marks equally.* • The factor investigated named, and the organism named (2) • Aseptic preparation — sterilised agar plates and equipment, the inoculating loop flamed, work beside a Bunsen burner (2) • The plates inoculated with the same volume or number of the microorganism (1) • Several plates set up differing only in the factor being tested, all other conditions held constant (2) • Incubated at a stated temperature for a stated time, then the colonies counted or their diameters measured and the results compared (1) A control plate and a stated safety precaution are creditable alternatives to any of these elements.	**8**

Question 5 — 50 marks

Candidates answer any five of Questions 2 to 7. Each carries 50 marks.

Indicative mark allocation: (a)(i) 4 · (a)(ii) 3 · (a)(iii) 2 · (a)(iv) 4 · (a)(v) 4 · (b)(i) 4 · (b)(ii) 5 · (b)(iii) 4 · (b)(iv) 3 · (c)(i) 2 · (c)(ii) 4 · (c)(iii) 4 · (d)(i) 3 · (d)(ii) 4 = 50 marks.

(a) The heart (17 marks)

Part	Acceptable Answer(s)	Marks
(i) Vessels A and B ***2 marks each***	A: **aorta** B: **pulmonary artery**	**4**
(ii) The valve when the ventricles contract	The valve **opens** (2). When the ventricles contract the pressure inside the right ventricle rises above the pressure in the pulmonary artery, which forces the semilunar valve open so that blood is ejected out of the ventricle into the artery (1).	**3**
(iii) The letter X	Marked in the **wall of the right atrium**, near the point where the vena cava enters — the position of the sino-atrial node.	**2**
(iv) Carbon dioxide in A and B	The concentration is **lower in A and higher in B** (2). A is the aorta, carrying oxygenated blood that has just returned from the lungs where carbon dioxide was removed; B is the pulmonary artery, carrying deoxygenated blood from the right ventricle to the lungs, which has collected carbon dioxide from respiring tissues throughout the body (2).	**4**
(v) Artery against vein	*2 marks for the difference, 2 for the detail or diagram.* An artery has a **thick muscular and elastic wall** with a relatively narrow lumen, to withstand and smooth out the high pressure of blood leaving the heart; a vein has a **much thinner wall** with a wider lumen and carries blood at low pressure. Accept instead that veins contain **valves** along their length to prevent backflow while arteries do not.	**4**

Examiner note on (a)(ii). *The labelled valve is the semilunar valve at the base of the pulmonary trunk — the three pocket-shaped cusps immediately below vessel B, with no chordae attached — and not an atrioventricular valve. The atrioventricular valve is drawn lower in the same cut-away as thin leaflets attached by chordae tendineae to a papillary muscle, and is not the structure labelled. A candidate who answers "closes" has read the label as the atrioventricular valve; that is the error the diagram invites, and it earns nothing, but examiners should recognise it rather than treat it as carelessness.*

(b) The circulatory system (16 marks)

Part	Acceptable Answer(s)	Marks
(i) The two circuits ***2 marks each***	The **pulmonary circuit**, between the heart and the lungs, and the **systemic circuit**, between the heart and the rest of the body.	**4**

Part	Acceptable Answer(s)	Marks
(ii) The pathway of one circuit	*The circuit must be named and the pathway given in order.* **Pulmonary:** deoxygenated blood leaves the right ventricle through the pulmonary artery, travels to the lungs where it is oxygenated in the capillaries around the alveoli, and returns through the pulmonary vein to the left atrium. **Systemic:** oxygenated blood leaves the left ventricle through the aorta, travels through arteries and arterioles to the capillaries of the body tissues where oxygen is delivered, and returns through venules and veins to the vena cava and the right atrium.	**5**
(iii) A blocked coronary artery	The region of heart muscle supplied by that artery is cut off from its blood supply, so it receives no oxygen or glucose (2); those cardiac muscle cells cannot respire aerobically and die, which is a heart attack, a myocardial infarction. The damaged area can no longer contract, so the heart pumps less effectively and the rhythm may be disturbed (2).	**4**
(iv) Blood pressure	The force that the blood exerts against the walls of the blood vessels as it flows through them (2), usually measured in the arteries and expressed as a systolic value over a diastolic value (1).	**3**

(c) The pressure trace (10 marks)

Part	Acceptable Answer(s)	Marks
(i) The letter X	Written anywhere on a **steeply rising part of either curve** — between about 0 and 0.1 s, or between 0.5 and 0.6 s — where the pressure is climbing sharply because the ventricle is contracting.	**2**
(ii) Heart rate	The graph shows **two complete beats in 1.0 s**, so one beat takes 0.5 s (2), and the rate is 60 ÷ 0.5 = **120 beats per minute** (2).	**4**
(iii) At rest	**No** (1). A rate of 120 bpm is far above a normal resting rate of about 60 to 80 bpm, and trained athletes typically have resting rates lower still, often between 40 and 60 (2). The trace must therefore have been recorded during or shortly after exercise (1). Error carried forward from (ii).	**4**

