

IB Biology SL Paper 2 Mock Paper (second set, 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. At 25 ° C, 2.0 cm³ of 0.50% hydrogen peroxide solution is mixed with 2.0 cm³ of potato extract and 24.0 cm³ of oxygen is collected in 60 seconds. (a) Calculate the mean rate of oxygen production at 25 ° C, in cm³ s⁻¹. (b) The same apparatus is warmed to 40 ° C and 40.8 cm³ of oxygen is collected in 60 seconds. Calculate the rate at 40 ° C, in cm³ s⁻¹. (c) Calculate the percentage increase in rate from 25 ° C to 40 ° C. (d) Explain why the rate is close to zero at 80 ° C. (e) Explain how the rate of oxygen production represents enzyme activity in this experiment.

答案 : Answer: (a) rate = volume / time = 24.0 / 60 = 0.40 cm³ s⁻¹. (b) rate at 40 ° C = 40.8 / 60 = 0.68 cm³ s⁻¹. (c) percentage increase = (0.68 - 0.40) / 0.40 x 100 = 70.0 per cent. (d) 80 ° C is above the optimum temperature. The hydrogen bonds and ionic bonds holding the enzyme protein together break, the active site changes shape (denaturation) and the substrate can no longer bind, so the reaction almost stops. Denaturation is irreversible. (e) Catalase catalyses 2H₂O₂ to 2H₂O plus O₂. With the same substrate concentration, volume and time, the volume of oxygen released per unit time is proportional to the number of enzyme-substrate complexes formed, so it measures enzyme activity. Marking notes: 1 mark each for (a) to (e); (d) must mention denaturation and change of active site.

2. The rate of oxygen production of an aquatic plant is measured at different light intensities: 3.0 cm³ per hour at 20 units, 5.5 at 40 units, 6.4 at 60 units and 6.4 at 80 units. Temperature is kept at 25 ° C and carbon dioxide is sufficient. (a) Calculate the percentage increase in the rate when light intensity rises from 20 to 40 units. (b) Describe the change beyond 60 units and explain it. (c) Describe one change in the experimental design that would show carbon dioxide becomes the limiting factor above 60 units. (d) Explain why oxygen production per unit time is a better measure than leaf colour. (e) Predict the effect on the rate at 35 ° C and 80 units, and explain it.

答案 : Answer: (a) percentage increase = $(5.5 - 3.0) / 3.0 \times 100 = 83.3$ per cent. (b) Between 60 and 80 units the rate stays at 6.4 cm³ per hour, so the curve plateaus. Light is now in excess and the limiting factor has become carbon dioxide concentration or temperature, including enzyme amount and activity, so more light gives no further increase in the light-dependent reactions. (c) At 80 units, raise the carbon dioxide concentration, for example from 0.04 per cent to 0.08 per cent. If the rate of oxygen production rises, carbon dioxide was the limiting factor. (d) Oxygen is a direct, measurable product of the light-dependent reactions and is proportional to their rate. Leaf colour is a subjective observation that lags behind and is affected by chlorophyll breakdown and leaf age, so it cannot quantify a rate. (e) The rate rises slightly above 6.4 cm³ per hour because 35 ° C is closer to the optimum for the photosynthetic enzymes and enzyme activity in carbon fixation increases; above the optimum the enzymes denature and the rate falls again. Marking notes: 1 mark each for (a) to (e); (b) must state the plateau and a limiting factor.

3. Yeast breaks down glucose into ethanol and carbon dioxide in anaerobic conditions. 5.0 g of glucose is fully fermented at 25 ° C and 1 atm (molar mass of glucose 180.16 g mol⁻¹, molar gas volume 24.0 dm³ mol⁻¹). (a) Calculate the number of moles of glucose in 5.0 g. (b) Write the balanced equation for anaerobic respiration and calculate the moles of carbon dioxide produced. (c) Calculate the volume of carbon dioxide produced at 25 ° C and 1 atm, in dm³. (d) Explain why aerobic respiration yields far more ATP per mole of glucose than anaerobic respiration. (e) State one industrial use of this fermentation and explain why anaerobic conditions are needed.

答案 : Answer: (a) $n = 5.0 / 180.16 = 0.0278$ mol. (b) $C_6H_{12}O_6$ to $2C_2H_5OH$ plus $2CO_2$, so each mole of glucose gives 2 moles of carbon dioxide and $n(CO_2) = 0.0278 \times 2 = 0.0555$ mol. (c) $V = n \times 24.0 = 0.0555 \times 24.0 = 1.33$ dm³, about 1332 cm³. (d) Anaerobic respiration relies on glycolysis alone, so glucose is only partly oxidised and the net yield is 2 ATP. Aerobic respiration oxidises pyruvate completely to carbon dioxide and water, electrons pass down the electron transport chain to oxygen and oxidative phosphorylation produces about 30 to 32 ATP, so the energy yield is far higher. (e) Bread making, where carbon dioxide from yeast raises the dough, or brewing and bioethanol production. Anaerobic conditions are needed because in air yeast switches to aerobic respiration, so ethanol and carbon dioxide yields fall sharply and the product does not meet specification. Marking notes: 1 mark each for (a) to (e); (b) needs both the equation and the mole value.

