IB Biology SL Paper 2 Mock Paper (10 questions, 50 marks, 75 minutes, calculator allowed)

IB DP 第一年（Grade 11） Biology | 時限：75 分鐘 | 總分：50 分 | 共 10 題

Section A (Questions 1 to 5, 25 marks)

Answer ALL questions. A calculator may be used. Show your working in calculations, give numerical answers to three significant figures unless told otherwise, and state units in every final answer. All data are examples and this is not a past paper of any examination board.

1. Students took 8 random quadrats of 0.25 m2 in a meadow. The numbers of wood sorrel plants recorded were: 12, 9, 15, 11, 14, 10, 13, 8. (a) Calculate the mean density in plants per square metre. (b) The meadow measures 40 m by 25 m. Estimate the total number of wood sorrel plants. (c) Explain why the quadrats must be placed at random, and why too few samples give a poor estimate.

答案：(a) Total = 92 plants in 8 quadrats, so mean = 92 / 8 = 11.5 per quadrat. Density = 11.5 / 0.25 = 46 plants per m2. (b) Area = 40 x 25 = 1,000 m2, so the estimate is 46 x 1,000 = 46,000 plants. (c) Choosing spots where the plant looks abundant would overestimate the mean; random placement avoids this bias. 8 quadrats cover only 2.00 m2, that is 0.2% of the meadow, and light, water and trampling vary across the site, so too few samples give an unreliable estimate. Marking notes: 2 marks (a) for the mean and the division by quadrat area, 2 marks (b), 1 mark (c).

2. In a grassland ecosystem the gross primary production is 45,000 kJ m-2 per year and producers lose 18,000 kJ m-2 per year in respiration. Primary consumers ingest 5,400 kJ m-2, of which 900 kJ m-2 is egested in faeces; secondary consumers assimilate 450 kJ m-2. (a) Calculate the net primary production (NPP). (b) Calculate the efficiency of energy transfer from producers (NPP) to primary consumers, and from primary consumer assimilation to secondary consumers, as percentages to one decimal place. (c) Give two reasons why so much energy is lost between trophic levels.

答案：(a) NPP = GPP - respiration = 45,000 - 18,000 = 27,000 kJ m-2 per year. (b) Producers to primary consumers: 4,500 / 27,000 x 100% = 16.7%. Primary to secondary consumers: 450 / 4,500 x 100% = 10.0%. (c) Most energy is lost as heat during respiration and cannot be passed on. Also, not all plant material is eaten (wood, roots, dead leaves) and not all ingested food is digested, so some energy leaves the food chain in faeces. Marking notes: 1 mark (a), 2 marks (b) one per efficiency, 2 marks (c) one per reason.

3. Two pea plants were crossed. The 200 offspring were: 52 purple round, 48 purple wrinkled, 45 white round and 55 white wrinkled. (a) Write the genotypes of the two parents, using B/b for flower colour and R/r for seed shape. (b) Calculate the expected number of each phenotype for independent assortment (1:1:1:1). (c) Calculate chi-squared, where chi-squared = sum of (observed - expected) squared / expected, to two decimal places. (d) The critical value of chi-squared for df = 3 is 7.81. State your conclusion.

答案：(a) The parents are BbRr (purple round) and bbrr (white wrinkled); the cross is a test cross. (b) Expected for each phenotype = 200 / 4 = 50. (c) chi-squared = (52-50) squared / 50 + (48-50) squared / 50 + (45-50) squared / 50 + (55-50) squared / 50 = 1.16. (d) chi-squared = 1.16 is less than 7.81, so the deviation from a 1:1:1:1 ratio is not significant; the data support independent assortment of two genes on different chromosomes. Marking notes: 1 mark (a), 1 mark (b), 2 marks (c) for expected values and the sum of squares, 1 mark (d).

4. Red-green colour blindness is X-linked recessive (Xc). A carrier mother (XcX) and a father with normal colour vision (XY) have children. (a) List the possible genotypes of their children, stating the sex of each. (b) Calculate the probability that a son is colour-blind. (c) Calculate the probability that a daughter is a carrier. (d) If such couples had 320 children in total, how many would be expected to be colour-blind? Explain why far more males than females are affected.