(d) Muscle (7 marks)

Part	Acceptable Answer(s)	Marks
(i) Mitochondria in cardiac muscle	Cardiac muscle contracts continuously throughout life without resting, so it has a very high and unbroken demand for energy (2). Mitochondria are the site of aerobic respiration, which releases ATP, so a large number of them is needed to supply that demand (1).	**3**

Part	Acceptable Answer(s)	Marks
(ii) An antagonistic muscle pair	*2 marks for the principle, 2 for a correct worked example or labelled diagram.* Muscles can only pull, not push, so they are arranged in pairs that work in opposition: when one contracts the other relaxes and the joint moves one way; to reverse the movement the second contracts and the first relaxes. At the elbow, contraction of the biceps with the triceps relaxed flexes the arm; contraction of the triceps with the biceps relaxed extends it again. A diagram should show the two muscles attached by tendons across the joint, with the direction of movement marked.	**4**

Question 6 — 50 marks

Candidates answer any five of Questions 2 to 7. Each carries 50 marks.

Indicative mark allocation: (a)(i) 2 · (a)(ii) 3 · (a)(iii) 2 · (a)(iv) 2 · (a)(v) 4 · (a)(vi) 4 · (a)(vii) 6 · (b)(i) 4 · (b)(ii) 6 · (b)(iii) 3 · (b)(iv) 2 · (c) 12 = 50 marks.

(a) The Venus flytrap (23 marks)

Part	Acceptable Answer(s)	Marks
(i) Why it must consume insects	The boggy soil it grows in is very poor in nitrogen, and the plant obtains the nitrogen it needs for making proteins from the bodies of the insects it digests.	**2**
(ii) Why not for energy	The Venus flytrap is green and contains chlorophyll (1), so like other plants it makes its own food by photosynthesis and gets its energy from sunlight; the insects supply minerals rather than energy (2).	**3**
(iii) A structural adaptation	Leaves modified into hinged traps that fold together; spiny teeth along the leaf edges that interlock to stop the insect escaping; sensitive trigger hairs on the inner surface; glands that secrete digestive enzymes.	**2**
(iv) A biotic factor	The availability of insects as prey; competition from other plants; grazing or trampling by animals; disease; collection by humans.	**2**
(v) Climate warming	*2 marks for the answer, 2 for the justification; either answer is acceptable where justified.* **Yes:** the plant is restricted to damp, boggy habitats within a small natural range, and a warmer climate would dry those bogs out; a species confined to so small an area has nowhere to migrate to, so the population would be endangered. **No:** warming may extend the growing season and increase the number of insects available, and the plant may tolerate a range of temperatures.	**4**
(vi) Two other carbon sinks *2 marks each*	The **oceans**; **forests** and other vegetation; **soil**; **fossil fuel deposits**; limestone and other carbonate rocks.	**4**
(vii) Diagram of the carbon cycle	*1 mark per correct labelled component or arrow, to a maximum of 6.* Carbon dioxide in the atmosphere; photosynthesis removing it into plants; respiration by plants and animals returning it; feeding transferring carbon from plants to animals; death and decomposition by bacteria and fungi; combustion of fossil fuels or wood; fossil fuel formation. Arrows must point in the correct direction.	**6**

(b) Light intensity and photosynthesis (15 marks)

Part	Acceptable Answer(s)	Marks
(i) Completing the table	Light intensity = $1 \div d^2$: d = 1 m → **1**; d = 0.8 → **1.56**; d = 0.6 → **2.78**; d = 0.4 → **6.25**; d = 0.2 → 25 *1 mark per correct value.* Accept 1.6, 2.8 and 6.3.	**4**
(ii) The graph	*2 marks for both axes labelled with quantity and unit, with light intensity on the horizontal axis and rate of photosynthesis on the vertical; 2 for suitable scales using more than half the grid; 2 for the five points plotted accurately and joined.*	**6**
(iii) Conclusion	As the light intensity increases the rate of photosynthesis increases (1) — from 10 bubbles per minute at an intensity of 1 to 25 at an intensity of 6.25 (1) — but the rate then levels off, since it is the same at 6.25 and at 25, showing that above a certain intensity some other factor has become limiting (1).	**3**
(iv) A variable to control	The temperature of the water; the concentration of carbon dioxide or hydrogencarbonate; the same plant or the same length of plant; the time over which bubbles are counted; the colour of the light.	**2**

(c) The non-cyclic pathway (12 marks)

Part	Acceptable Answer(s)	Marks
Required elements	*Marked by required elements; a labelled diagram earns the marks equally.* • Light is absorbed by chlorophyll in the thylakoid membrane, exciting electrons to a higher energy level (2) • The excited electrons leave the chlorophyll and pass along a chain of electron carriers in the membrane (2) • As they pass down the chain they release energy, which is used to make ATP from ADP and phosphate (2) • Photolysis: water is split into hydrogen ions, electrons and oxygen, the electrons replacing those lost by the chlorophyll (2) • Oxygen is released as a by-product (1) • The electrons and hydrogen ions are finally accepted by $NADP^+$, which is reduced to NADPH (2) • The ATP and NADPH produced pass to the light-independent reaction (1)	**12**

Question 7 — 50 marks

Candidates answer any five of Questions 2 to 7. Each carries 50 marks.