4. A cross between two fruit flies gives 240 offspring: 168 show the dominant phenotype and 72 show the recessive phenotype. The expected ratio is 3 to 1. (a) Calculate the expected numbers of dominant and recessive offspring. (b) Calculate the chi-squared value. (c) With one degree of freedom the 5 per cent critical value is 3.841. Decide whether the result deviates significantly from 3 to 1 and explain. (d) Suggest one biological reason that could make an observed ratio depart from 3 to 1. (e) Explain why a chi-squared test is used instead of simply comparing percentages.

答案 : Answer: (a) dominant = $240 \times \frac{3}{4} = 180$ and recessive = $240 \times \frac{1}{4} = 60$. (b) chi-squared = sum of (O - E) squared divided by E = $(168 - 180)^2 / 180 + (72 - 60)^2 / 60 = 0.80 + 2.40 = 3.20$. (c) The value 3.20 is below the critical value of 3.841, so at the 5 per cent level the 3 to 1 hypothesis is not rejected. The difference between observed and expected numbers is explained by random sampling error and is not significant. (d) For example, differential survival of dominant individuals before counting, incomplete dominance or codominance making some phenotypes hard to classify, too small a sample, or parents that were not true homozygotes. (e) The chi-squared test takes sample size into account and tests whether the deviation exceeds random error. Comparing percentages alone cannot distinguish a deviation of 12 out of 240 from 1.2 out of 24 in statistical terms. Marking notes: 1 mark each for (a) to (e); (c) needs both the comparison and the conclusion.

5. Energy data for a grassland ecosystem in kJ per square metre per year: producers 45,000; primary consumers 4,500; secondary consumers 405; tertiary consumers 32.4. (a) Calculate the efficiency of energy transfer from producers to primary consumers. (b) Calculate the efficiencies from primary to secondary and from secondary to tertiary consumers. (c) Calculate the energy of the tertiary consumers as a percentage of the producers. (d) Explain why the number of trophic levels is usually limited to four or five. (e) State two main fates of the remaining energy at each level.

答案 : Answer: (a) efficiency = $4,500 / 45,000 \times 100 = 10.0$ per cent. (b) primary to secondary = $405 / 4,500 \times 100 = 9.0$ per cent and secondary to tertiary = $32.4 / 405 \times 100 = 8.0$ per cent. (c) $32.4 / 45,000 \times 100 = 0.072$ per cent. (d) Only about one tenth of the energy passes to the next level. The rest is lost as heat from respiration, lost in undigested material and excreta, or remains in parts that are not eaten. Energy therefore falls sharply with each level, and by the fourth or fifth level it cannot support a viable population, so the number of trophic levels is limited. (e) Two main fates: energy is lost as heat from respiration used to maintain metabolism, and energy in egested material, dead bodies and uneaten remains passes to decomposers and no longer flows along the food chain. Some energy is also stored in biomass for growth. Marking notes: 1 mark each for (a) to (e).

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. A length of mRNA has a coding region of 900 nucleotides and a stop codon of 3 nucleotides. (a) Calculate the number of amino acids in the protein. (b) Calculate the total number of nucleotides in this mRNA. (c) State where transcription and translation take place in the cell. (d) A substitution of A by G at nucleotide 300 of the coding region causes a missense mutation. Explain the possible effect on the protein. (e) Explain why a stop codon does not code for an amino acid but is still essential.

答案 : Answer: (a) Each amino acid is coded by 3 nucleotides, one codon, so the number of amino acids = $900 / 3 = 300$. (b) Total = $900 + 3 = 903$ nucleotides. (c) Transcription occurs in the nucleus, where mRNA is made from the DNA template. Translation occurs on ribosomes in the cytoplasm after the mRNA leaves the nucleus through a nuclear pore. (d) A missense mutation changes one codon so a different amino acid may be inserted. If that amino acid lies in the active site or affects the three-dimensional folding, the protein may lose or reduce its function. Effects are greater if a start or stop signal is affected. (e) Stop codons UAA, UAG and UGA do not bind tRNA or an amino acid, but the ribosome must read one before it releases the completed polypeptide and dissociates. Without a stop signal translation continues and produces an abnormally long, non-functional protein. Marking notes: 1 mark each for (a) to (e).

7. A potometer records that the water column moves 2.4 cm³ in 20 minutes on a leafy shoot. The total leaf area is 0.0150 m². (a) Calculate the rate of water uptake per minute, in cm³ min⁻¹. (b) Calculate the rate of water uptake per hour, in cm³ h⁻¹. (c) Calculate the transpiration rate per unit leaf area, in dm³ m⁻² h⁻¹. (d) Explain why transpiration is expressed per unit leaf area rather than per leaf. (e) Predict how the rate changes in windier conditions and explain.