答案：(a) Sons: XcY (colour-blind) or XY (normal). Daughters: XcX (carrier) or XX (normal). (b) A son receives his Y from the father and one of the mother X chromosomes at random, so the probability of colour blindness in a son is 0.5. (c) A daughter always receives the normal X from her father and has a 0.5 chance of receiving Xc from her mother, so the probability of being a carrier is 0.5. (d) Only sons can be affected, and they are 1/2 x 1/2 = 1/4 of all children: 320 x 0.25 = 80. Males have only one X chromosome, so a recessive allele is expressed directly; a female must inherit the recessive allele on both X chromosomes, which is much less likely. Marking notes: 1 mark (a) for all four genotypes, 1 mark (b), 1 mark (c), 2 marks (d) for the number and the explanation.

5. A student measured the initial rate of a hydrogen peroxide enzyme at different substrate concentrations (rate in arbitrary units, a.u.): 0.10 mmol dm-3: 14.0 、0.20 mmol dm-3: 21.0 、0.40 mmol dm-3: 28.0 、0.80 mmol dm-3: 33.6 、1.60 mmol dm-3: 37.3. (a) Describe how the initial rate changes with substrate concentration. (b) Estimate the maximum rate Vmax and justify your estimate. (c) Estimate the Michaelis constant Km, the substrate concentration at which the rate is half of Vmax. (d) State how Vmax and Km change when a competitive inhibitor is added.

答案：(a) From 0.10 to 0.40 mmol dm-3 the rate rises from 14.0 to 28.0 a.u., almost in proportion; raising the concentration to 1.60 mmol dm-3 only lifts the rate to 37.3 a.u., so the curve flattens towards a plateau. (b) Vmax is about 42 a.u.; at the plateau the rate no longer rises with substrate concentration because all active sites are occupied. (c) Half of Vmax is 21 a.u., reached at 0.20 mmol dm-3, so Km is about 0.20 mmol dm-3. (d) A competitive inhibitor competes for the active site, so Vmax is unchanged (high substrate outcompetes the inhibitor) but Km increases because more substrate is needed for the same rate. Marking notes: 1 mark (a), 1 mark (b), 1 mark (c), 2 marks (d) one each for Vmax and Km.

Section B (Questions 6 to 10, 25 marks)

Answer ALL questions. A calculator may be used. Show your working in calculations, give numerical answers to three significant figures unless told otherwise, and state units in every final answer. All data are examples and this is not a past paper of any examination board.

6. Five potato strips (initial mass 2.50 g each) were left for 30 minutes in sucrose solutions from 0.0 to 0.8 mol dm-3. After blotting, their masses were 2.700、2.575、2.500、2.350、2.225 g. (a) Calculate the percentage change in mass for each strip, to one decimal place. (b) Estimate the sucrose concentration of the potato cell sap and justify your answer. (c) Explain why the 0.8 mol dm-3 strip lost mass. (d) Explain why the strips are blotted dry before weighing.

答案：(a) Percentage change in mass: 0.0 mol dm-3: +8.0%, 0.2 mol dm-3: +3.0%, 0.4 mol dm-3: +0.0%, 0.6 mol dm-3: -6.0%, 0.8 mol dm-3: -11.0%. (b) The strip in 0.4 mol dm-3 shows no change in mass, so there is no net movement of water and the cell sap is about 0.4 mol dm-3 sucrose. (c) The 0.8 mol dm-3 solution has a lower water potential than the cell sap, so water leaves the cells by osmosis; the cells lose turgor and the tissue shrinks, so mass falls. (d) Solution on the surface would add to the reading; blotting means the balance records only the tissue, so the percentage changes are comparable between strips. Marking notes: 2 marks (a) for all five values (1 mark for three or four), 1 mark each for (b), (c) and (d).

7. A 15-year-old student at rest has a tidal volume of 0.50 dm3 and a breathing rate of 15 per minute. After vigorous exercise the tidal volume is 1.20 dm3 and the rate is 32 per minute. Vital capacity is 4.2 dm3 and residual volume is 1.2 dm3. (a) Calculate the minute ventilation at rest and after exercise, in dm3 per minute. (b) Calculate how many times greater the ventilation is after exercise. (c) Calculate the total lung capacity. (d) Explain how the increase in ventilation helps muscles to keep contracting.