Indicative mark allocation: (a)(i) 6 · (a)(ii) 6 · (a)(iii) 4 · (a)(iv) 4 · (b)(i) 4 · (b)(ii) 5 · (c) 10 · (d)(i) 3 · (d)(ii) 8 = 50 marks.

(a) Biomolecules (20 marks)

Part	Acceptable Answer(s)	Marks
(i) Matching the formulae ***2 marks each***	A ($C_9H_{14}N_4O_3$): **protein** B ($CH_3(CH_2)_nCOOH$): **lipid** C ($C_6H_{12}O_6$): **carbohydrate**	**6**
(ii) Reasons ***2 marks each***	**A:** it contains **nitrogen** as well as carbon, hydrogen and oxygen, and nitrogen is present in the amino acids that make up proteins but not in carbohydrates or lipids. **B:** it is a long hydrocarbon chain ending in a **carboxyl (–COOH) group**, which is the structure of a fatty acid, the building block of lipids. **C:** it contains carbon, hydrogen and oxygen only, with hydrogen and oxygen in the ratio 2 : 1 as in water, which is the general pattern of a carbohydrate; $C_6H_{12}O_6$ is glucose.	**6**
(iii) Two sources of lipids ***2 marks each***	Butter, cream, cheese or milk; vegetable or olive oil; oily fish such as salmon or mackerel; nuts and seeds; avocado; meat fat.	**4**
(iv) Two proteins in metabolism ***2 marks each***	**Enzymes** such as amylase, catalase or pepsin; **hormones** such as insulin; carrier proteins in membranes; haemoglobin. A named example is creditable in place of the class.	**4**

(b) The glucose test strips (9 marks)

Part	Acceptable Answer(s)	Marks
(i) Identifying 1% glucose	The student dips a test strip into the sample, waits the stated time, and compares the colour of the strip against the chart on the bottle (2); a sample containing 1% glucose turns the strip **medium brown**, the colour printed against 1% on the chart (2).	**4**
(ii) A 0.375% solution	**No** (2). Justification (3): the chart gives colours only at fixed concentrations — 0, 0.1, 0.25, 0.5, 1 and 2% — and 0.375 lies between two of them, 0.25 and 0.5. The strip would turn a colour somewhere between mint green and olive brown, which the student could not match to any printed square, so they could say only that the value lies between 0.25 and 0.5%. The technique gives a reading to the nearest step on the chart rather than a precise value.	**5**

(c) The human digestive system (10 marks)

Part	Acceptable Answer(s)	Marks
Labelled diagram	*1 mark per correctly drawn and labelled structure, to a maximum of 10.* Mouth; salivary glands; oesophagus; stomach; liver; gall bladder; pancreas; small intestine with duodenum and ileum; large intestine or colon; caecum and appendix; rectum; anus. The structures must be drawn in the correct relative positions and connected in the correct order; a label pointing to the wrong structure earns nothing.	**10**

(d) Enzyme action (11 marks)

Part	Acceptable Answer(s)	Marks
(i) Selective catalysts	Enzymes speed up biochemical reactions without being used up (1), and each enzyme catalyses only one reaction or one type of reaction, because the shape of its active site fits only one particular substrate (2).	**3**
(ii) How enzymes function ***2 marks per stage***	**Stage 1:** the substrate and the enzyme are separate; the enzyme has an active site with a shape complementary to that of the substrate. **Stage 2:** the substrate enters and binds to the active site, forming the enzyme-substrate complex; the active site may change shape slightly to fit the substrate more closely, which is the induced fit. **Stage 3:** the reaction takes place while the substrate is held in the active site — here the substrate is broken into two products — and the enzyme lowers the activation energy needed. **Stage 4:** the products no longer fit the active site and are released, leaving the enzyme unchanged and free to bind another substrate molecule and repeat the process.	**8**

This marking scheme is indicative. The paper prints a total of 50 marks for each question and no sub-part marks, so all internal splits are those of this scheme; they reconcile to 50 marks for each question and to 300 marks for the six questions a candidate answers. Examiners should use professional judgement when awarding marks and should credit all reasonable responses not listed here. Prepared by SimpleStudy for study purposes; not an official State Examinations Commission document.