答案 : Answer: (a) rate = $2.4 / 20 = 0.12$ cm³ min⁻¹. (b) $0.12 \times 60 = 7.2$ cm³ h⁻¹. (c) 7.2 cm³ h⁻¹ is 0.0072 dm³ h⁻¹, and dividing by 0.0150 m² gives 0.48 dm³ m⁻² h⁻¹. (d) Transpiration occurs through stomata and the leaf surface, so it is proportional to leaf surface area. Shoots differ greatly in leaf size and number, so leaf area is needed to compare plants or treatments fairly. (e) The rate increases. Wind removes water vapour from around the leaf, making the concentration gradient of water vapour between the air spaces and the outside air steeper, so diffusion is faster. Very strong wind or closure of stomata may reduce the rate instead. Marking notes: 1 mark each for (a) to (e); (c) requires correct unit conversion.

8. An adult produces 180 dm³ of glomerular filtrate per day and excretes 1.5 dm³ of urine. Plasma glucose concentration is 1.0 g dm⁻³ and the urine contains no glucose. (a) Calculate the volume of water reabsorbed per day, in dm³. (b) Calculate the percentage of water reabsorbed. (c) Calculate the mass of glucose filtered per day, in grams, and explain why none appears in the urine. (d) State where most reabsorption occurs in the nephron and describe the mechanism. (e) Predict the effect on urine volume and concentration if ADH secretion increases.

答案 : Answer: (a) $180 - 1.5 = 178.5$ dm³. (b) $178.5 / 180 \times 100 = 99.17$ per cent. (c) $1.0 \text{ g dm}^{-3} \times 180 \text{ dm}^3 = 180 \text{ g}$. All the glucose is actively reabsorbed by sodium-glucose cotransport in the proximal convoluted tubule and returned to the blood, so normally no glucose appears in the urine. (d) Most reabsorption occurs in the proximal convoluted tubule, where water follows sodium ions and glucose by osmosis after their active transport. The rest is reabsorbed in the loop of Henle, distal convoluted tubule and collecting duct, and ADH controls the water permeability of the collecting duct. (e) More ADH raises the water permeability of the collecting duct, so more water is reabsorbed, urine volume falls and urine becomes more concentrated. Marking notes: 1 mark each for (a) to (e).

9. The basic reproduction number R_0 of an infectious disease is 4.0, meaning one infected person infects 4 others on average in a fully susceptible population. (a) Calculate the percentage of the population that must be vaccinated to reach herd immunity. (b) Recalculate the required coverage if R_0 rises to 5.0 and compare the two values. (c) Explain why herd immunity cannot protect every individual. (d) Describe the roles of memory B cells and memory T cells in vaccine-induced immunological memory. (e) Explain why other public health measures are still needed when R_0 is very high.

答案 : Answer: (a) required coverage $= (1 - 1 / R_0) \times 100 = (1 - 1 / 4.0) \times 100 = 75$ per cent. (b) With $R_0 = 5.0$ it is $(1 - 1 / 5.0) \times 100 = 80$ per cent, five percentage points higher than at $R_0 = 4.0$. The more transmissible the pathogen, the higher the coverage needed to break transmission chains. (c) Herd immunity only reduces the overall chance of transmission. It cannot guarantee protection for each person: infants, immunocompromised patients, people for whom the vaccine is ineffective and those who decline vaccination may still be infected, so individual protection still depends on their own immunity. (d) Memory B cells proliferate rapidly on re-exposure to the same antigen and differentiate into plasma cells that release large amounts of specific antibody. Memory T cells rapidly mount cell-mediated responses, helping to activate B cells and killing infected cells, so the response is faster and stronger. (e) The coverage required may exceed what can be achieved, and vaccines are only partly effective at blocking transmission. Measures such as masks, ventilation, testing and isolation are still needed to lower the effective transmission rate, otherwise the epidemic still spreads. Marking notes: 1 mark each for (a) to (e).

10. A recessive genetic disease affects 4 per cent of a closed population of 5,000 people that is in Hardy-Weinberg equilibrium. (a) Calculate the recessive allele frequency q . (b) Calculate the dominant allele frequency p . (c) Calculate the carrier, heterozygous, genotype frequency and convert it to a number of people. (d) Calculate the number of affected people. (e) State two conditions required for Hardy-Weinberg equilibrium and explain how inbreeding changes the proportion of carriers.

答案 : Answer: (a) $q^2 = 0.04$, so $q = 0.2$. (b) $p = 1 - q = 1 - 0.2 = 0.8$. (c) carrier frequency $= 2pq = 2 \times 0.8 \times 0.2 = 0.32$, which is 32 per cent, and $5000 \times 0.32 = 1600$ people. (d) affected people $= 5000 \times 0.04 = 200$. (e) Conditions include a large population and random mating, and also no mutation, no migration and no natural selection acting on the locus. Inbreeding raises the proportion of homozygotes, so the number of affected recessive individuals rises and the proportion of carriers falls, while allele frequencies themselves do not change. Marking notes: 1 mark each for (a) to (e); (c) needs both the frequency and the number.