答案：(a) At rest: 0.50 x 15 = 7.5 dm3 per minute. After exercise: 1.20 x 32 = 38.4 dm3 per minute. (b) 38.4 / 7.5 = 5.12 times greater. (c) Total lung capacity = vital capacity + residual volume = 4.2 + 1.2 = 5.4 dm3. (d) A larger ventilation keeps the oxygen partial pressure difference between alveoli and blood steep, so oxygen diffuses in faster, and it removes carbon dioxide faster so blood pH does not fall. Muscles can therefore keep respiring aerobically and make the ATP needed for contraction. Marking notes: 2 marks (a) one each, 1 mark (b), 1 mark (c), 1 mark (d).

8. An athlete at rest has a heart rate of 70 beats per minute and a stroke volume of 70 cm3. During vigorous exercise the heart rate is 150 beats per minute and the stroke volume is 120 cm3. (a) Calculate the cardiac output at rest and during exercise, in dm3 per minute. (b) Calculate how many times greater the cardiac output is during exercise, to three significant figures. (c) Calculate the percentage increase in stroke volume, to three significant figures. (d) Explain the benefit of the higher cardiac output to the tissues.

答案：(a) Cardiac output = heart rate x stroke volume. At rest: 70 x 70 = 4,900 cm3 per minute = 4.9 dm3 per minute. During exercise: 150 x 120 = 18,000 cm3 per minute = 18.0 dm3 per minute. (b) 18,000 / 4,900 = 3.673 times greater. (c) (120 - 70) / 70 x 100% = 71.429%. (d) A higher cardiac output delivers more oxygenated blood to skeletal muscle, so oxygen and glucose arrive faster and carbon dioxide and lactate are removed faster, allowing aerobic respiration to continue for longer. Marking notes: 2 marks (a) one each, 1 mark (b), 1 mark (c), 1 mark (d).

9. The polymerase chain reaction starts from a single double-stranded DNA molecule and doubles the number of molecules each cycle. Each cycle takes 1.5 minutes. (a) Calculate the number of DNA molecules after 30 cycles. (b) Calculate the total time needed for all the cycles, in minutes. (c) In a double-stranded DNA sample, adenine (A) makes up 28% of all bases. Calculate the percentage of guanine (G). (d) State the purpose of heating to about 95 degrees C in each PCR cycle.

答案： (a) Number of molecules = 2 to the power 30 = 1,073,741,824. (b) 30 x 1.5 = 45 minutes. (c) A pairs with T, so T is also 28%. Together A and T make 56%, leaving 44% shared equally between G and C, so G = C = 22%. (d) The high temperature breaks the hydrogen bonds so the double helix separates into two single strands, which act as templates for primers and new strands. Marking notes: 2 marks (a), 1 mark (b), 1 mark (c), 1 mark (d).

10. A student counted the bubbles released per minute by the same water plant at 10, 20, 30 and 40 cm from a lamp: 10 cm: 48, 20 cm: 12, 30 cm: 5, 40 cm: 3. (a) State how light intensity depends on distance, and calculate the change in intensity when the distance is doubled. (b) Calculate the relative light intensity at 20 to 40 cm, taking the 10 cm value as 1.00 (three decimal places). (c) Predict the number of bubbles per minute at 5 cm. (d) Explain why the 30 cm and 40 cm results differ by only 2 bubbles.

答案： (a) Light intensity is inversely proportional to the square of the distance (I is proportional to 1/d squared). Doubling the distance from 10 to 20 cm gives 0.25, one quarter of the original intensity, and the bubble count falls from 48 to 12, also one quarter. (b) Relative intensities: 10 cm = 1.000, 20 cm = 0.250, 30 cm = 0.111, 40 cm = 0.062. (c) At 5 cm the intensity is (10 / 5) squared = 4 times that at 10 cm, so the count should be about 48 x 4 = 192 bubbles per minute. (d) At those distances the intensity is already very low (0.111 and 0.062) and light is the limiting factor, with the rate close to the compensation point; counting whole bubbles of unequal size also adds error, so a difference of 1 or 2 bubbles is not significant. Marking notes: 2 marks (a), 1 mark (b), 1 mark (c), 1 mark (d).

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